ISSN electrónico: 2172-9077
DOI: 10.48047/fjc.28.01.04

VIRTUAL REALITY FOR MENTAL HEALTH AND IN THE REHABILITATION OF VIOLENT BEHAVIOURS

Realidad virtual en salud mental y rehabilitación de conductas violentas

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Fecha de recepción del artículo: 01/03/2024
Fecha de aceptación definitiva: 16/03/2024

RESUMEN

La realidad virtual inmersiva crea un mundo digital que induce la ilusión de presencia, y que abarca tanto la sensación de estar dentro del entorno virtual representado (ilusión de lugar) como la creencia en la plausibilidad de los eventos que ocurren dentro de él (ilusión de plausibilidad). Estas ilusiones persisten a pesar de que el usuario es consciente de estar en un lugar físicamente diferente y de que el entorno es artificial, y los usuarios responden a los eventos virtuales como si fueran reales en todas las dimensiones fisiológicas, emocionales, conductuales y cognitivas. Además, la realidad virtual permite la ilusión de «encarnación» dentro de un cuerpo virtual y facilita la adopción de perspectivas de otros en escenarios virtuales. La posibilidad adicional de crear entornos sociales y la obtención de respuestas realistas ofrecen herramientas útiles para las aplicaciones de la salud mental, incluido el tratamiento de fobias, ansiedad social, trastorno de estrés postraumático, paranoia, esquizofrenia y comportamiento violento. La realidad virtual sirve como una herramienta única para el compromiso emocional y cognitivo en un entorno controlado, que facilita la exploración de perspectivas y el desarrollo de la empatía. Este artículo también explora la integración de la realidad virtual en los programas de rehabilitación para delincuentes violentos, y enfatiza sus beneficios como una alternativa segura, personalizable y rentable a los métodos terapéuticos convencionales. Se proporciona una visión general completa del estado actual y las posibles direcciones futuras de la realidad virtual en contextos de salud mental y rehabilitación.

Palabras clave: realidad virtual; salud mental; psicoterapia; cuerpos virtuales; comportamientos violentos; violencia de género; rehabilitación; prisiones

ABSTRACT

Immersive virtual reality creates a digital world that induces the illusion of presence, encompassing both the sense of being within the depicted virtual environment (place illusion) and the belief in the plausibility of events occurring within it (plausibility illusion). These illusions persist despite the user's awareness of being in a physically different location and the environment being artificial, and users respond to virtual events as if they were real across physiological, emotional, behavioural, and cognitive dimensions. Furthermore, virtual reality enables the illusion of "embodiment" within a virtual body and facilitates the adoption of perspectives from others in virtual scenarios. The possibility of additionally creating social environments and the elicitation of realistic responses offer useful tools for mental health applications, including the treatment of phobias, social anxiety, PTSD, paranoia, schizophrenia, and violent behaviour. Virtual reality serves as a unique tool for emotional and cognitive engagement in a controlled setting, facilitating the exploration of perspectives and the development of empathy. This paper also explores the integration of virtual reality into rehabilitation programmes for violent offenders, emphasizing its benefits as a safe, customizable, and cost-effective alternative to conventional therapeutic methods. A comprehensive overview of the current state and potential future directions of virtual reality in mental health and rehabilitation contexts is provided.

Key words: virtual reality; mental health; psychotherapy; virtual bodies; violent behaviours; gender-based violence; rehabilitation; prisons

1. The illusion of Presence in VR and the basis of VR for psychotherapy

A person has a fear of heights so profound that it affects their daily living. They cannot travel by underground train because it requires them to go down to the platform on an escalator. They cannot go into a department store because they know they cannot go to visit departments other than those on the ground floor. They cannot visit certain family members who live in apartment blocks because they cannot ascend the lift, and even if they could, they would be unable to be near a window of the apartment. If we think of the number of situations in our lives when we are faced with heights it should be clear that such an extreme phobia could make social life intolerable. Yet, there are therapies that can overcome this. A therapeutical strategy can be Cognitive Behavioural Exposure Therapy where patients are gradually exposed to the situation they fear, with a therapist helping them to reframe their way of conceptualising their anxiety and behaviour, over several sessions. Of course, this requires a lot of work, with the patient gradually being exposed, session by session, week by week to situations that might cause just that bit much more anxiety than last time, and the counsellor helping the patient to tolerate this. The therapist might typically give the patient exercises to do away from the therapy office – stand on a chair, climb a flight of steps, go up a short escalator in a station and so on. However, the therapist is not with the patient during these exercises.

Virtual Reality (VR) affords the whole treatment cycle taking place in the office of the therapist, with the therapist there, guiding the patient in real time, observing their reactions, and deciding the level of anxiety that the patient might next be able to tolerate. For a review of VR in field of heights see (Giraldy and Novaldo 2022). A VR head-mounted display (HMD) delivers a surrounding 3D stereo image, ideally with a wide field of view and high resolution. Images are generated to the HMD either through a computer embedded within it, or via a connection to another computer. The HMD is tracked with 6 degrees of freedom so that as the participant moves their head, so the images of the virtual scene displayed to the HMD screens are updated accordingly. More recent HMDs also have built in eye tracking. Hence a participant can look around a computer-generated scene in full stereo 3D much as they would look around a real environment. Similarly, HMDs typically produce spatialized audio, so that sounds appear to originate from different directions, depending on the spatial locations of their origins. Hence overall in VR participants perceive in a manner similar to how they perceive in physical reality – head turns, eye movements, bending to look underneath (virtual) objects, turning their head to hear a sound better, moving closer to an object to see or hear it better, and so on. These methods of perception using the body are referred to as sensorimotor contingencies (Noë 2004; O'Regan and Noë 2001) and are at the basis of a fundamental perceptual illusion that arises for participants in VR, the illusion of 'being there' in the environment generated by the displays, or Place Illusion (PI). Moreover, if the actions of the participant in the environment result in plausible responses (for example, push on a virtual door and it opens) a second illusion that we refer to as Plausibility (Psi) will typically be generated – the illusion that the events in the VR are really happening. These two together, PI and Psi are typically referred to as presence (Sanchez-Vives and Slater 2005; Sheridan 1992; Slater 2009; Slater et al. 2022).

Presence typically leads to behaviours in VR that matches real life behaviour in similar circumstances (Sanchez-Vives and Slater 2005). Hence a person with fear of heights in physical reality will also demonstrate fear of heights in virtual reality, and the same goes for many other conditions that require therapeutic interventions. Hence cognitive behavioural exposure therapy has been very successfully employed using VR for many years (for a review see Freeman (2007)), and for an actual application of cognitive behavioural exposure therapy for fear of heights see Freeman et al. (2019).
Hence overall VR has proven to be an excellent tool for psychological therapy, and in the rest of this paper we expand on this, and show various practical implications, that go beyond psychological problems such interventions for perpetrators of gender violence, and its use in prisons. Here we broadly address issues ranging from psychological therapy for specific problems that have led people to

approach a counsellor or psychotherapist or employ self-help methods, and physical enhancement through sports and exercise. Psychotherapy is one of the fields of applications of virtual reality that has been most exploited, however, it has been widely used in many fields and for an overview see Slater and Sanchez-Vives (2016). Moreover, what is referred to as 'virtual reality' is not always immersive and often consists of screens sometimes in combination with a tracking system. In this section we review VR in psychological and psychiatric rehabilitation.

2. Applications of virtual reality in mental health

Although there are very many types of treatment of psychological problems, one of the most widely used is cognitive behavioural therapy (CBT), for a review and meta-analysis see (van Dis et al. 2020; Hofmann et al. 2012). This approach challenges clients' habitual ways of thinking and helps them to reconceptualize their problems. This and most methods of psychological and psychotherapy contain two critical elements. The first is gradual and controlled exposure to the anxiety provoking situation, known as exposure therapy. For example, to overcome a fear of spiders first look at photographs of spiders, then plastic models and so on until ultimately faced with a real spider – a process that might take several months in severe cases. The second element is skill acquisition – for example, therapy for fear of public speaking must eventually involve the client in actual public speaking, and learning how to behave in that situation, if only to test the success or otherwise of the therapeutic intervention.

Each of these interrelated elements obviously requires that the patient actually experience a degree of anxiety, otherwise there is nothing for the therapist to work with. For example, if showing a photograph of a spider does not provoke anxiety then it is useless in the process of gradually exposing the client to spiders to learn to control their fears, while in the context of CBT also reframing their normal ways of thinking about spiders. On the other hand, with something like 'fear of public speaking' it is more difficult to gradually expose people to this, since in severe cases – someone with an actual phobia – clients could never be forced to do a 'small amount' of speaking in front of an audience – and simply showing photographs of an audience is unlikely to provoke sufficient anxiety.

Immersive VR provides an excellent tool for the exposure therapy process in particular. People tend to respond realistically to events and situations portrayed in VR. Hence when clients seeking therapy are presented with a situation that would be anxiety provoking for them in reality they should respond similarly in VR. In the following sections we illustrate how VR has been used in treatment of a variety of conditions. It should be stressed that VR by itself is not a 'treatment' – rather this is always in the context of some method such as exposure therapy or CBT.

2.1. Specific Anxieties and Phobias

Do people fear heights in VR even if they know that there is no precipice in VR? If people have a sense of being in the place depicted by the VR and there is an element of danger, then they should respond appropriately. A particular environment called 'the pit room' (Slater, Usoh, and Steed 1995) was invented to test this. In that experiment participants were required to walk across a room. The catch was that there was a square hole cut out of the floor in the room so that the floor was actually a narrow ledge by the walls on which people could walk, overlooking a precipice of about 18m. Participants could choose to either glide across the precipice or carefully make their way around the edge of the room by the hole. It was found that the walking led to a greater illusion of presence indicated by a greater likelihood that people would walk around the edges rather than go across the hole. These findings were later studied by (Meehan et al. 2002) who showed that when people approach the precipice there are physiological changes such as an increase in heart rate concomitant with increased stress.

A study by Diemer et al. (2016) investigated fear of heights (acrophobia) and focused on the extent to which patients and controls would exhibit different responses across a range of subjective and

physiological responses (skin conductance, ECG and cortisol levels). Participants were required to stand on top of a virtual three-stored building and look down to the ground. There was a massive increase in subjective anxiety in the patient group compared to the controls, but at first sight no important difference between the groups with respect to physiological responses. However, when considering HR immediately after the moments that participants were instructed to look down, then the response amongst the patients was greater than amongst the controls. The study results demonstrate the utility of VR in provoking sufficient anxiety responses to be useful in a therapeutic context.

It is likely that the first study using HMD-based immersive VR for the treatment of an anxiety disorder was the work by Hodges et al. (1995) on acrophobia, see also (Rothbaum et al. 1995a, 1995b). This used an exposure therapy approach where individuals who had been identified as suffering from acrophobia were able to experience riding an elevator, standing on a balcony or a bridge, compared to a waiting list control group who did not experience the VR. The authors were particularly interested in discovering whether the sense of presence induced by the experience would be powerful enough to evoke useful responses. Although the overall sample size of this study was small (n=17) the authors found a high degree of presence – with some reporting feeling 'terrified' after their first exposures - and the results remarkable, with overwhelming differences between the exposure and the control group demonstrating the effectiveness of the VR based therapy. It is important to realize that this study was carried out with equipment that today would be regarded as primitive – using a Virtual Research Flight Helmet rendering at 10 frames per second as 'the bottom line', but nevertheless with strong positive results.

A successful fear of heights intervention that employed CBT therapy was described in Freeman et al. (2018), which moreover employed the novel idea of a virtual therapist. Patients were required to go up various levels of a building, but the level was always assessed by a virtual therapist that could decide the appropriate level for the patient to go, depending on their answers to a set of simple questions to assess their level of anxiety. Seinfeld et al. (2016) also used a VR scenario to investigate the anxiety induced by a virtual lift in people with different degrees of fear of heights. In this case it was found that music could reduce the subjective anxiety produced by fear of heights with respect to a silent environment.

The use of VR can save time and cost is critical in some applications. While it is not too difficult to visit a few heights, consider fear of flying where 'in vivo' exposure requires airplane journeys or at least full simulations of these. While some airlines offer this type of service the cost per person can range between approximately $400 (for an on-the-ground course) to at least $2000 including a flight experience, effectively ruling out exposures for all but wealthy individuals. This point was emphasized in the first application that used VR for fear of flying (Hodges et al. 1996; Rothbaum et al. 1996). As the papers pointed out although there is considerable expense in building the virtual models for such a treatment, they can be used for many stages of the process of taking an airplane trip each of which may generate its own specific anxiety – the pre-boarding, the pre-takeoff, the takeoff, the immediate period after takeoff, and the period leading up to and during the landing. Moreover, once the model has been built it can be used repeatedly by many people. This was only a case study with one individual, but it set the scene for future applications and provided a proof of concept. This was followed up by Rothbaum et al. (2000). Participants wore a Virtual Research VR6 HMD and sat in a special chair that could give deliver vibratory and sound feedback through a subwoofer. A final test involved participants taking an actual flight, and there was a 6 month follow up period. The results showed again that the VR therapy performed at least as well as standard exposure therapy in reducing the fear of flying across multiple measures.

Carlin, Hoffman, and Weghorst (1997) were also one of the first to recognize how the presence inducing capability of VR could be used for therapy by using it for phobia of spiders, including the ingenious idea of registering the virtual spider with a physical object that felt like a spider. Hence while

the participant would see a spider through the HMD on trying to touch that virtual spider, she or he would actually feel something like a real spider. Their case study on a single individual was followed up by several others (Garcia et al. 2002; Hoffman et al. 2003; Renaud, Bouchard, and Proulx 2002). Another powerful demonstration of the utility of VR has been shown – since in VR the virtual spiders can be shown in multiple contexts, and of course multiple times. This approach has been shown to further enhance the positive therapeutic outcome (Shiban et al. 2015; Shiban, Pauli, and Mühlberger 2013).
Overall a large amount of research has gone into the area of clinical psychology/psychotherapy using VR (Gamito, Rizzo, and Brown 2023; Krijn et al. 2004; Meyerbröker and Emmelkamp 2011; Opriş et al. 2012). In social and economic terms this is worth the effort, furthermore, considering the reduction in social and individual cost and suffering that new methods might bring about. According to the US National Institute of Mental Health just over 18% of the adult US population suffer from anxiety disorders and depression, with 4% classified as severe.

2.2. Social Phobia

The specific anxieties and phobias discussed above are relatively easy to represent in immersive virtual reality. There are anxiety disorders that involve interactions with other people, and this is far more difficult to address because the very nature of social interaction is largely unpredictable and necessarily involves the actions of the participant. We refer to the class of problems called 'social anxiety' or in more extreme manifestations 'social phobia'. The American Psychiatric Association's official definition includes (American Psychiatric Association 2013) "A persistent fear of one or more social or performance situations in which the person is exposed to unfamiliar people or to possible scrutiny by others. The individual fears that he or she will act in a way (or show anxiety symptoms) that will be embarrassing and humiliating." A person with this type of problem will have excessive anxiety that she or he knows to be unreasonable and will attempt to avoid situations that provoke such anxiety. The prevalence of social phobia in the US is about 7% of the adult population with 2% classified as severe.
A particularly prevalent type of social anxiety is fear of public speaking (Pull 2012). Exposure therapy in this domain is quite costly and difficult to organize – clients eventually have to speak to real audiences, which requires either setting up artificial situations with actors or role playing or taking advantage of actually planned talks. The first is costly, and the second requires the participant to do exactly what she or he is afraid of! Here the gap between reality and virtual reality is ideal – someone with a phobia of speaking in public can nevertheless be persuaded to speak to a virtual audience. Although this generates strong anxiety it is at a diminished level compared to really speaking in public, but nevertheless can be successfully used in exposure therapy. North, North, and Coble (1998) showed this with a virtual audience displayed on a screen. Pertaub, Slater, and Barker (2002) exposed people to three different types of audience as in a small seminar room, via a head-mounted display: an extremely positive audience that maintained eye contact with the speaker throughout and gave a standing ovation at the end, an extremely negative audience that yawned, never looked at the speaker, and started to walk out during the talk, and a neutral audience. They found that even experienced speakers were unable to present their talk to the negative audience. The evidence suggested that VR could offer an efficient and relatively cheap way to carry out therapy despite the complexity of this social interaction. A set of case studies using VR for fear of public speaking was presented in (Anderson et al. 2003).

Wallach, Safir, and Bar-Zvi (2009) carried out a randomized control trial comparing standard CBT (n = 30) with CBT but where the exposure component was with VR (n = 28) and a waiting list control group (n = 30). They found that using VR for the CBT exposures compared well with standard imaginal methods (i.e., imagining speaking in front of an audience) over 11 sessions of treatment. The results suggested that the CBT treatment methods both showed significant improvements over the waiting list, as would be expected, and that the VR condition was at least as effective as the CBT imaginal

method across a range of outcome measures – although twice as many participants dropped out of the CBT study compared with the VR. Moreover, participants maintained this improvement in a one-year follow-up study (Safir, Wallach, and Bar-Zvi 2012).

Another randomized control study was reported by (Anderson et al. 2013) which n = 97 participants with fear of public speaking as their primary social anxiety were randomly assigned to one of three groups: VR exposure therapy, the 'gold standard' of group therapy and a waiting list. An important measure was that participants had eventually to deliver an actual talk. Once again, the VR treatment was shown to be at least as effective as standard exposure therapy across a range of outcome measures, and both were superior to the waiting list control group.

Aymerich-Franch, Kizilcec, and Bailenson (2014) carried out a novel study on fear of public speaking with a non-patient group. They embodied a virtual body that either had a self-similar face or a different face. The hypothesis was that they would show less anxiety when having the face of another compared to the self-similar one. As pointed out in Anderson et al. (2013) although a mass of evidence does suggest the efficacy of VR for exposure therapy for fear of public speaking – see also (Cláudio et al. 2013; Opriş et al. 2012) – further randomized control studies are needed, and we would add ideally with a 'double blind' component – so that neither subjects nor experimenters are unconsciously biased towards one type of treatment or other.

Exposure therapy requires several sessions where each time the speaker has to perform in front of a larger or more difficult audience. Banakou et al. (2023) compared traditional VR exposure therapy over 5 sessions, with a single session. In this single session the participant started out talking with a virtual counsellor about fear of public speaking, and then over the course of approximately 20 minutes that counsellor morphed into an entire seated audience. Most of the changes happened in peripheral vision, since the participant was always talking with and concentrating on the counsellor immediately in front. A week later the participant had to return to present a famous rock band on stage to a large virtual audience, and their degree of anticipatory anxiety and anxiety during their presentation was measured. It was found that the single exposure method was at least as good as the multiple exposure in reducing anxiety, and that both were better than a control group where the participant only spoke to a single virtual character about everyday matters. This example illustrates an approach that can only be carried out in VR, making use of the power of the medium to enable events that are impossible in reality.

Fear of public speaking is the type of social anxiety that has received the most attention for virtual reality therapy, see the survey by Vanni et al. (2013). However, social anxiety encompasses a host of other aspects – such as meeting new people, going to parties, interactions with members of the opposite gender, eating in front of other people, problems in interacting with authority figures, etc. It is a complex syndrome, because, for example, someone may have a morbid fear of going to parties but be quite relaxed when speaking in front of an audience of hundreds.

There have been few studies that have attempted to cover these more complex social interactions. Klinger et al. (2005) compared CBT with VR exposure therapy. Four aspects of social anxiety were tackled: performance anxiety (public speaking), intimacy (personal interactions with others), scrutiny (social interaction while being watched by strangers), assertiveness (the patients had to stand up for their own opinions) – e.g. in the face of criticism. The VR was not immersive but shown on a large screen. The problem of displaying and interacting with virtual humans was solved simply by the virtual humans being 2D video recordings of real people textured into the virtual environment, in fixed interactions with the patient. The CBT exercises were carried out through role-playing with real people. The study found that both CBT and the VR method clearly improved the condition of patients across 6 different outcome measures with remarkably similar results between the two.

Parrish et al. (2015) had 41 adolescents experience a party and public speaking scenario and two neutral scenarios. The participants became more stressed in the party and public speaking

environments. (Powers et al. 2013) compared anxiety when talking with real people compared to virtual. They showed increased anxiety relative to baseline in the VR condition.

Apart from VR being typically less costly and logistically simpler to employ than for example setting up situations such as role-playing with real people, it has a major advantage that it is possible to gather information that is difficult to obtain, if not impossible, through interactions in real life. In real-life encounters, even with actors, the situation is not well controlled. VR here has the clear advantage that the virtual conversational partner of course cannot be disturbed by the patient wearing eye equipment, and also the situation is controlled. However, one of the disadvantages of VR is that the virtual human characters still today have nowhere near the capability of real humans to understand and react appropriately in social interaction settings. This requires a natural language understanding and generation of natural language and all the associated body movements and facial expression in real-time. Novel AI approaches for avatar control should strongly contribute to this needed improvement (Butt, Ahmad, and Shafique 2021).

Using human-controlled avatars as a solution to this problem, Pan et al. (2012) carried out an experiment with shy male participants who had anxieties about interacting with members of the opposite sex were approached by a virtual female who talked to them. Both the anxious and confident groups showed a substantial increase in physiological arousal indicating stress when the virtual women first approached, but the greatest decrease in stress was amongst those in the anxious group.

Studies in this domain often concentrate on whether VR exposure to virtual characters generates sufficient anxiety in people with social anxiety disorder. Studies have demonstrated that VR tends to generate anxiety in various social situations, essential for its effective use in therapy (Emmelkamp, Meyerbröker, and Morina 2020). Although it is almost certainly the case that VR does not generate the same anxiety as real social interactions, the question as to whether it generates sufficient anxiety so that adaptation through VR exposure carries over to real world encounters, with long-term beneficial outcomes, remains to be seen. More recently, the advent of large language models (LLM) such as ChatGPT have dramatically enhanced the possibility of interaction with virtual human characters. It is now possible to speak in real-time to a LLM driven virtual human, for example (Shoa, Oliva et al. 2023), and where the character, via the LLM can engage in therapeutic counselling with the participant.

2.3. Post-traumatic stress disorder

Post-traumatic stress disorder (PTSD) can occur when a person experiences a violent or otherwise life-threatening traumatic event. It is characterized by frequent flashbacks, nightmares, extreme arousal in response to sudden events such as loud noises, a deadening of emotions, disconnection and drifting apart from other people, and an inability to focus on memories of the original event. Amongst people who have experienced a traumatic event the incidence is around 30% and about 40% amongst combat war veterans, although estimates vary widely amongst researchers. A major review of treatments by Bisson and Andrew (2009) found that 'trauma focused cognitive behavioural therapy' (whether individually or in a group setting) and Eye Movement Desensitization and Reprocessing (EMDR) were effective in reducing symptoms. Each of these requires the patient to focus on the trauma, using imaginal techniques. The CBT approach as usual includes exposure therapy, where the patient has to revisit the trauma or events associated with the trauma in imagination many times as part of the process of anxiety extinction and reframing. For example, someone with PTSD due to a traffic accident would need to get used again to driving in traffic first in imagination. As was pointed out by Rothbaum et al. (2001) some patients do not benefit from CBT approaches, they speculate because of the difficulty in imagining or even talking about the traumatic events. Indeed, an inability to focus on the traumatic events is one of the presenting symptoms of PTSD, and yet some ability to do so is

required for successful therapy. Immersive VR provides an obvious way out of this problem, since as we have argued several times above, the patient can re-experience prototypical aspects of the traumatic events, with sufficient anxiety but where the gap between reality and virtual reality is enough to allow them to do so.

Rothbaum et al. (2001) pointed out that there are several potential advantages to VR therapy for PTSD - conducting the therapy in the office (without field trips) therefore also minimizing potential embarrassment of the patient exhibiting symptoms in public, exactly controlling the stimuli with therefore some control over the level of anxiety produced and minimizing the chance of adverse reactions. Almost all studies that have used VR have been for exposure therapy typically in a CBT context. A single case study with a Vietnam War veteran was reported by Rothbaum et al. (1999) concentrating heavily on the representation of Huey helicopters. (Rothbaum et al. 2001) later gave results for between 5 and 9 patients (depending on the measure used), which had a 6-month follow-up, and where there were reported reduction in symptoms of between 15% and 67%. Attention moved to the use of VR in exposure therapy for veterans in the Iraq and Afghanistan wars post 9/11. (Gerardi et al. 2008) also reported a case study with a single patient, the system was described in (Rizzo et al. 2009), and a review of the evidence in (Gerardi et al. 2010). (Reger et al. 2011) described a study with n = 31 patients in a military mental health clinic. Of interest is the fact that patients were recruited to this study only if other treatments had already been tried and failed. The paper reports that there were reductions in symptoms that were both statistically and clinically significant.

Gonçalves et al. (2012) in a meta-review found that virtual reality exposure realized results that were superior to a waiting list control group but did not have statistically superior results compared to normal exposure therapy. The authors pointed out that on the whole dropout rates were not lower than traditional methods. Nevertheless, the use of VR seemed to be appropriate especially for some patients who are unable to engage in traditional (imaginal based) exposure. Other meta-reviews (Botella et al. 2015; Motraghi et al. 2014) also considered the suitability of the treatment protocols used in VR exposure therapy, and also the acceptability of the method. Although as with other studies they found that VR has several advantages mentioned above, they also called for more controlled studies with wider samples (size and cultures).

In summary it can be argued that PTSD is a condition that is ideal for treatment with VR exposures. For some patients who are resistant to imaginal techniques, there may be no other method, and ability with VR is possible to present scenarios that may be impossible in reality, yet which are potentially therapeutically valuable. However, it can also be seen that the literature abounds with single case studies, small samples, and the lack of properly constituted clinical trials with a large sample size and with a longitudinal follow up.

2.4. Paranoia

Social anxiety disorder patients fear that others are evaluating them negatively. People with paranoia (persecutory delusions) additionally have unfounded beliefs that others are persecuting them and wish to actively do them harm (Schutters et al. 2012). Around 10-15% of the population experience these types of persecutory thoughts (Freeman 2007; Olfson et al. 2014) and this is very common in patients with psychosis. It has also been shown using a VR study that paranoid ideation exists on a continuum from low levels, through non-clinical but nevertheless clear persecutory feelings, through to clinical conditions (Freeman et al. 2010). A study by Freeman (2008) exposed 200 people from the general population to a virtual environment where they were amongst a number of neutrally behaving virtual characters on a 4-minute simulated journey on the London Underground train system. The study found that more than 40% had some paranoid thoughts in relation to these virtual characters, although these virtual humans displayed no negative behaviours whatsoever towards the participants.

VR has been argued to uniquely provide an important potential for the breakdown of unfounded persecutory beliefs and importantly the safety and avoidance behaviours in which patients engage to try to allay their fears (Fornells-Ambrojo et al. 2008, 2015). The first point is that if a person has persecutory thoughts with respect to a virtual character displayed in VR, those beliefs are demonstrably false. In any encounter with real people, for example in naturally occurring situations or contrived situations for role play, it might be the case that the persecutory thoughts are justified (there is no way to prove that they are not). However, with a virtual human the truth of such thoughts cannot be maintained. Second, in carrying out safety behaviours (such as avoidance of eye contact, keeping a substantial distance away from other people) patients may actually generate in others the very hostility that they fear. However, it is impossible to upset a virtual character (unless it is specifically programmed to behave that way) so that this type of negative feedback cycle cannot occur. Finally, as is the case with the specific and social phobias, patients may be willing to face their fears (enter a room full of virtual people) even though this generates quite uncomfortable feelings, whereas they may not be willing to do so in reality. The illusion of presence (Place Illusion and Plausibility) that VR delivers are critical to its successful use in this domain.

The first question considered by psychologists was whether indeed people do experience paranoid thoughts in relation to virtual characters. (Freeman et al. 2003) carried out an experiment in VR to assess this and found that the extent to which people experience persecutory thoughts from entirely virtual characters was positively correlated with the degree of paranoia they experience in everyday life. The results demonstrated that VR could be used both to investigate the etiology of paranoia, for example as in (Freeman et al. 2005), and eventually be used for treatment. Valmaggia et al. (2007) showed that VR could be used safely with patients at risk of psychosis (n = 21). Fornells-Ambrojo et al. (2008) exposed 20 clinically paranoid patients to the train ride, with a follow-up one week later. Similarly, it was found that the scenario could be safely used with clinical patients and that paranoid thoughts were clearly generated by the experience, a study followed up in (Fornells-Ambrojo et al. 2015). Valmaggia et al. (2015) has also exposed patients with ultra-high risk of psychosis to the tube train scenario, and found that it was safe to do so. In a rare longitudinal study Freeman et al. (2013) examined four weeks after their hospital attendance 106 people who had actually been assaulted, in order to understand the relationship between post-traumatic stress disorder and paranoid thoughts that may have generalized from the incident.

We mention these studies because while they use techniques that are of course possible in everyday life or contrived settings with real people, VR makes it particularly easy to expose people to those types of social situations where persecutory thoughts are likely to occur, and under controlled and safe conditions.

VR has been extensively used in the study of paranoia, but it is also starting to be used in treatment (Freeman et al. 2016; Moritz et al. 2014). In the last, it was found that the CBT in conjunction with exposure therapy outperformed the exposure therapy by itself, although in fact the differences between the two procedures were quite small. VR therapy can also utilize other strategies, such as compassionate imagery, to challenge negative self-perceptions and views of others, leading to reduced paranoia (Brown et al. 2020).

2.5. Schizophrenia

Most attention has been paid to paranoia amongst the psychoses regarding the use of VR. As reported in the review by Veling, Moritz, and Gaag (2014) VR was beginning to be used for the assessment and treatment of psychoses, apart from paranoia, especially schizophrenia (Freeman 2008). There have been three main approaches. First, using VR as a way to characterize aspects of schizophrenic patients through comparisons with healthy controls. This has been applied to cognitive flexibility in decision making (Han, Kim, and Kim 2012), memory impairment (Weniger and Irle 2008),

and wayfinding (Hanlon et al. 2006). In all these examples, VR (usually screen based) provides a setting in which people carry out some tasks and then differences between patients and controls are assessed. The second type of application has been to use virtual reality in the context of skills training. Here patients are put into a virtual environment where they learn, for example, to carry out social tasks that they would normally encounter in everyday life (Park et al. 2009, 2011; Rus-Calafell, Gutiérrez-Maldonado, and Ribas-Sabaté 2014). These studies report positive outcomes, but typically employ quite small sample sizes without control conditions. The third type of application made use of virtual reality to simulate aspects of the schizophrenic condition. Park et al. (2011) developed such an application not for patients themselves, but for non-patients for the purposes of decreasing stigmatization through an enhancement of empathy. Banks et al. (2004) developed such a system that could be used, for example, by medical students to help them understand the subjective world of such patients.

A highly innovative use of the simulation approach resulted in a potentially new form of therapy. Leff et al. (2013) developed 'Avatar Therapy' where patients create a virtual human representation of their hallucinatory persecutor, engage with it, but where the interaction is under the control of the therapist so that eventually the patient gains mastery over it.

A systematic review by (Bisso et al. 2020) found evidence supporting the effectiveness and versatility of VR in treating a variety of psychotic symptoms. This includes positive symptoms like delusions and hallucinations, as well as negative symptoms like cognitive and social skills deficits. The review also highlighted the safety and tolerability of VR interventions, with no reports of serious side effects and promising long-term effects of the therapy.

3. VR for the reduction of violent behaviour

The benefits of virtual reality range over many areas, and all in all, the increasing use of virtual reality for practical and therapeutic purposes warrants a deeper understanding of the factors that contribute to making the virtual experience seem more real. An important factor to this end is virtual embodiment. Virtual embodiment refers to the process of replacing a person's physical body with a virtual one. Achieving this requires specific technical equipment at a minimum, including a stereoscopic head-mounted display (HMD) with a wide field-of-view (allowing the user to see the virtual body) and head tracking. Additionally, multisensory correlations, such as synchronized visual and tactile (visuotactile) or visual and motor (visuomotor) information, can further enhance the experience (Kokkinara and Slater 2014; Llobera, Sanchez-Vives, and Slater 2013; Maselli and Slater 2013, 2014; Neyret et al. 2020; Sanchez-Vives et al. 2010; Slater et al. 2008; Spanlang et al. 2014). Under the right conditions, including first-person perspective (1PP) and visuotactile or visuomotor synchrony, virtual embodiment can lead to the illusion of body ownership (Slater et al. 2009). This perceptual illusion makes the virtual body feel like the person's own, even if it doesn't resemble their real body.

One of the factors that modulates the perception of realness of virtual environments is the perspective from which they are experienced. Embodiment in virtual environments allows fro of others in a certain situation or social interaction. For example, the embodiment in someone of a different race consistently leads to a decrease to a decrease in the implicit racial bias (Banakou, Hanumanthu, and Slater 2016; Maister et al. 2015) provided that the social context in which this occurs is a positive one (Banakou et al. 2020). A neural network model providing a mechanism that explains these results can be found in Bedder et al. (2019).

To explore the potential of VR in rehabilitating perpetrators of gender violence, we designed a scenario where a male participant embodies a female avatar experiencing verbal and psychological abuse from a male partner. This allowed the participant to confront the situation from the victim's perspective. To investigate whether this experience would be impactful in men without the story of gender violence, a study in two group experiencing first person perspective (1PP) and third person

perspective (3PP) was carried out by Gonzalez-Liencres et al. (2020). A virtual body witnessed from a 1PP induced physiological reactions and subjective responses to stimuli that are reminiscent of real-life situations, whereas a virtual body observed from a third-person perspective did not generate the same physiological changes and subjective sensations, at least not to the same degree. The experimenter had slight control over the virtual man throughout the scene, since he could make the virtual man say, "Look at me!" when the participant looked away, or "Shut up!" and "I told you to shut up!" when the participant spoke, which facilitated the virtual man-woman interaction. The study revealed that there was no problem for the men to embody the body of a woman, and also that they responded to the virtual aggression to some extent as if it were real. 1PP participants considered the experience more real, more threatening with a high potential to empathize with the female victim of intimate partner violence, with more intense feelings of fear, helplessness, alertness, and vulnerability, as revealed by the qualitative analysis of the interviews. 3PP participants responded in a more detached manner, had a less threatening impression although they did feel uncertainty, anxiety and repulsion (Gonzalez-Liencres et al. 2020). Skin conductance responses revealed significant responses to events (like threatening invasion of the peri personal space), albeit no significant differences were detected between 1PP and 3PP.

This same approach has been used with domestic violence offenders. In Seinfeld et al. (2018) a group of male domestic violence offenders and a control group without a history of violence experienced a virtual scene of abuse in first-person perspective. Studies have found that offenders have difficulties in accurately recognizing emotions such as fear and anger, which has been hypothesized to hinder offenders' compassionate responses (Chapman, Gillespie, and Mitchell 2018). After being embodied in a female victim, offenders improved their ability to recognize fearful female faces and reduced their bias towards recognizing fearful faces as happy. Seinfeld et al. (2018) demonstrated that a virtual domestic abuse scene experienced from the perspective of a female victim can positively increase offenders' sensitivity to recognize fear in fearful female facial expressions and reduce offenders' bias towards misclassifying facial expressions as expressing happiness rather than fear.

A similar approach was used in Seinfeld et al. (2022), however in this study male participants with and without a history of intimate partner violence (IPV) were embodied in a virtual child perspective, while witnessing a domestic violence scene where a male avatar verbally assaulted a female avatar. They intended to evaluate the impact of the VR experience on the emotion recognition skills of males with a history of IPV perpetration in comparison to a group of males without a history of violence. Strong evidence was found that the controls increased their sensitivity to recognize fear in male faces after the VR experience, compared with the males with a history of IPV perpetration. Males with a history of IPV perpetration after the VR seemed to have a tendency to respond with fear rather than with happiness when presented with female faces, which is coherent with the results found in Seinfeld et al. (2018). Regarding physiological responses during the VR scene, heart rate deceleration was larger in the controls than the males with a history of IPV perpetration, when the male avatar approached the female avatar and invaded her and the child's personal space. Therefore, embodiment from a child's perspective during a conflict situation in VR impacted emotion recognition, physiological reactions, and attitudes towards violence.

This use of VR to change perspective in the context of intimate partner violence has been also investigated in brain imaging studies (Borst et al. 2020; Seinfeld et al. 2021). These studies detect changes in the default mode network activation depending on the perspective, which is probably at the basis of the changes in emotion recognition and empathy.

In the next sections we discuss how the potential of VR scenarios and virtual embodiment and perspective taking can be integrated into rehabilitation programs for intimate partner violence aggressors and more generally, violent behaviour.

4. Integration of virtual reality tools into rehabilitation programs for violent offenders

The available evidence supports the idea that, similar to other forms of criminal behaviour, violent offending can be mitigated through rehabilitation programs that align with the principles of matching the program's intensity with the offender's risk level, addressing the specific needs of the participants, and designing interventions to maximize behavioural change responses tailored to each specific profile (Dowden and Andrews 2000; Polaschek et al. 2005). A frequent constraint associated with the application of this 'need' principle in addressing violent behaviour, especially among prison-based populations is the challenge of safely practicing in real-life situations that are difficult and potentially triggering (Woicik et al. 2023).

In recent years there has been a core of research that supports multiple advantages of the use of VR tools in diverse rehabilitation programs. These tools enable interaction with a simulated reality, offering an immersive, safe, cost-effective, and entirely customizable alternative compared to traditional methods such as face-to-face or in vivo exposure therapy maintaining a high ecological validity (Despoti et al. 2022). The VR has emerged as a highly promising and powerful tool for data collection, cognitive and behavioural modification, capable of aligning with the specific needs of the program or the subjects (Cornet and Gelder 2023). In terms of research, VR has the potential to generate and assess objective metrics, and also help tackle methodological challenges such as sample size, validity, and causal inference. This underscores the transformative potential of VR across all levels required by a violence rehabilitation program, from cognition to behaviour.

From a patient-centered perspective, one specific utility of this tool is its possibility to track multiple parameters of behaviour (e.g. eye and movement tracking), enabling the extraction of accurate data for analyzing individual performance. This functionality proves invaluable not only for research purposes but also for enhancing the overall constant improvement of the tool and, more importantly, aiding in the maximal personalization of therapeutic protocols to maximize the desired outcomes.

4.1. The rehabilitation protocol for violence offenders: main addressed issues

The main target domains in terms of violent offenders' rehabilitation treatments are based on dynamic factors that mediate and maintain criminal behaviour, namely attitudinal factors, impulsivity, affective control, and poor lifestyle habits (Bonta and Andrews 2017; Polaschek 2006).

Given the common occurrence of impairments among criminal offenders across multiple levels, the preferred approach to treatment typically involves multicomponent programs (Day and Doyle 2010). Most of these programs for addressing violent behaviour are grounded in the Personal, Interpersonal, and Community Reinforcement perspective. This perspective asserts that individuals possess control over their actions, and this control is influenced by cognitive processing (Andrews and Bonta 2010). On the contrary, The Cognitive Behavioural Therapy (CBT), which is often the first-choice treatment in psychotherapy, is not typically the preferred treatment for this type of offender due to the fundamental requirement of willing a voluntary change, a component often lacking in these profiles (Day et al. 2008; Smeijers et al. 2018). Therefore, it is essential to address the different altered components for the individual to gain insight into their processes and limitations, thus facilitating the modification of violent behaviour. Specifically, key areas for treatment target include cognitive processing, recognition and regulation of emotions, and empathy. Our previous work supports VR as a promising method for specifically addressing the enhancement of emotional recognition as a precursor to empathy while maintaining cost efficiency (Barnes, Sanchez-Vives, and Johnston 2022; Johnston et al. 2023; Seinfeld et al. 2018). This approach has the potential to reduce treatment times and allows for customized treatment adjusted to the patient's needs.

4.2. Empathy and emotion in the psychotherapeutic rehabilitation treatment of aggression with VR

As previously mentioned, the level of immersion in VR experiences is determined by the sense of presence or place illusion, the plausibility illusion of the scene, and the embodiment illusion when a virtual body is present (Maselli and Slater 2013; Slater et al. 2009). These elements of the VR tool have been shown to be specific properties that enable the understanding and training of emotion recognition, control, and empathy in an exclusive experiential manner (Seinfeld et al. 2018, 2022). Individuals have the opportunity to expose themselves to a variety of stimuli, such as different bodies, behaviours, and scenarios, experiencing them firsthand from another perspective. It has been observed that experiences of 'perspective-taking' in virtual reality can increase prosocial behaviour towards others (Loon et al. 2018) and also improve recognition of emotions in the victim (Seinfeld et al. 2018; Ventura et al. 2021). When considering empathy within this context, the prevailing conception, as described by Davis (1980), posits that it comprises an affective component involving the experience of others' emotional states and a cognitive component involving the ability to imagine and understand others' mental processes. Experiences with interventions among such populations reveal that empathy cannot be viewed merely as a direct predictor of violence but rather as a moderator influencing the connection between risk factors and actual perpetration (Barnes et al. 2022).

In our prior research, where we implemented a VR program for rehabilitating intimate partner violence perpetrators in prison populations, we conceptualized empathy primarily as a cognitive risk factor, using an embodied perspective-taking, and emotion recognition measured through cognitive tasks as outcomes of this perspective-taking experience. The implementation of this program yielded several advantages, including implicit learning that led to improvements in empathic skills and behavioural responses to violent interactions (Barnes et al., 2022).

Lara and Rueda (2021) mention several pieces of evidence indicating that the key to increasing empathy using the 'embodiment' feature with this tool lies in truly experiencing the cognitions and emotions of the other with perspective-taking. It highlights that in order for this process to be effective, providing instructions and context beforehand is crucial.

Similarly, high levels of immersion in VR lead to more significant emotional reactions, affecting factors such as arousal, valence, and overall emotional intensity (Gall et al. 2021; Mancuso et al. 2023; Marín-Morales et al. 2020). This —empathy and the level of emotional reactivity—are critical features in the rehabilitation treatment of violent offenders, as their inability to recognize and subsequently control emotions often underlies their lack of adaptive strategies in reacting to various stimuli (Barnes et al. 2022; Palix et al. 2022; Seidel et al. 2013; Seinfeld et al. 2018).

Ingram et al. (2019) provided an instance of how VR can enhance empathy and reduce aggression. Their study involved testing several VR scenarios, such as simulating parties or observing fights in hallways, aimed at immersing adolescents in realistic situations to prevent aggressive behaviour towards their peers. The results revealed a significant increase in empathy levels among participants following the VR intervention. Moreover, this intervention correlated with a decrease in bullying perpetration, a change that was mediated by the increase in empathy experienced by the participants.
Another recent intervention with significant potential for inclusion in rehabilitation programs was conducted by Ivarsson et al. (2023). Using the Virtual Reality Aggression Prevention Training (VRAPT), they aimed to preventing aggressive behaviours targeting the emotional sphere on incarcerated violent offenders exhibiting early onset and complex needs. This pilot study aimed to pinpoint behavioural changes resulting from VRAPT, specifically targeting emotion regulation, aggression, and levels of anger.

The immersive VR experience employed a role-play approach, centered on identifying and recognizing several aspects of emotional responses within observed avatars, including facial expressions,

voice modulation, and body language. The study yielded promising results, demonstrating reductions in violent tendencies and improvements in emotion regulation among participants. Furthermore, the study underscored the importance of personalized treatment approaches tailored to individual needs and emphasized the necessity need for further research in this area to refine interventions and optimize outcomes.

4.3. Utilizing VR Tools for Cognitive-Focused Intervention in the Rehabilitation of Violent Offenders

Within the clinical practice with offenders' population, the presence of cognitive distortions (pattern of biased or irrational way of information processing), and cognitive deficits (impairments in the cognitive functioning e.g. memory, problem-solving, or language skills) has been frequently described (Barnes et al. 2022; Ross and Fabiano 1985). This aligns with findings indicating a strong relationship between cognitive distortions and violent behaviour (Chereji, Pintea, and David 2012).
These generalized cognitive impairments have been also identified as hindrances to the effectiveness of psychotherapy. More specifically, deficits in cognitive skills within the offender population impede the correct execution of specific tasks within these rehabilitation programs, requiring a certain level of verbal and written proficiency or the comprehension of abstract concepts (Barnes et al. 2022; Muñoz García-Largo et al. 2020). Therefore, addressing these cognitive deficits can be crucial when designing programs utilizing VR technology within this specific population.

Considering the association between violence and cognitive impairments, over the years, programs targeting the cognitive sphere have been employed as part of the treatment in rehabilitating these violent profiles, resulting in reductions in violence and recidivism rates (Polaschek et al. 2005).

Some examples of traditional psychotherapeutic programs cognition-focused programs within this population include: Cognitive Skills Training, which addresses interpersonal deficits, decision-making, goal setting, and general thinking skills (Robinson 1995); the Cognitive Self-Change Program, based on cognitive processing errors and targeting attitudes, beliefs, and thinking patterns that support violent behaviour (Bush 1995); the Montgomery House Violence Prevention Project, a multidimensional approach aimed at reducing violence by restructuring offense-supportive cognition to subsequently influence self-control (Dowden, Blanchette, and Serin 2001); and the Violence Prevention Unit Program, a multidimensional, high-intensity cognitive-behavioural program that emphasizes the restructuring of offense-supportive thinking (Polaschek et al. 2005).

Recent data on cognitive rehabilitation using VR in the presence of cognitive deficits has reported longer-lasting effects compared to traditional approaches (Weng et al. 2019). One representative program currently under testing by Klein Schaarsberg et al. (2022) is Street Temptations. This program addresses cognitive distortions to induce a behavioural change in aggression using VR and is tailored for adolescents grappling with disruptive behaviour issues. Its fundamental treatment approach is rooted in reflective functioning (Fonagy et al. 1991). This utilizes VR to foster social perspective-taking, employing emotionally engaging scenarios to confront self-serving cognitive distortions through the process of mentalization, yielding very promising data so far.

Woicik et al. (2023) conducted a study to assess the initial effects of the Virtual Reality Aggression Prevention Training (VRAPT) on a prison-based population, reporting a reduction in self-reported aggression, anger, provocation, emotion regulation, and observed verbal aggression.

The intervention protocol was grounded in the theoretical framework of the Social Information Processing (SIP) model, which suggests that individuals progress through various cognitive steps when processing social information, including encoding social cues, interpreting them, formulating responses, and selecting response strategies. This model offers insight into how these steps can contribute to violent outcomes, influenced by individual and situational factors (Crick and Dodge 1994).

The treatment comprised two parts: the first focusing on early social information processing stages related to emotion recognition, and the second on later stages involving interactive scenarios. The VR interventions included an emotion recognition task featuring avatars displaying various emotions (anger, disgust, fear, happiness, sadness, surprise, or neutral), an aggression catwalk where avatars exhibited neutral or aggressive behaviour, and an interactive scenario allowing for personalization of avatar interactions. Additionally, the study highlighted the feasibility of implementing the intervention in a prison setting and again, stressed the significance of personalized VR scenarios that address individual needs.

The integration of VR into distinct rehabilitation programs for addressing violence from a cognitive perspective within psychiatric populations is currently under evaluation. Given the high prevalence of aggressive behaviour within these patients, psychiatric populations are notably considered at-risk, making the exploration of VR interventions particularly pertinent (Bo et al. 2011; Broderick et al. 2015; Verstegen et al. 2017).

Klein Tuente et al. (2020) conducted a study evaluating an intervention targeting aggressive behaviour in forensic psychiatric inpatients using the VRAPT. This treatment program incorporated VR exercises also based on the SIP model, aiming to address cognitive-emotional processes associated with aggressive behaviour.

The intervention consisted of multiple components: the first focused on early information processing, involving the recognition of emotional and aggressive behaviour in others. The second component focused on information labelling, requiring participants to cognitively determine behavioural outcomes in given situations. The final step involved generating, evaluating, and enacting responses, with an emphasis on de-escalation in potentially violent situations.

Utilizing the VR tool, the intervention immersed participants in everyday scenarios and social interactions featuring aggressive situations, facilitated through personalized role-play guided by therapists. Physiological responses, including heart rate and galvanic skin response, were also measured during the sessions.

Although the study did not observe significant reductions in aggressive behaviour compared to a control group, it did report positive effects on self-reported aggression, anger control skills, impulsivity, and hostility. However, these effects were not sustained at a 3-month follow-up. A notable finding of the study is the suggestion that incorporating childhood trauma and emotional states into aggression treatments could be crucial for improving outcomes, highlighting the relevance of these variables as potential mediators in the observed findings.

In summary, virtual reality interventions such as VRAPT have demonstrated remarkable effectiveness in addressing violent behaviours from different perspectives. These interventions are not limited to violent offenders but extend their benefits to diverse populations at risk of developing aggressive tendencies. By simulating various scenarios, VRAPT has proved to enable participants to practice coping strategies in a safe and controlled environment, ultimately empowering them to respond more adaptively in real-life situations.

Overall, virtual reality interventions represent a groundbreaking approach in the field of violence research, management, and prevention. By harnessing the immersive capabilities of VR technology, these interventions offer a promising avenue for improving outcomes across diverse populations by addressing the complex interplay of cognitive, emotional, and behavioural factors underlying aggressive behaviour.

5. The use of virtual reality as a tool for rehabilitation in prisons: the example of Catalan prisons

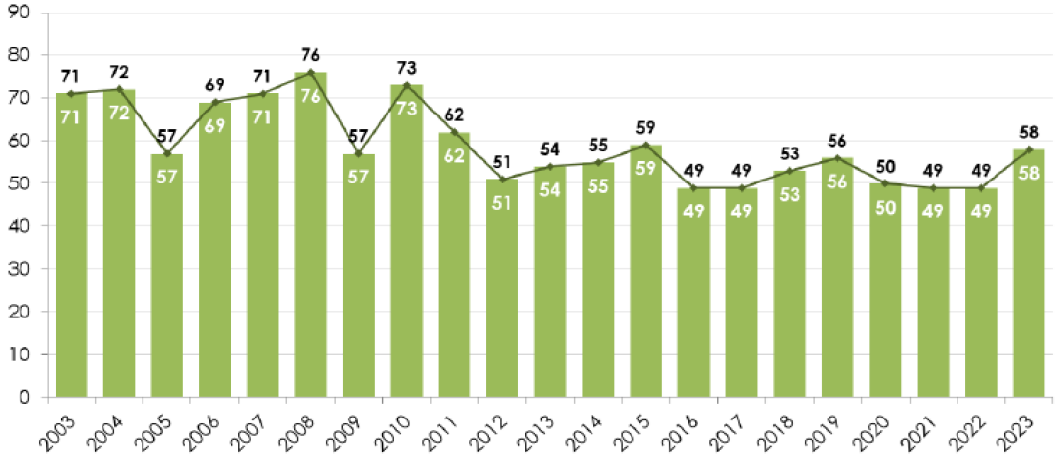
Violence in general, and specifically gender-based violence, poses a significant social problem for various reasons. This includes the persistent number of female victims that fails to decrease significantly over the years, the challenge of constructing a new model of masculinity, and even a societal model that no longer accepts a relationship dynamic between men and women often based on control and inequality. The World Health Organization (WHO) defines violence against women as:

> «Any act of gender-based violence that results in, or is likely to result in, physical, sexual, or psychological harm or suffering to women, including threats of such acts, coercion, or arbitrary deprivation of liberty, whether occurring in public or in private life» (World Health Organization 2013).

Estimates from the same organization, based on various studies across different countries, provide truly alarming data. It is considered that one in three women (30%) has experienced some form of physical and/or sexual violence by a partner or sexual violence by someone who was not their partner, or both (Manandhar et al. 2018; World Health Organization 2021).

In Spain, according to data published by the State Observatory for Gender Violence, the number of women murdered each year by their partners has been increasing since 2003. As can be seen, the problem is far from being resolved since 58 women were murdered by their partners in 2023.

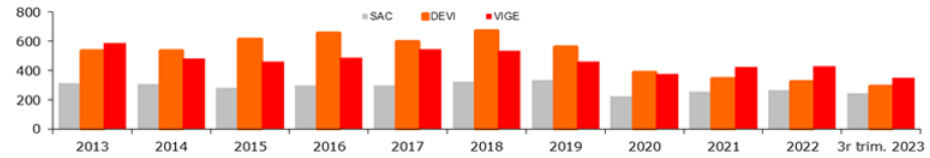
Table 1. Total, female fatalities between 2003 and 2023.



Data published by the Ministry of Equality of Spain. Government Delegation against Gender Violence.

According to data from the penitentiary system of Catalonia, men participating in specific gender-based violence programs also present a very relevant picture regarding the need to allocate resources to this phenomenon from the perspective of aggressor rehabilitation:

Table 2. Inmates participating in specific programs for sexual offenses (SAC), general violence offenses (DEVI), and gender-based violence offenses (VIGE).



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	3r trim. 2023
SAC	315	306	282	296	299	326	336	224	256	266	246
DEVI	534	535	613	654	599	671	559	385	347	322	293
VIGE	585	482	461	487	543	534	460	378	426	430	348

Data published by the Department of Justice, Rights, and Memory of the Government of Catalonia.

The data published up to the third quarter of 2023 paints a concerning picture: an average of approximately 500 men participate each year in gender-based violence programs in prisons, solely in the Catalan territory. This situation calls upon all institutions to focus their efforts on the development of new models and intervention strategies for this criminal profile.

Since 2019, the Secretary of Penitentiary Measures, Rehabilitation, and Victim Care has implemented a new intervention model aimed at addressing the diverse intervention needs of individuals serving custodial sentences in penitentiary centers in Catalonia. This set of interventions follows the most current and rigorous international scientific standards and is based on all interventions that have demonstrated their effectiveness in reducing recidivism.

Undoubtedly, gender inequality in many aspects is a significant contributor to, or a large part of the explanation for, these rates of violence. There is also no doubt about the need to unite efforts to protect women who are victims of this situation, investing in all necessary resources from various sectors of society. But as obvious as it may seem, it is worth remembering that intervention with the perpetrator becomes essential to break this cycle. This requires involvement from institutions and society at large to develop strategies that help men understand that another type of relationship is possible.

The penitentiary environment is an institution where it is necessary to work with those men whose behaviour is clearly marked by the use of violence, often in its most extreme expression, such as femicide. The goal of these interventions undoubtedly remains, once again, the protection of potential new victims.

5.1. The Catalan model of penitentiary rehabilitation

The Catalan model of penitentiary rehabilitation is fundamentally based on the theoretical Risk-Needs-Responsivity (RNR) model (Andrews and Bonta 2024), which states that a comprehensive initial risk assessment will guide therapists in deciding the level of intervention intensity, such that higher levels of risk necessitate higher intervention intensities. Additionally, it advocates for intervening based on the criminogenic needs of the individual, which are directly related to criminal behaviour and are susceptible to change. Lastly, it introduces the concept of responsivity, emphasizing the need to intervene with the individual in the most beneficial way possible, addressing any factors that may act as obstacles in their process of change.

On the other hand, it is also based in the Satisfactory Lives model, which emphasizes rehabilitating criminal behaviour by focusing on addressing basic life needs and human rights (Day and Doyle 2010; Gannon et al. 2015; Ward et al. 2006).

This intervention model is structured around the following intervention phases (Redondo and Antonio Andrés Pueyo 2019):

Evaluation Phase: This phase specifies and details the initial and final assessment process of individuals' criminogenic needs. This phase is an indispensable step in designing individualized interventions for each subject.

Intervention Phase: In this treatment model, the intervention for incarcerated individuals is a dynamic process. Therefore, there are different types of interventions based on their intensity:

1. Socio-educational Intervention: This is a brief intervention aimed at raising awareness among individuals about the risks associated with certain behaviours. It is applied to individuals with a low risk of reoffending or those requiring low-intensity intervention for their criminogenic needs. It also prepares individuals for further participation in more intense and comprehensive programs.
2. Psychoeducational Intervention: In these intervention programs, various needs are addressed, including motivation for change, low self-concept of self-efficacy, erroneous thought patterns and cognitive distortions, difficulties in recognizing and managing emotions, lack of communication and interpersonal relationship skills, and aspects related to the risks of relapse into criminal behaviour. These intervention programs have longer durations than the previous ones.
3. Specific Intervention Phase: In this phase, inmates are offered participation in intensive interventions targeting very specific issues. These programs are of longer duration and are highly focused on the type of violent crime committed:

a. Specific Intervention for Substance Abuse.
b. Specific Intervention in General Violence.
c. Specific Intervention in Gender-based Violence.
d. Specific Intervention in Sexual Violence.

5.2. The use of VR in Catalan prisons

From the general model of rehabilitation within the Catalan penitentiary system outlined above, we can understand the context in which Virtual Reality Intervention (VRI) emerges, starting from 2019-20, which is specifically aimed at profiles of men who have committed gender-based violence offenses.

Shortly after implementing the intervention model based on individual needs, the penitentiary services of Catalonia adopted Immersive Virtual Reality to complement and enhance the array of treatment programs for men convicted of gender-based violence, initially as a pilot project in two penitentiary centers (Mas d'Enric, in the province of Tarragona, and Quatre Camins, in the province of Barcelona) and gradually extending it to the rest of the penitentiary centers.

This technology is being applied in all Catalan penitentiary centers, and as of the start of the project, over 1500 men convicted of gender-based violence offenses have benefited from this innovative methodology. The reason for initiating this project was the need to implement more effective rehabilitation initiatives to prevent future incidents and reduce the risk of recidivism in such violent behaviours. Alongside traditional interventions described earlier, these digital tools serve as support and add value to the treatment. While traditional programs address individual needs and adapt to the specific circumstances of each perpetrator of gender-based violence, penitentiary services face various

challenges, such as the brevity of sentences in this type of offense and the need to modify behaviours associated with socially validated masculine identities.

Studies of VRI interventions where the perpetrator is placed in the victim's perspective, have shown that VRI has the potential to improve empathy, enhance recognition of the offense and motivation for change, and train non-violent behaviours, although individual differences among these men play an important role in the outcomes (Barnes 2020; Barnes et al. 2022).

Observations made through research suggest the following:

- Personalization of VR interventions are crucial, as they can benefit different profiles of offenders to varying degrees (Barnes 2020, Barnes et al.2022)
- So far, VRI interventions in prison may be more effective in profiles of low-intensity gender-based violence offenders (Barnes, 2020)
- It is likely that the effectiveness of VRI will increase in the future with personalized therapeutic interventions (Barnes 2020, Barnes et al. 2022, Seinfield et al. 2018)

The use of VRI in prison suggests that it is a promising method for reducing specific risk factors for violent behaviour in perpetrators of gender-based violence and improving emotional recognition as a precursor to empathy (Barnes 2020; Johnston 2021; Seinfeld et al. 2018), while also providing a cost-efficient way to personalize treatment to the participants' needs through different scenarios.

5.3. Challenges of the VRI program implementation in Catalan prisons

Since the beginning of the VRI project in prisons, various challenges have been taken into account that respond to the complex penitentiary reality. Some of these challenges have been as follows:

5.3.1. Inmates' cognitive competencies

Just as in the general population, the prison population is heterogeneous in many aspects. One of these inter-individual differences that we immediately noticed is the variation in cognitive competencies. In our penitentiary centers, there are men with superior competencies, with intellectual capacities that have allowed them access to medium or even higher educational levels. However, there is also a significant portion of the population with very limited cognitive capabilities, for various reasons: affected by drug use, lack of education and/or intellectual stimulation, endogenous factors, etc. This fact, which could have been a potential difficulty for our team in introducing new technologies in the penitentiary environment, quickly turned into an interesting opportunity or advantage for universal access to treatment. Regarding the difficulties, in the studies carried out, we have found that some methods for evaluating the effectiveness of VRI are not suitable for this type of population. Thus, classical methods like self-report questionnaires are particularly challenging for those men with cognitive limitations. It is recommended, in this sense, to use indirect evaluation methods that in various studies have shown promising results, such as behavioural, indirect, or implicit measures (Johnston 2021; Rovira et al. 2009; Seinfeld et al. 2018; Slater et al. 2013). In terms of benefits at this level, we have observed that from a practical perspective, the use of VRI has represented progress in therapeutic empathy work with low-educated offenders or those with cognitive deficits. VRI has facilitated the understanding and improvement of empathy in these profiles, from an experiential rather than cognitive or intellectual standpoint. The perpetrator experiences emotions similar to the victim, and it is not as necessary for them to understand them from a cognitive perspective.

5.3.2. Psychological adjustment of the individual

Practical experience has also shown us the need to carefully consider the rigorous assessment of the psychological moment appropriate for participating in VRI sessions. Therefore, it is necessary

for multidisciplinary teams in penitentiary centers to carry out a psychological assessment that allows the exclusion of those individuals showing signs of maladjustment due to various causes: being under the influence of substance use, experiencing acute stress, acute symptoms of psychotic mental illness, etc. Primarily, this assessment is aimed at two objectives: the psychological and emotional protection of the individual and, on the other hand, the application of the technique at the most opportune moment and offering better results. Additionally, VRI interventions must be integrated into the specific gender-based violence program (explained in previous sections) with the accompaniment of the inmate's rehabilitation professionals.

5.3.3. The effect of VRI on different criminal profiles

Our studies have been carried out with different criminal profiles related to gender-based violence. Thus, in the population undergoing the VRI experience in the context of Alternative Sentencing Measures, a significant improvement in facial emotion recognition has been observed (Seinfeld et al. 2018). On the other hand, studies in the prison population suggest that the application of VRI has better results in less complex criminal profiles with offenses solely related to gender-based violence, or in any case, results may vary depending on the characteristics of the groups of offenders (Barnes 2020; Barnes et al. 2022). The possibility of customizing VR experiences for domestic violence offenders was explored by adding false interoceptive feedback representing fear, but no significant changes were found in the results (Johnston et al. 2023). This fact suggests the need for further research on the use of VRI in the prison population based on different criminogenic needs.

5.3.4. Social desirability in the penitentiary context

Another relevant element in the context of forensic evaluation in general, and more specifically in the penitentiary context, is social desirability. It is common to observe that individuals who have committed crimes and are being evaluated may tend to present the best version of themselves or even seek some kind of benefit if they participate in research studies. On the other hand, being in a penitentiary environment sometimes implies being subject to a series of implicit behavioural norms. Gender-based violence offenders, on their part, might try to present an image of themselves that they consider desirable in the prison environment, which could result in less genuine evaluations. This is another element supporting the need to employ indirect assessment techniques, physiological or behavioural.

5.4. The future of the use of virtual reality in the context of prisons

It is too early to have specific data on recidivism in gender-based violence with the application of these new tools. But it has been found that it may work differently in low-intensity profiles, which have committed exclusively gender-based violence offenses, and not so much in more complex profiles, which have other offenses in addition to this (Barnes 2020). This reaffirms that advances are likely to be achieved through the application of increasingly personalized therapeutic interventions.

Our experience in the field so far demonstrates that VR is a powerful tool that complements the rehabilitation programs currently being used in our centers. Our recommendation is to integrate this technology into the rehabilitation of gender-based violence offenders so that it can become an interesting improvement element. Professionals applying it in various centers report interesting information such as: inmates express a great impact of the virtual experience that facilitates understanding of the effect their behaviour has on the victim; on the other hand, it facilitates the recognition of responsibility in the offense during treatment; also, in addition to empathy improvements, professionals report that the use of VR serves as motivation for inmate treatment participation. It

represents, therefore, a promising tool that has shown encouraging results within a comprehensive treatment program (Barnes et al. 2023).

Our main future proposal focuses on the development of new additional scenes to address other essential aspects of penitentiary treatment, such as offense recognition and emotion management, or even scenes applicable to other types of violence such as sexual violence. Although these interventions represent promising advances, further research is needed to validate their effectiveness, explore their potential limitations, and refine their application. Obtaining more evidence in these areas will contribute to a more comprehensive understanding of how VR can be used to foster significant change in individuals who have committed offenses.

Other future contexts for the application of VR may focus on criminal population in the third-grade penitentiary life regime, including interventions in young adults and even in juvenile justice, to address violent behaviours such as parent-child violence. For now, in our research team, we continue to design new VR scenarios with the aim of addressing other criminal behaviours or psychosocial problems such as sexual violence, impulsivity, reducing anxiety levels in new prison admissions, or even improving training programs for penitentiary staff.

6. Acknowledgements

Supported by by Departament de Recerca i Universitats de la Generalitat de Catalunya (AGAUR 2021-SGR-01165 - NEUROVIRTUAL), supported by FEDER to MVSV and MS and by Ministerio de Ciencia e Innovación, Spain, PDI2020-117108RB-100-TEDIX (financed by AEI/10.13039/501100011033) to MS. Thanks to the Departament de Justícia i Memòria de la Generalitat de Catalunya. Dirección General de Asuntos Penitenciarios.

7. References

Anderson, C., L. Berkowitz, E. Donnerstein, L. Huesmann, J. Johnson, D. Linz, N. Malamuth, and E. Wartella. 2003. "The Influence of Media Violence on Youth." *Psychological Science in the Public Interest* 4:81–110.

Anderson, P. L., M. Price, S. M. Edwards, M. A. Obasaju, S. K. Schmertz, E. Zimand, and M. R. Calamaras. 2013. "Virtual Reality Exposure Therapy for Social Anxiety Disorder: A Randomized Controlled Trial." *Journal of Consulting and Clinical Psychology* 81(5):751–60.

Andrews, D. A., and J. Bonta. 2010. "Rehabilitating Criminal Justice Policy and Practice." *Psychology, Public Policy, and Law* 16:39 55.

Andrews, D. A., and J. Bonta. 2024. *The Psychology of Criminal Conduct*. 6a. Oxford, UK: Routledge.

Association, American Psychiatric. 2013. *Diagnostic and Statistical Manual of Mental Disorders*. DSM-5: American Psychiatric Pub.

Aymerich-Franch, L., R. F. Kizilcec, and J. N. Bailenson. 2014. "The Relationship between Virtual Self Similarity and Social Anxiety." *Frontiers in Human Neuroscience* 8.

Banakou, Domna, Alejandro Beacco, Solène Neyret, Marta Blasco-Oliver, Sofia Seinfeld, and Mel Slater. 2020. "Virtual Body Ownership and Its Consequences for Implicit Racial Bias Are Dependent on Social Context." *Royal Society Open Science* 7(12):201848. doi: 10.1098/rsos.201848.

Banakou, Domna, Parasuram D. Hanumanthu, and Mel Slater. 2016. "Virtual Embodiment of White People in a Black Virtual Body Leads to a Sustained Reduction in Their Implicit Racial Bias." *Frontiers in Human Neuroscience* 10.

Banakou, Domna, Tania Johnston, Alejandro Beacco, G. Senel, and Mel Slater. 2023. "Desensitizing Anxiety Through Imperceptible Change: A Paradigm for Single Session Exposure for Fear of Public Speaking." *Preprint*. doi: 10.5281/zenodo.10435475.

Banks, J., G. Ericksson, K. Burrage, P. Yellowlees, S. Ivermee, and J. Tichon. 2004. "Constructing the Hallucinations of Psychosis in Virtual Reality." *Journal of Network and Computer Applications* 27:1–11.

Barnes, N. 2020. "El proyecto V-Respect.Me en el Programa de violencia de género en los centros penitenciarios." in *Centre d'Estudis Jurídics i Formació Especialitzada (CEJFE*.

Barnes, N., T. Johnston, A. Gallego, and Maria V. Sanchez-Vives. 2023. "The use of Virtual Reality in Catalan Prisons: Challenges and Opportunities. Justice Trends." in *El uso de la Realidad Virtual en las Prisiones Catalanas: Retos y oportunidades - Revista JUSTICE TRENDS (justice-trends.press*.

Barnes, N., M. V. Sanchez-Vives, and T. Johnston. 2022. "On the Practical Use of Immersive Virtual Reality for Rehabilitation of Intimate Partner Violence Perpetrators in Prison." *Front Psychol*. doi: 10.3389/fpsyg.2022.787483.

Bedder, Rachel L., Daniel Bush, Domna Banakou, Tabitha Peck, Mel Slater, and Neil Burgess. 2019. "A Mechanistic Account of Bodily Resonance and Implicit Bias." *Cognition* 184:1–10. doi: 10.1016/j.cognition.2018.11.010.

Bisso, Emanuele, Maria Salvina Signorelli, Michele Milazzo, Marilena Maglia, Riccardo Polosa, Eugenio Aguglia, and Pasquale Caponnetto. 2020. "Immersive Virtual Reality Applications in Schizophrenia Spectrum Therapy: A Systematic Review." *International Journal of Environmental Research and Public Health* 17(17):6111. doi: 10.3390/ijerph17176111.

Bisson, J., and M. Andrew. 2009. *Psychological Treatment of Post-Traumatic Stress Disorder (PTSD)(Review*. The Cochrane Library.

Bo, Sune, Ahmad Abu-Akel, Mickey Kongerslev, Ulrik Helt Haahr, and Erik Simonsen. 2011. "Risk Factors for Violence among Patients with Schizophrenia." *Clinical Psychology Review* 31(5):711–26.

Bonta, J., and D. A. Andrews. 2017. *The Psychology of Criminal Conduct*. 6th ed. New York, NY: Routledge.

Borst, Aline W. de, Maria V. Sanchez-Vives, Mel Slater, and Beatrice de Gelder. 2020. "First-Person Virtual Embodiment Modulates the Cortical Network That Encodes the Bodily Self and Its Surrounding Space during the Experience of Domestic Violence." *eNeuro* 7(3). doi: 10.1523/ENEURO.0263-19.2019.

Botella, C., B. Serrano, R. M. Baños, and A. Garcia-Palacios. 2015. "Virtual Reality Exposure-Based Therapy for the Treatment of Post-Traumatic Stress Disorder: A Review of Its Efficacy, the Adequacy of the Treatment Protocol, and Its Acceptability." *Neuropsychiatric Disease and Treatment* 11(2533).

Broderick, Charles, Allen Azizian, Rebecca Kornbluh, and Katherine Warburton. 2015. "Prevalence of Physical Violence in a Forensic Psychiatric Hospital System during 2011–2013: Patient Assaults, Staff Assaults, and Repeatedly Violent Patients." *CNS Spectrums* 20(3):319–30. doi: 10.1017/S1092852915000188.

Brown, Poppy, Felicity Waite, Aitor Rovira, Alecia Nickless, and Daniel Freeman. 2020. "Virtual Reality Clinical-Experimental Tests of Compassion Treatment Techniques to Reduce Paranoia." *Scientific Reports* 10(1):8547. doi: 10.1038/s41598-020-64957-7.

Bush, J. 1995. "Cognitive Self-Change: A Program Manual." *Burlington, Vermont: Department of Corrections*.

Butt, Asad Hassan, Hassan Ahmad, and Muhammad Noman Shafique. 2021. "AI-Powered 'Voice Recognition Avatar': A New Way to Play Games." *International Journal of Gaming and Computer-Mediated Simulations (IJGCMS)* 13(3):1–17. doi: 10.4018/IJGCMS.290305.

Carlin, A. S., H. G. Hoffman, and S. Weghorst. 1997. "Virtual Reality and Tactile Augmentation in the Treatment of Spider Phobia: A Case Report." *Behav. Res. Ther* 35:153–58.

Chapman, Harriet, Steven M. Gillespie, and Ian J. Mitchell. 2018. "Facial Affect Processing in Incarcerated Violent Males: A Systematic Review." *Aggression and Violent Behavior* 38:123–38. doi: 10.1016/j.avb.2017.10.006.

Chereji, S. V., S. Pintea, and D. David. 2012. "The Relationship of Anger and Cognitive Distortions with Violence in Violent Offenders' Population: A Meta-Analytic Review." *European Journal of Psychology Applied to Legal Context* 4(1):59–77.

Cláudio, A. P., M. B. Carmo, T. Pinheiro, and F. Esteves. 2013. "A Virtual Reality Solution to Handle Social Anxiety." *International Journal of Creative Interfaces and Computer Graphics (IJCICG* 4(2):57–72.

Cornet, L., and J. L. Gelder. 2023. "Cognition, Criminal Conduct, and Virtual Reality: Understanding and Reducing Offending Using Simulated Environments." *Handbook of Clinical Neurology* 197(October):207–15. doi: 10.1016/B978-0-12-821375-9.00011-6.

Crick, Nicki R., and Kenneth A. Dodge. 1994. "A Review and Reformulation of Social Information-Processing Mechanisms in Children's Social Adjustment." *Psychological Bulletin* 115(1):74–101. doi: 10.1037/0033-2909.115.1.74.

Davis, Mark H. 1980. "A Multidimensional Approach to Individual Differences in Empathy."

Day, A., and P. Doyle. 2010. "Violent Offender Rehabilitation and the Therapeutic Community Model of Treatment."

Day, A., K. Howells, P. Mohr, E. Schall, and A. Gerace. 2008. "The Development of CBT Programmes for Anger: The Role of Interventions to Promote Perspective-Taking Skills." *Behavioural & Cognitive Psychotherapy* 36:299 312.

Despoti, A., E. Karatzanos, I. Patsaki, D. Tzoumi, G. Roussou, N. Leventakis, A. Papathanasiou, S. Nanas, and N. Dimitriadi. 2022. "Immersive Virtual Reality in Cognitive Rehabilitation: A Systematic Review." *Health & Research Journal* 8(3):225–41. doi: 10.12681/healthresj.28872.

Diemer, J., N. Lohkamp, A. Mühlberger, and P. Zwanzger. 2016. "Fear and Physiological Arousal during a Virtual Height Challenge—Effects in Patients with Acrophobia and Healthy Controls." *Journal of Anxiety Disorders* 37:30–39.

van Dis, Eva A. M., Suzanne C. van Veen, Muriel A. Hagenaars, Neeltje M. Batelaan, Claudi L. H. Bockting, Rinske M. van den Heuvel, Pim Cuijpers, and Iris M. Engelhard. 2020. "Long-Term Outcomes of Cognitive Behavioral Therapy for Anxiety-Related Disorders: A Systematic

Review and Meta-Analysis." *JAMA Psychiatry* 77(3):265–73. doi: 10.1001/jamapsychiatry.2019.3986.

Dowden, Craig, and D. A. Andrews. 2000. "Effective Correctional Treatment and Violent Reoffending: A Meta-Analysis." *Canadian Journal of Criminology* 42(4):449–67.

Dowden, Craig, Kelley Blanchette, and Ralph Serin. 2001. "Anger Management Programming for Federal Male Inmates: An Effective Intervention (R-82, 1999)." Pp. 24–24 in Vol. 13. Correctional Service of Canada.

Emmelkamp, Paul M. G., Katharina Meyerbröker, and Nexhmedin Morina. 2020. "Virtual Reality Therapy in Social Anxiety Disorder." *Current Psychiatry Reports* 22(7):32. doi: 10.1007/s11920-020-01156-1.

Fonagy, Peter, Miriam Steele, Howard Steele, George S. Moran, and Anna C. Higgitt. 1991. "The Capacity for Understanding Mental States: The Reflective Self in Parent and Child and Its Significance for Security of Attachment." *Infant Mental Health Journal* 12(3):201–18. doi: 10.1002/1097-0355(199123)12:3<201::AID-IMHJ2280120307>3.0.CO;2-7.

Fornells-Ambrojo, M., C. Barker, D. Swapp, M. Slater, A. Antley, and D. Freeman. 2008. "Virtual Reality and Persecutory Delusions: Safety and Feasibility." *Schizophr. Res* 104:228–36.

Fornells-Ambrojo, M., D. Freeman, M. Slater, D. Swapp, A. Antley, and C. Barker. 2015. "How Do People with Persecutory Delusions Evaluate Threat in a Controlled Social Environment? A Qualitative Study Using Virtual Reality." *Behav. Cogn. Psychother* 43:89–107.

Freeman, D. 2007. "Suspicious Minds: The Psychology of Persecutory Delusions." *Clin. Psychol. Rev* 27:425–57.

Freeman, D. 2008. "Studying and Treating Schizophrenia Using Virtual Reality: A New Paradigm." *Schizophr. Bull* 34:605–10.

Freeman, D., J. Bradley, A. Antley, E. Bourke, N. DeWeever, N. Evans, E. Černis, B. Sheaves, R. Waite, G. Dunn, M. Slater, and D. Clark. 2016. "Virtual Reality in the Treatment of Persecutory Delusions: A Randomised Controlled Experimental Study Testing How to Reduce Delusional Conviction." *British Journal of Psychiatry*.

Freeman, D., N. Evans, R. Lister, A. Antley, G. Dunn, and M. Slater. 2013. "Height, Social Comparison, and Paranoia:An Immersive Virtual Reality Experimental Study." *Psychiatry Res* 213:348–52.

Freeman, D., P. A. Garety, P. Bebbington, M. Slater, E. Kuipers, D. Fowler, C. Green, J. Jordan, K. Ray, and G. Dunn. 2005. "The Psychology of Persecutory Ideation II: A Virtual Reality Experimental Study." *The Journal of Nervous and Mental Disease* 193:309–15.

Freeman, D., P. Haselton, J. Freeman, B. Spanlang, S. Kishore, E. Albery, M. Denne, P. Brown, M. Slater, and A. Nickless. 2018. "Automated Psychological Therapy Using Immersive Virtual Reality for Treatment of Fear of Heights: A Single-Blind, Parallel-Group, Randomised Controlled Trial." *The Lancet Psychiatry* 5(8):625–32.

Freeman, D., K. Pugh, N. Vorontsova, A. Antley, and M. Slater. 2010. "Testing the Continuum of Delusional Beliefs: An Experimental Study Using Virtual Reality." *J Abnorm Psychol* 119:83–92.

Freeman, D., M. Slater, P. Bebbington, P. A. Garety, E. Kuipers, D. Fowler, A. Met, C. M. Read, J. Jordan, and V. Vinayagamoorthy. 2003. "Can Virtual Reality Be Used to Investigate Persecutory Ideation?" *J. Nerv. Ment. Dis* 191:509–14.

Freeman, Daniel, Rachel Lister, Felicity Waite, Ly-Mee Yu, Mel Slater, Graham Dunn, and David Clark. 2019. "Automated Psychological Therapy Using Virtual Reality (VR) for Patients with Persecutory Delusions: Study Protocol for a Single-Blind Parallel-Group Randomised Controlled Trial (THRIVE)." *Trials* 20(1):87. doi: 10.1186/s13063-019-3198-6.

Gall, D., D. Roth, J. P. Stauffert, J. Zarges, and M. E. Latoschik. 2021. "Embodiment in Virtual Reality Intensifies Emotional Responses to Virtual Stimuli." *Frontiers in Psychology* 12(September):1–11. doi: 10.3389/fpsyg.2021.674179.

Gamito, Pedro, Albert Rizzo, and J. David Brown. 2023. "Editorial: Virtual Reality for Therapy, Psychological Interventions, and Physical and Cognitive Rehabilitation." *Virtual Reality* 27(1):1–1. doi: 10.1007/s10055-023-00771-6.

Gannon, T. A., E. Alleyne, H. Buler, H. Danby, A. Kapoor, l Lovell, and C. Ciardha. 2015. "Specialist Group Therapy for Psychological Factors Associated with Fire Setting: Evidence of a Treatment Effect from a Non-Randomized Trial with Male Prisoners»." *Behaviour Research and Therapy* 73:42–51.

Garcia, S. M., K. Weaver, G. B. Moskowitz, and J. M. Darley. 2002. "Crowded Minds: The Implicit Bystander Effect." *Journal of Personality and Social Psychology* 83(843).

Gerardi, M., J. Cukor, J. Difede, A. Rizzo, and B. O. Rothbaum. 2010. "Virtual Reality Exposure Therapy for Post-Traumatic Stress Disorder and Other Anxiety Disorders." *Current Psychiatry Reports* 12:298–305.

Gerardi, M., B. O. Rothbaum, K. Ressler, M. Heekin, and A. Rizzo. 2008. "Virtual Reality Exposure Therapy Using a Virtual Iraq: Case Report." *Journal of Traumatic Stress* 21(209).

Giraldy, David, and Wilson Novaldo. 2022. "A Systematic Literature Review: Acrophobia Treatment with Virtual Reality." *Engineering, MAthematics and Computer Science (EMACS) Journal* 4:33–38. doi: 10.21512/emacsjournal.v4i1.8077.

Gonçalves, R., A. L. Pedrozo, E. S. F. Coutinho, I. Figueira, and P. Ventura. 2012. "Efficacy of Virtual Reality Exposure Therapy in the Treatment of PTSD: A Systematic Review." *PLoS One* 7:e48469.

Gonzalez-Liencres, Cristina, Luis E. Zapata, Guillermo Iruretagoyena, Sofia Seinfeld, Lorena Perez-Mendez, Jorge Arroyo-Palacios, David Borland, Mel Slater, and Maria V. Sanchez-Vives. 2020. "Being the Victim of Intimate Partner Violence in Virtual Reality: First- Versus Third-Person Perspective." *Frontiers in Psychology* 11:820. doi: 10.3389/fpsyg.2020.00820.

Han, K., I. Y. Kim, and J. J. Kim. 2012. "Assessment of Cognitive Flexibility in Real Life Using Virtual Reality: A Comparison of Healthy Individuals and Schizophrenia Patients." *Computers in Biology and Medicine* 42:841–47.

Hanlon, F. M., M. P. Weisend, D. A. Hamilton, A. P. Jones, R. J. Thoma, M. Huang, K. Martin, R. A. Yeo, G. A. Miller, and J. M. Cañive. 2006. "Impairment on the Hippocampal-Dependent Virtual Morris Water Task in Schizophrenia." *Schizophr. Res* 87:67–80.

Hodges, L. F., R. Kooper, T. C. Meyer, B. O. Rothbaum, D. Opdyke, J. J. Degraaff, J. S. Williford, and M. M. North. 1995. "Virtual Environments for Treating the Fear of Heights." *Computer* 28:27–34.

Hodges, L. F., B. A. Watson, G. D. Kessler, B. O. Rothbaum, and D. Opdyke. 1996. "Virtually Conquering Fear of Flying." Pp. 42–49 in *Ieee Computer Graphics and Applications Ieee Comput Graph Ieee Comput Graph*. Vol. 16.

Hoffman, H. G., A. Garcia-Palacios, A. Carlin, T. A. Furness, and C. Botella-Arbona. 2003. "Interfaces That Heal: Coupling Real and Virtual Objects to Treat Spider Phobia." *Int. J. Hum. Comput. Interact* 16:283–300.

Hofmann, S. G., A. Asnaani, I. J. Vonk, A. T. Sawyer, and A. Fang. 2012. "The Efficacy of Cognitive Behavioral Therapy: A Review of Meta-Analyses." *Cognitive Therapy and Research* 36:427–40.

Ingram, Katherine M., Dorothy L. Espelage, Gabriel J. Merrin, Alberto Valido, Jennifer Heinhorst, and Mary Joyce. 2019. "Evaluation of a Virtual Reality Enhanced Bullying Prevention Curriculum Pilot Trial." *Journal of Adolescence* 71:72–83.

Ivarsson, David, Carl Delfin, Pia Enebrink, and Märta Wallinius. 2023. "Pinpointing Change in Virtual Reality Assisted Treatment for Violent Offenders: A Pilot Study of Virtual Reality Aggression Prevention Training (VRAPT)." *Frontiers in Psychiatry* 14.

Johnston, T. 2021. "Assessment, Prevention and Rehabilitation of Intimate Partner Violence through Immersion in Virtual Reality. Modifying Cognitions, Emotions and Behaviours through Embodied Perspective Taking." Doctoral dissertation., University of Barcelona, Spain.

Johnston, Tania, Sofia Seinfeld, Cristina Gonzalez-Liencres, Nicolas Barnes, Mel Slater, and Maria V. Sanchez-Vives. 2023. "Virtual Reality for the Rehabilitation and Prevention of Intimate Partner Violence – From Brain to Behavior: A Narrative Review." *Frontiers in Psychology* 13.

Klein Schaarsberg, Renée E., Arne Popma, Ramón J. L. Lindauer, and Levi van Dam. 2022. "The Effects of a Virtual Reality–Based Training Program for Adolescents With Disruptive Behavior Problems on Cognitive Distortions and Treatment Motivation: Protocol for a Multiple Baseline Single-Case Experimental Design." *JMIR Research Protocols* 11(5):e33555. doi: 10.2196/33555.

Klein Tuente, Stéphanie, Stefan Bogaerts, Erik Bulten, Marije Keulen-de Vos, Maarten Vos, Hein Bokern, Sarah van IJzendoorn, Chris N. W. Geraets, and Wim Veling. 2020. "Virtual Reality Aggression Prevention Therapy (VRAPT) versus Waiting List Control for Forensic Psychiatric Inpatients: A Multicenter Randomized Controlled Trial." *Journal of Clinical Medicine* 9(7):2258. doi: 10.3390/jcm9072258.

Klinger, E., S. Bouchard, P. Legeron, S. Roy, F. Lauer, I. Chemin, and P. Nugues. 2005. "Virtual Reality Therapy versus Cognitive Behavior Therapy for Social Phobia: A Preliminary Controlled Study." *CyberPsychol. Behav* 8:76–88.

Kokkinara, E., and M. Slater. 2014. "Measuring the Effects through Time of the Influence of Visuomotor and Visuotactile Synchronous Stimulation on a Virtual Body Ownership Illusion." *Perception* 43(43):58.

Krijn, M., P. M. G. Emmelkamp, R. P. Olafsson, and R. Biemond. 2004. "Virtual Reality Exposure Therapy of Anxiety Disorders: A Review." *Clinical Psychology Review Clin Psychol Rev Clin Psychol Rev* 24:259–81.

Lara, Francisco, and Jon Rueda. 2021. "Virtual Reality Not for 'Being Someone' but for 'Being in Someone Else's Shoes': Avoiding Misconceptions in Empathy Enhancement." *Frontiers in Psychology* 12.

Leff, J., G. Williams, M. A. Huckvale, M. Arbuthnot, and A. P. Leff. 2013. "Computer-Assisted Therapy for Medication-Resistant Auditory Hallucinations: Proof-of-Concept Study." *The British Journal of Psychiatry* 202:428–33.

Llobera, J., M. V. Sanchez-Vives, and M. Slater. 2013. "The Relationship between Virtual Body Ownership and Temperature Sensitivity." *J. R. Soc. Interface* 10:1742–5662.

Loon, Austin van, Jeremy Bailenson, Jamil Zaki, Joshua Bostick, and Robb Willer. 2018. "Virtual Reality Perspective-Taking Increases Cognitive Empathy for Specific Others." *PLOS ONE* 13(8):e0202442. doi: 10.1371/journal.pone.0202442.

Maister, L., M. Slater, M. V. Sanchez-Vives, and M. Tsakiris. 2015. "Changing Bodies Changes Minds: Owning Another Body Affects Social Cognition." *Trends Cogn. Sci* 19:6–12.

Manandhar, Mary, Sarah Hawkes, Kent Buse, Elias Nosrati, and Veronica Magar. 2018. "Gender, Health and the 2030 Agenda for Sustainable Development." *Bulletin of the World Health Organization* 96(9):644.

Mancuso, V., F. Bruni, C. Stramba-Badiale, G. Riva, P. Cipresso, and E. Pedroli. 2023. "How Do Emotions Elicited in Virtual Reality Affect Our Memory? A Systematic Review." *Computers in Human Behavior* 146(August 2022):107812. doi: 10.1016/j.chb.2023.107812.

Marín-Morales, J., C. Llinares, J. Guixeres, and M. Alcañiz. 2020. "Emotion Recognition in Immersive Virtual Reality: From Statistics to Affective Computing." *Sensors (Basel* 10;20(18):5163. doi: 10.3390/s20185163.

Maselli, A., and M. Slater. 2013. "The Building Blocks of the Full Body Ownership Illusion." *Front. Hum. Neurosci* 7.

Maselli, A., and M. Slater. 2014. "Sliding Perspectives: Dissociating Ownership from Self-Location during Full Body Illusions in Virtual Reality." *Front. Hum. Neurosci* 8(693).

Meehan, M., B. Insko, M. C. Whitton, and F. P. Brooks. 2002. "Physiological Measures of Presence in Stressful Virtual Environments." Pp. 645–53 in *Proceedings of SIGGRAPH*. Vol. 21.

Meyerbröker, K., and P. M. G. Emmelkamp. 2011. "Virtual Reality Exposure Therapy in Anxiety Disorders: A Systematic Review of Process and Outcome Studies." *Depress. Anxiety* 27:933–44.

Moritz, S., M. Voigt, U. Köther, L. Leighton, B. Kjahili, Z. Babur, D. Jungclaussen, R. Veckenstedt, and K. Grzella. 2014. "Can Virtual Reality Reduce Reality Distortion? Impact of Performance Feedback on Symptom Change in Schizophrenia Patients." *Journal of Behavior Therapy and Experimental Psychiatry* 45:267–71.

Motraghi, T. E., R. W. Seim, E. C. Meyer, and S. B. Morissette. 2014. "Virtual Reality Exposure Therapy for the Treatment of Posttraumatic Stress Disorder: A Methodological Review Using CONSORT Guidelines." *Journal of Clinical Psychology* 70:197–208.

Muñoz García-Largo, Leticia, Gabriel Martí-Agustí, Carles Martin-Fumadó, and Esperanza L. Gómez-Durán. 2020. "Intellectual Disability Rates among Male Prison Inmates." *International Journal of Law and Psychiatry* 70:101566. doi: 10.1016/j.ijlp.2020.101566.

Neyret, Solène, Xavi Navarro, Alejandro Beacco, Ramon Oliva, Pierre Bourdin, Jose Valenzuela, Itxaso Barberia, and Mel Slater. 2020. "An Embodied Perspective as a Victim of Sexual Harassment in Virtual Reality Reduces Action Conformity in a Later Milgram Obedience Scenario." *Scientific Reports* 10(1):6207. doi: 10.1038/s41598-020-62932-w.

Noë, A. 2004. *Action In Perception*. Cambridge, MA: MIT Press.

North, M. M., S. M. North, and J. R. Coble. 1998. "Virtual Reality Therapy: An Effective Treatment for the Fear of Public."

Olfson, M., R. Lewis-Fernández, M. M. Weissman, A. Feder, M. J. Gameroff, D. Pilowsky, and M. Fuentes. 2014. "Psychotic symptoms in an urban general medicine practice." *Am. J. Psychiatry*.

Opriş, D., S. Pintea, A. García-Palacios, C. Botella, Ş. Szamosközi, and D. David. 2012. "Virtual Reality Exposure Therapy in Anxiety Disorders: A Quantitative Meta-analysis." *Depress. Anxiety* 29:85–93.

O'Regan, J. K., and A. Noë. 2001. "What It Is like to See: A Sensorimotor Theory of Perceptual Experience." *Synthese* 129:79–103.

Palix, J., A. Abu-Akel, V. Moulin, M. Abbiati, J. Gasser, C. Hasler, D. Marcot, C. Mohr, and E. Dan-Glauser. 2022. "The Utility of Physiological Measures in Assessing the Empathic Skills of Incarcerated Violent Offenders." *International Journal of Offender Therapy and Comparative Criminology* 66(1):98–122. doi: 10.1177/0306624X21994056.

Pan, X., M. Gillies, C. Barker, D. M. Clark, and M. Slater. 2012. "Socially Anxious and Confident Men Interact with a Forward Virtual Woman: An Experimental Study." *PLoS One* 7:e32931.

Park, K. M., J. Ku, S. H. Choi, H. J. Jang, J. Y. Park, S. I. Kim, and J. J. Kim. 2011. "A Virtual Reality Application in Role-Plays of Social Skills Training for Schizophrenia: A Randomized, Controlled Trial." *Psychiatry Research* 189:166–72.

Park, K. M., J. Ku, I. H. Park, J. Y. Park, S. I. Kim, and J. J. Kim. 2009. "Improvement in Social Competence in Patients with Schizophrenia: A Pilot Study Using a Performance-based Measure Using Virtual Reality." *Human Psychopharmacology: Clinical and Experimental* 24:619–27.

Parrish, D. E., H. K. Oxhandler, J. F. Duron, P. Swank, and P. Bordnick. 2015. *Feasibility of Virtual Reality Environments for Adolescent Social Anxiety Disorder*. Research on Social Work Practice:1049731514568897.

Pertaub, D. P., M. Slater, and C. Barker. 2002. "An Experiment on Public Speaking Anxiety in Response to Three Different Types of Virtual Audience." *Presence: Teleoperators and Virtual Environments* 11:68–78.

Polaschek, D. L. L. 2006. "Violent offender programmes: Concept, theory & practice." in *Offender Behaviour Programmes- Development*, edited by C. R. Hollin and E. J. Palmer.

Polaschek, D. L. L., N. J. Wilson, M. R. Townsend, and L. R. Daly. 2005. "Cognitive-Behavioral Rehabilitation for High-Risk Violent Offenders: An Outcome Evaluation of the Violence Prevention Unit." *Journal of Interpersonal Violence* 20(12):1611–27. doi: 10.1177/0886260505280507.

Powers, M. B., N. F. Briceno, R. Gresham, E. N. Jouriles, P. M. Emmelkamp, and J. A. Smits. 2013. "Do Conversations with Virtual Avatars Increase Feelings of Social Anxiety?" *Journal of Anxiety Disorders* 27:398–403.

Pull, C. B. 2012. "Current Status of Knowledge on Public-Speaking Anxiety." *Current Opinion in Psychiatry* 25:32–38.

Redondo, Santiago, and Antonio Andrés Pueyo. 2019. "El modelo de intervención dirigido a las necesidades de los individuos, 2019. Desarrollado en el marco del proyecto de investigación 'Estudi per a la revisió i acreditació de programes de tractament en l'àmbit penitenciari' (codi FBG70048- Fundació Bosch i Gimpera." in *encargado al Grup d'Estudis Avançats en Violència de la Universitat de Barcelona y financiado por el Centre d'Estudis Jurídics i Formació Especialitzada, Departament de Justícia de la Generalitat de Catalunya*.

Reger, G. M., K. M. Holloway, C. Candy, B. O. Rothbaum, J. Difede, A. A. Rizzo, and G. A. Gahm. 2011. "Effectiveness of Virtual Reality Exposure Therapy for Active Duty Soldiers in a Military Mental Health Clinic." *Journal of Traumatic Stress* 24(1):93–96.

Renaud, P., S. Bouchard, and R. Proulx. 2002. "Behavioral Avoidance Dynamics in the Presence of a Virtual Spider." Pp. 235–43 in *Ieee Transactions on Information Technology in Biomedicine Ieee T Inf Technol B Ieee T Inf Technol B*. Vol. 6.

Rizzo, A., G. Reger, G. Gahm, J. Difede, and B. O. Rothbaum. 2009. "Virtual Reality Exposure Therapy for Combat-Related PTSD." Pp. 375–99 in *Post-Traumatic Stress Disorder*. Springer.

Robinson, David. 1995. *The Impact of Cognitive Skills Training on Post-Release Recidivism among Canadian Federal Offenders*. Correctional Service Canada, Correctional Research & Development Ottawa, Ontario.

Ross, Robert R., and Elizabeth Fabiano. 1985. *Time to Think: A Cognitive Model of Delinquency Prevention and Offender Rehabilitation*. Institute of Social Sciences & Arts, Incorporated.

Rothbaum, B. O., L. Hodges, R. Alarcon, D. Ready, F. Shahar, K. Graap, J. Pair, P. Hebert, D. Gotz, B. Wills, and D. Baltzell. 1999. "Virtual Reality Exposure Therapy for PTSD Vietnam Veterans: A Case Study." *Journal of Traumatic Stress J Trauma Stress J Trauma Stress* 12:263–71.

Rothbaum, B. O., L. F. Hodges, R. Kooper, D. Opdyke, J. S. Williford, and M. North. 1995a. "Effectiveness of Computer-Generated (Virtual-Reality) Graded Exposure in the Treatment of Acrophobia." *American Journal of Psychiatry Am J Psychiat Am J Psychiat* 152:626–28.

Rothbaum, B. O., L. F. Hodges, R. Kooper, D. Opdyke, J. S. Williford, and M. North. 1995b. "Virtual-Reality Graded Exposure in the Teatment of Acrophobia - a Case-Report." *Behav. Ther* 26:547–54.

Rothbaum, B. O., L. F. Hodges, D. Ready, K. Graap, and R. D. Alarcon. 2001. "Virtual Reality Exposure Therapy for Vietnam Veterans with Posttraumatic Stress Disorder." *Journal of Clinical Psychiatry J Clin Psychiat J Clin Psychiat* 62:617–22.

Rothbaum, B. O., L. Hodges, S. Smith, J. H. Lee, and L. Price. 2000. "A Controlled Study of Virtual Reality Exposure Therapy for the Fear of Flying." *J. Consult. Clin. Psychol* 68:1020–26.

Rothbaum, B. O., L. Hodges, B. A. Watson, G. D. Kessler, and D. Opdyke. 1996. "Virtual Reality Exposure Therapy in the Treatment of Fear of Flying: A Case Report." *Behaviour Research and Therapy Behav Res Ther Behav Res Ther* 34:477–81.

Rovira, A., D. Swapp, B. Spanlang, and M. Slater. 2009. "The Use of Virtual Reality in the Study of People's Responses to Violent Incidents." *Front. Behav. Neurosci* 3(59). doi: 10.3389/neuro.08.059.2009.

Rus-Calafell, M., J. Gutiérrez-Maldonado, and J. Ribas-Sabaté. 2014. "A Virtual Reality-Integrated Program for Improving Social Skills in Patients with Schizophrenia: A Pilot Study." *Journal of Behavior Therapy and Experimental Psychiatry* 45:81–89.

Safir, M. P., H. S. Wallach, and M. Bar-Zvi. 2012. "Virtual Reality Cognitive-Behavior Therapy for Public Speaking Anxiety: One-Year Follow-Up." *Behav. Modif* 36:235–46.

Sanchez-Vives, M. V., and M. Slater. 2005. "From Presence to Consciousness Through Virtual Reality." *Nature Reviews Neuroscience* 6:332–39.

Sanchez-Vives, M. V., B. Spanlang, A. Frisoli, M. Bergamasco, and M. Slater. 2010. "Virtual hand illusion induced by visuomotor correlations." *PLoS One* 5:e10381.

Schutters, S. I., M. Dominguez, S. Knappe, R. Lieb, J. Os, K. R. Schruers, and H. U. Wittchen. 2012. "The Association between Social Phobia, Social Anxiety Cognitions and Paranoid Symptoms." *Acta Psychiatr. Scand* 125:213–27.

Seidel, E. M., D. M. Pfabigan, K. Keckeis, A. M. Wucherer, T. Jahn, C. Lamm, and B. Derntl. 2013. "Empathic Competencies in Violent Offenders." *Psychiatry Res* 30;210(3):1168-75. doi: 10.1016/j.psychres.2013.08.027.

Seinfeld, Arroyo-Palacios J., Iruretagoyena G., Hortensius R., Zapata L., and Borland D. 2018. "Offenders Become the Victim in Virtual Reality: Impact of Changing Perspective in Domestic Violence." *Sci. Rep* 8(2692). doi: 10.1038/s41598-01819987-7.

Seinfeld, S., B. S. Hasler, D. Banakou, and J. Levy. 2022. "Editorial: Virtual Reality and Empathy." *Frontiers in Psychology* 13(2017). doi: 10.3389/fpsyg.2022.1089006.

Seinfeld, Sofia, Ilias Bergstrom, Ausias Pomes, Jorge Arroyo-Palacios, Francisco Vico, Mel Slater, and Maria V. Sanchez-Vives. 2016. "Influence of Music on Anxiety Induced by Fear of Heights in Virtual Reality." *Frontiers in Psychology* 6.

Seinfeld, Sofia, Minye Zhan, Marta Poyo-Solanas, Giulia Barsuola, Maarten Vaessen, Mel Slater, Maria V. Sanchez-Vives, and Beatrice de Gelder. 2021. "Being the Victim of Virtual Abuse Changes Default Mode Network Responses to Emotional Expressions." *Cortex* 135:268–84. doi: 10.1016/j.cortex.2020.11.018.

Sheridan, T. B. 1992. "Musings on Telepresence and Virtual Presence." *Presence: Teleoperators and Virtual Environments* 1:120–26.

Shiban, Y., P. Pauli, and A. Mühlberger. 2013. "Effect of Multiple Context Exposure on Renewal in Spider Phobia." *Behaviour Research and Therapy* 51:68–74.

Shiban, Y., I. Schelhorn, P. Pauli, and A. Mühlberger. 2015. Effect of Combined Multiple Contexts and Multiple Stimuli Exposure in Spider Phobia: A Randomized Clinical Trial in Virtual Reality. *Behaviour Research and Therapy* 71: 45-53.

Shoa, A., Oliva, R., Slater, M., & Friedman, D. 2023. Sushi with Einstein: Enhancing Hybrid Live Events with LLM-Based Virtual Humans. In *Proceedings of the 23rd ACM International Conference on Intelligent Virtual Agents* pp. 1-6.

Slater, M. 2009. "Place Illusion and Plausibility Can Lead to Realistic Behaviour in Immersive Virtual Environments." *Philos Trans R Soc Lond* 364:3549–57.

Slater, M., D. Perez-Marcos, H. H. Ehrsson, and M. Sanchez-Vives. 2008. "Towards a Digital Body: The Virtual Arm Illusion." *Front. Hum. Neurosci* 2.

Slater, M., D. Perez-Marcos, H. H. Ehrsson, and M. V. Sanchez-Vives. 2009. "Inducing Illusory Ownership of a Virtual Body." *Front. Neurosci* 3:214–20.

Slater, M., A. Rovira, R. Southern, D. Swapp, J. J. Zhang, C. Campbell, and M. Levine. 2013. "Bystander Responses to a Violent Incident in an Immersive Virtual Environment." *PLoS One* e52766. doi: 10.1371/journal.pone.0052766.

Slater, M., M. Usoh, and A. Steed. 1995. "Taking Steps: The Influence of a Walking Technique on Presence in Virtual Reality." *ACM Trans. Comput.-Hum. Interact* 2:201–19.

Slater, Mel, Domna Banakou, Alejandro Beacco, Jaime Gallego, Francisco Macia-Varela, and Ramon Oliva. 2022. "A Separate Reality: An Update on Place Illusion and Plausibility in Virtual Reality." *Frontiers in Virtual Reality* 3.

Slater, Mel, and Maria V. Sanchez-Vives. 2016. "Enhancing Our Lives with Immersive Virtual Reality." *Frontiers in Robotics and AI* 3.

Smeijers, Danique, Erik Bulten, Jan Buitelaar, and Robbert-Jan Verkes. 2018. "Treatment Responsivity of Aggressive Forensic Psychiatric Outpatients." *International Journal of Offender Therapy and Comparative Criminology* 62(12):3834–52.

Spanlang, B., J. M. Normand, D. Borland, K. Kilteni, E. Giannopoulos, A. Pomes, M. Gonzalez-Franco, D. Pérez Marcos, J. Arroyo Palacios, X. N. Muncunill, and M. Slater. 2014. "How to Build an Embodiment Lab: Achieving Body Representation Illusions in Virtual Reality." *Frontiers in Robotics and AI* 1. doi: 10.3389/frobt.2014.00009.

Valmaggia, L. R., F. Day, P. Garety, D. Freeman, A. Antley, M. Slater, D. Swapp, I. Myin-Germeys, and P. McGuire. 2015. "Social Defeat Predicts Paranoid Appraisals in People at High Risk for Psychosis." *Schizophr. Res* 168:16–22.

Valmaggia, L. R., D. Freeman, C. Green, P. Garety, D. Swapp, A. Antley, C. Prescott, D. Fowler, E. Kuipers, and P. Bebbington. 2007. "Virtual Reality and Paranoid Ideations in People with an 'at-Risk Mental State'for Psychosis." *The British Journal of Psychiatry* 191(51):63–68.

Vanni, F., C. Conversano, A. Del Debbio, P. Landi, M. Carlini, C. Fanciullacci, and L. Dell'Osso. 2013. "A Survey on Virtual Environment Applications to Fear of Public Speaking." *Eur. Rev. Med. Pharmacol. Sci* 17:1561–68.

Veling, W., S. Moritz, and M. Gaag. 2014. "Brave New Worlds—Review and Update on Virtual Reality Assessment and Treatment in Psychosis." *Schizophrenia Bulletin* 40:1194–97.

Ventura, Sara, Georgina Cardenas, Marta Miragall, Giuseppe Riva, and Rosa Baños. 2021. "How Does It Feel to Be a Woman Victim of Sexual Harassment? The Effect of 360°-Video-Based Virtual Reality on Empathy and Related Variables." *Cyberpsychology, Behavior, and Social Networking* 24(4):258–66. doi: 10.1089/cyber.2020.0209.

Verstegen, Nienke, Vivienne de Vogel, Michiel de Vries Robbé, and Martijn Helmerhorst. 2017. "Inpatient Violence in a Dutch Forensic Psychiatric Hospital." *Journal of Forensic Practice* 19(2):102–14. doi: 10.1108/JFP-04-2016-0020.

Wallach, H. S., M. Safir, and M. Bar-Zvi. 2009. "Virtual Reality Cognitive Behavior Therapy for Public Speaking Anxiety: A Randomized Clinical Trial." *Behav. Modif* 33:314–38.

Ward, T., J. Vess, R. M. Collie, and T. A. Gannon. 2006. "Risk Management or Goods Promotion: The Relationship between Approach and Avoidance Goals in Treatment for Sex Offenders»." *Aggression and Violent Behavior* 11(4):378–93.

Weng, Wenqi, Jiaming Liang, Jiang Xue, Tingfei Zhu, Yuxing Jiang, Jiayu Wang, and Shulin Chen. 2019. "The Transfer Effects of Cognitive Training on Working Memory among Chinese Older Adults with Mild Cognitive Impairment: A Randomized Controlled Trial." *Frontiers in Aging Neuroscience* 11:212.

Weniger, G., and E. Irle. 2008. "Allocentric Memory Impaired and Egocentric Memory Intact as Assessed by Virtual Reality in Recent-Onset Schizophrenia." *Schizophrenia Research* 101:201–9.

Woicik, Kasja, Chris N. W. Geraets, Stéphanie Klein Tuente, Erik Masthoff, and Wim Veling. 2023. "Virtual Reality Aggression Prevention Treatment in a Dutch Prison-Based Population: A Pilot Study." *Frontiers in Psychology* 14.

World Health Organization. 2013. *Responding to Intimate Partner Violence and Sexual Violence against Women: WHO Clinical and Policy Guidelines*. World Health Organization.

World Health Organization. 2021. "Addressing Violence against Women in Health and Multisectoral Policies: A Global Status Report."