Cognition, Criminal Conduct and Virtual Reality: Understanding and Reducing Offending Using Simulated Environments

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PREPRINT. FINAL VERSION TO APPEAR IN:
Cornet, L. J. M. & van Gelder, J. L. (2023). Cognition, Criminal Conduct and Virtual Reality: Understanding and Reducing Offending Using Simulated Environments. In: H. Swaab and G. Meynen (Eds). Handbook of Clinical Neurology: Brain and Crime . San Diego: Elsevier.

Authors' Note

This work was supported by a European Research Council Consolidator Grant (Grant Number 772911– CRIMETIME).

Abstract

Over the past years, research has shown that virtual reality (VR) technology can be used to observe, interpret, and change human behavior and cognition in a variety of domains. This chapter explores the potential of VR as a tool to observe, interpret, and change human behavior and cognition as they relate to antisocial behavior. We review the criminological research literature as well as research literature from related disciplines on VR applications that has focused on observing and reducing antisocial behavior. Our findings suggest that the key merits of VR in the domain of crime and antisocial behavior are its ability to provide safe learning environments that would otherwise involve risk, the possibility of generating ethical and ecologically valid virtual alternatives for real-life situations, and the development and use of stimuli that are impossible to create in real life. These unique characteristics make VR a promising tool to observe criminal behavior as it takes place and to develop prevention and intervention programs to reduce antisocial behavior.

Keywords*: virtual reality, cognition, antisocial behavior, observation, behavioral change*

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1. Virtual Reality: What is it?

Your daughter's gaming efforts on her new Nintendo console, the IKEA kitchen planner you use to design your new kitchen, the virtual hotel tours your partner 'took' from behind the computer monitor when planning the family's next summer holiday, and your eldest's dealings on online Massively Multiplayer Games, are all examples of activities taking place in virtual environments. They are interactive experiences in the sense that the user influences the course of events in the virtual scenario unfolding on the computer screen or the display of a handheld device. In this contribution, the focus is on virtual environments that are experienced in immersive fashion, or immersive virtual reality (henceforth: VR). The key difference with virtual environments experienced on a screen is that immersive VR perceptually surrounds the user with all visual input other than that which is generated by the computer being blocked (see Slater, 2018). Generally, the resulting illusion of displacement to the artificial virtual environment is achieved through a head-mounted display (HMD), also referred to as 'VR goggles'.

Research shows that our brain strongly relies on visual input (e.g., Hirst et al., 2018). However, VR goggles not simply present the user with a visual image. In VR, slightly different images are presented to each eye, resulting in 'stereo vision' (Slater, 2009c). This allows for the perception of depth and three-dimensionality. Another technical aspect of VR that is crucial to create realistic experiences is *head-tracking*. Trackers located on the HMD track the position and orientation of the head and send this information to the rendering computer which feeds it back in near-real time to the HMD. Every time the user moves his/her head, the VR environment changes and presents a new viewpoint. The continuous flow of data running from the computer to the user and (near) real-time updating generates a naturalistic or intuitive viewing experience that mimics critical properties of the real-world viewing experience (Pan & Hamilton, 2018). Flaws in the process can cause nausea and an experience known as 'cybersickness' in VR parlance. Cybersickness describes the physical unease that can be experienced due to discrepancies between the internal expectations of the user and the actual VR feedback, e.g., a delay between the user's head movement and the visual feedback from the VR. Symptoms can vary from motion sickness, to ocular strain, and degraded limb and postural control (Ames et al., 2005; Riva, 2003; Schuemie et al., 2001).

The success rate in achieving a subjective feeling of having stepped inside the virtual environment is dependent on several factors, including the hardware and software used and properties related to the individual. For example, ill-conceived virtual environments, low refresh rates due to slow hardware, and a user's susceptibility to cybersickness may each affect the experience in a negative way. If successful, however, the perceptual immersion in the virtual environments generates the sense that the user has 'stepped into' the virtual environment. This sensation or psychological state of 'being there' i.e., in the place depicted by the virtual reality rather than the physical place where the user's body is actually located and the tendency to respond to the virtual events and environments as if they were real, is known as 'presence' (Slater, 2004; Slater et al., 2006). Whereas adding layers of immersion, e.g., spatial audio, haptic feedback, may serve the goal of increasing a sense of presence, the two are distinct as immersion refers to the actual configuration of the VR setup, whereas presence refers to a psychological state that reflects emotional, physical and cognitive engagement with the virtual environment (Van Gelder et al., 2014). Interestingly, research has shown that the level of realism of a VR environment appears to be far less important for presence than other parameters (Sanchez-Vives & Slater, 2005). It has been suggested that "the fact that minimal cues are enough to induce presence implies that the absence of some degree of sensory information is not distracting, and is probably filled in by cortical processing" (Sanchez-Vives & Slater, 2005, p. 337).

The better the VR can present the user with a three-dimensional experience, without creating cybersickness, the more likely it is that the user feels engulfed in the virtual environment and experiences presence. However, not everyone is easily drawn into virtual environments, and some even fail to develop a sense of presence (Wirth et al., 2007). In the context of VR, presence "occurs when part or all of a person's perception fails to accurately acknowledge the role of technology that makes it appear that s/he is in a physical location and environment different from her/his actual location and environment in the physical world" (Wirth et al., 2007, p. 495). Research has shown that the higher feelings of presence, the more likely it is that the user will show behavior that is comparable to behavior s/he would show in similar situations in real life (Van Gelder et al., 2019). This unique characteristic offers the opportunity to get more insight into relevant behavior.

Few studies have investigated the neural correlates of subjective feelings of presence within a virtual environment (see also Mishra et al., 2021). For example, Baumgartner and colleagues (2008) found that specific prefrontal cortex areas are strongly involved in modulating presence. Their study showed that feelings of presence are associated with *down-regulating* activation in the right dorsolateral prefrontal cortex (DLPFC), an area that is known to be involved in egocentric processing of visual environments. In addition, feelings of presence are also associated with *up-regulating* activation of medial prefrontal cortex structures, areas that are known to be involved in self-reflective and stimulus-independent thoughts. These exact neural activation patterns were not found in adults with low feelings of presence nor in children. The authors argue that 'adults appear to control and regulate their presence experience by critically evaluating and monitoring the presented VE (Virtual

Environment) stimuli, and/or by directing attention away from the external virtual reality to internal self-reflective mental processes.' (p.10).

Similar findings, including a negative relationship between feelings of presence and activation in the DLPFC, were obtained in a study by Clemente and colleagues (2014). The authors conducted an fMRI study with 14 adult participants who participated in three different VR conditions (only photographs of a virtual room, automatic navigation through the same room and free navigation through the room with a joystick). Participants in the free navigation condition felt more present compared to those in the automatic navigation and photograph condition. Furthermore, the authors found that feelings of presence were associated with increased activation of the parietal and occipital brain regions, including the cuneus and the right insula. The cuneus is known to be related to visual processing whereas the insula is known to be related to emotion and regulation of the body's homeostasis, including interpersonal experiences and self-awareness. The authors argue that 'the insula may play a key role in guiding behavior in the VE based on the presented stimuli and the sense of presence' (p. 12).

A review by Jäncke, Cheetham and Baumgartner (2009 p.52) on the neural underpinnings of presence concludes that presences is "associated with activation of a distributed network, which includes the dorsal and ventral visual stream, the parietal cortex, the premotor cortex, mesial temporal areas, the brainstem and the thalamus. Secondly, the dorsolateral prefrontal cortex (DLPFC) is identified as a key node of the network as it modulates the activity of the network and the associated experience of presence. Thirdly, children lack the strong modulatory influence of the DLPFC on the network due to their unmatured frontal cortex.".

2. Examples of VR applications

Over the past decades, researchers and practitioners in a variety of domains, including medical training, sports, the military, policing, physical rehabilitation, astronaut training, education, and mental healthcare, have embraced VR technology as a tool to better understand, observe, support, change, and improve human cognition and behavior (Bailenson, 2018). The immersive nature of VR is the critical distinguishing feature that sets it apart from other digital technologies we are familiar with, such as personal computers, smartphones, and wearables. As Rizzo and Koenig (2017, p. 880) phrase it: “By way of VRs capacity to immerse a user within an interactive computer-generated simulation, new possibilities exist that can go beyond the simple automation of previous clinical assessment and intervention approaches”.

As was explained in the previous section, immersive VR shuts off the user from real world perceptual input and, to some extent, can ‘trick’ the brain by blurring the line between reality and illusion in such a way that users can experience absorption in the new ‘reality’. If well-designed, it may only take a few seconds before the user starts to think and act as if s/he is in the real world (Nee et al., 2019; Van Gelder et al., 2019). That is, even though the user is perfectly aware that the virtual world is artificial rather than real, and that what is being viewed is generated by a piece of software code, s/he nevertheless tends to respond realistically to virtual environments, which can induce physiological and emotional reactions in similar ways as their real-life counterparts and generate behavioral responses that mimic those of their real-life equivalents. For example, people maintain more distance and show an increase in skin conductance level when approaching outgroup avatars as opposed to ingroup avatars (Dotsch & Wigboldus, 2008), and people involved as bystanders during violent incidents in VR are likely to intervene following realistic behavioral patterns (Gonzalez-

Franco & Lanier, 2017; Rovira et al., 2009).

One particularly telling illustration of how VR experiments also allow for studying phenomena that are not open to experimental study via other methods for ethical reasons, is a study conducted by Slater and colleagues (2006). The researchers carried out a variation of Stanley Milgram's 1960s classic obedience experiment. Milgram's experiment intended to understand obedience by demonstrating that people would administer severe and dangerous electric shocks to a stranger when instructed to do so by an authority figure. In their 'virtual reprise', Slater and colleagues applied a similar paradigm to the one used by Milgram but used an immersive virtual environment rather than a bogus physical laboratory setting. Furthermore, instead of examining obedience in itself, the authors looked at the extent to which participants would respond to such an extreme social situation as if it were real. That is, in Slater's experiment, participants delivered 'electric shocks' to a virtual 'trainee' when she made errors during a word association memory test. The virtual trainee protested against the shocks in similar ways as the confederate in the Milgram study. The variable of interest here is whether participants in this study would experience such high levels of presence that they would display signs of distress or behaviors that indicated that the virtual person was being treated as real. The results of the experiment indicate that even though participants knew that neither the trainee nor the shocks were real, they tended to respond to the situation at the subjective, behavioral (e.g., withdrawal from the experiment) and physiological (e.g., heart rate, skin conductance) levels as if they were.

The unique technology behind VR offers the possibility to expose users to situations that are difficult (e.g., recreating the exact same situation over and over again), expensive (e.g., flight training), risky (e.g., surgical procedures), unethical (e.g., behavioral monitoring of child abusers during interaction with a child), or simply impossible (e.g., embodying an avatar of the opposite gender or superhero) to realize in real life. An apt illustration of a VR success story is virtual reality exposure therapy (VRET) for the treatment of specific phobias and other anxiety disorders, such as post-traumatic stress disorder (PTSD). With VRET for specific phobia, patients are confronted with virtual representations of the objects or situations that they fear (e.g., spiders, flying, heights, enclosed spaces, public speaking). Although patients are fully aware that the situation is not real, VR triggers the same fear structures in the brain as actually being there in reality, which provides the therapist with the opportunity to help reduce anxiety levels to a more manageable level (Bowman & McMahan, 2007; Rizzo & Koenig, 2017). Importantly, VRET shows that anxiety reduction generated by VR transfers to the real world as therapeutic results gained by practicing in virtual reality. Ample research shows that VRET outperforms in vitro exposure therapy and is at least as effective, and possibly superior, to regular in vivo exposure for specific phobias and PTSD (Botella et al., 2015; Donker, Cornelisz, van Klaveren, et al., 2019; Maples-Keller et al., 2017; Parsons & Rizzo, 2008; Powers & Emmelkamp, 2008; Rizzo et al., 2009).

From a practitioner's perspective, the draw of using VR to treat phobia is that VR allows for generating and practicing with various relevant scenario's repeatedly without having to leave the therapist's office and hence implicates a logistical and likely also financial advantage over treatment that is delivered *in vivo.* It should be noted that high levels of immersion and sophisticated equipment are not strictly necessary as the effect of VRET on reducing phobia symptoms has been shown already in the 1990s with bulky headsets and rudimentary graphics in comparison to what is available today. Recently, Donker et al. (2019) showed that even a cardboard viewer used in combination with a smartphone generates reductions in fear symptoms comparable to those achieved by *in vivo* therapy.

In sum, VR technology allows for the creation of realistic experimental, training, and therapeutic settings that allow for manipulation, interaction, consistency across trials, while retaining both experimenter control and ecologically validity. Furthermore, as will also be discussed in more detail below, immersive virtual reality settings, allow for both researching and addressing behavior that would be unethical, impractical, costly, or even impossible to address in real life contexts.

3. VR as a tool to understand and reduce antisocial behavior

Despite its potential to affect human cognition and behavior, VR is still rarely used within the field of criminology and antisocial behavior (Cornet & Van Gelder, 2020). Traditional methods developed to study, understand, and predict criminal thoughts and action usually include indirect and retrospective measurement methods, such as interviews, surveys, and registration data, relying on introspection and self-disclosure. Although these limitations of conventional methods apply to social scientific and behavioral research more generally, they are compounded for the study of crime as criminology is "the only science where (…) deception is intentional and endemic. In addition to the understandable incentive for offenders to misrepresent the facts towards those collecting information (whether police, prosecutors, courts, correctional agents, or researchers), other data sources are also highly suspect. Many victims and criminal justice actors have incentives to misrepresent the truth in particular circumstances" (Eck & Liu, 2008, p. 196).

Furthermore, behavioral intervention programs aimed at reducing antisocial behavior often involve thinking and role-playing exercises or scenario-type written exercises in which offenders must imagine how they would respond to that situation in real life and change their behavior accordingly. Scenario-type methods are unlikely to serve as valid proxies of real-life decision making. For one thing, written scenarios are unlikely to fully capture the more visceral and emotional aspects involved in real-world offending, which commonly occurs during ‘hot’ and altered states-of-mind (Exum & Bouffard, 2010). Secondly, a short narrative is unlikely to adequately reflect the complex reality of real-life decision making situations, and to realistically incorporate important nuances of social experience (Christian et al., 2010; Ditto et al., 2006; Parkinson & Manstead, 1993).

Consider, for example, aggression regulation training. Exposure to actual provocation in forensic settings is restricted, which makes it difficult, if not impossible, to train patients to control the anger of others and themselves by provoking them in real life social situations (Klein Tuente et al., 2018). The use of VR can render it safer to provoke participants, as the participant faces a virtual character rather than an actor or a trainer. In addition, it is also safer for the participant to express his aggression towards an avatar than towards a human being (e.g., trainer, therapist, co-participant) as there is less concern regarding jeopardizing the therapeutic relationship (Klein Tuente et al., 2018). Furthermore, it is likely that VR intervention programs will be experienced as more engaging and motivating than traditional intervention programs, especially among adolescents who are familiar with using interactive technology in their daily lives (Cornet & Van Gelder, 2020).

In comparison to imaginal approaches, VR may also benefit participants with a lower imaginative ability. Imaginal approaches are not sensitive to differences in individuals’ ability to visualize themselves in hypothetical situations. If the validity of a scenario relies on the degree to which participants are able to imagine themselves in the fictitious situation, those lacking the ability to easily do so may respond differently to the scenario compared to those who can do it without effort. Hence, imaginal exercises may inadvertently capture individual variation in people’s ability to imagine themselves in the situation, rather than actual reactions to it (van Gelder et al., 2019, 2022). VR-based scenarios, in contrast, which perceptually immerse users in the situation of interest are better able to capture important nuances of social experience, as a rich contextual information can be provided including information about the nonverbal behavior of others (e.g., facial expressions of anger, happiness or contempt, and body posture) which signal important cues determining a perceivers' social responses (Van Gelder et al., 2022).

Furthermore, VR scenarios are also more likely to elicit relevant emotions and states of physiological arousal compared to written or imaginal exercises. Jouriles and colleagues (2009, 2011) had participants role-play as potential victims of sexual assault in a resistance training comparing an *in vivo* condition and an equivalent VR environment. They found that the VR condition was more effective at eliciting participant emotion and immersion in the role-play, speculating that VR may have made participants less self-conscious in a virtual environment than in the laboratory. Therefore, we reason that the VR environment may support perspective taking.

With the unique characteristics of VR to directly observe behavior as it takes place and provide realistic training environments, we argue that the technology could meaningfully contribute to the existing toolbox of assessment methods and intervention programs to better understand and reduce criminal and antisocial behavior. In the remainder of this chapter, we provide an overview of VR technology and its potential to better understand and reduce antisocial behavior. Below, we will describe how VR can be used as a tool to observe criminal behavior as it takes place, and thus, provide the opportunity to better understand antisocial behavior. Next, we will describe how VR can be used as a training tool to reduce antisocial behavior. We will conclude with a short discussion of several practical and ethical considerations involved in the use of VR.

3.1 Observing criminal behavior as it takes place

As mentioned earlier, traditional research methods, including interviews, surveys, and official registration data, tend to inquire about past events. The analyses of registration data (e.g., criminal records) offers little in way of understanding offender decision making or for purposes of offender rehabilitation. The limitations of introspective and retrospective methods such as surveys and interviews are also well-documented; narrator bias, social desirability and the limitations of human memory are only some of the problems plaguing such methods. Furthermore, these methods measure criminal behavior indirectly and are proxies for measuring actual behavior at best. Observational methods remedy these limitations to some extent, but when it comes to the study of criminal conduct, such methods pose additional challenges. Observation studies, like the analysis of CCTV footage, do not allow for linking offender characteristics to behavior and possibilities for experimental variation tend to be limited or absent. Experiments, such as those undertaken in university labs, in contrast, are restricted in terms of the type and severity of the behavior studied for ethical and practical reasons and the sterile and the often contrived nature of many lab experiments restricts their ecological validity (Blascovich et al., 2002; Loomis et al., 1999).

VR allows for realistic and hence ecologically valid experimental settings that offer possibilities for manipulation, interaction, consistency across trials and hence replication, and experimenter control. That is using immersive experimental settings, researchers can guarantee high experimental control, as well as validity through realistic simulations of real-life situations and study behavior that would be unethical in real life contexts. Arguably, VR allows for the observation of criminal conduct *as it takes place* and do so in very detailed and multi-faceted ways (Van Gelder et al., 2017). VR systems allow for registering spatial patterns, pose, force and limb movement, as well as eye-movement. VR systems can also be combined with sensors measuring the user's physiological state (e.g., heart rate, skin conductance, respiration rate) and with brain functioning techniques, including electroencephalography (EEG) (for an example of the set-up see Yu et al., 2022) and fMRI combined with an MRI-compatible VR set-up (e.g., Clemente et al., 2014; Qian et al., 2021). This richer measurement of behavior can give excellent rewards and allows for measuring implicit and natural behaviors in very subtle and detailed ways (Pan & Hamilton, 2018).

3.2 VR as an intervention tool to reduce antisocial behavior

VR can be usefully applied to create learning environments that support acquiring new behavior. One reason why VR is such a promising tool to practice new behavior is that, as described before, VR offers the opportunity to provide interactive, realistic, safe and ecologically valid learning environments that can be tailored to individual needs for which real-life situations would be difficult, costly, or unethical to use (Cornet & Van Gelder, 2020). In addition, VR supports the process of learning new behavior by involving not only the brain, but the entire body.

In recent decades, research has demonstrated that the way we think, act, and reason, is not solely grounded in our brains, but involves the whole body. This notion is known as 'embodied cognition' and refers to the idea that our cognitive abilities are shaped by aspects of our body (e.g., Shapiro, 2012). Neuroscientific research shows that thinking about concepts, such as objects, spatial information, faces and flavors, evokes sensorimotor responses, or "body-related activity" in the brain (Macedonia, 2019; Pulvermüller, 2013). In fact, our mental representations of the surrounding world and our experiences are stored through various systems of the body, including memory, perception (e.g., vision), emotion, and action (e.g., movement) (e.g., Barsalou, 2008, 2010). By way of illustration, research by Kontra and colleagues (2015) showed that students who physically experienced, e.g., by holding and tilting, a spinning bicycle wheel performed better on a subsequent quiz about a physics concept known as 'angular momentum' compared to students who just observed a wheel spinning. Interestingly, the increase in performance was mediated by activation of sensorimotor brain regions suggesting that ‘doing’ instead of just ‘observing’ can foster learning outcomes (Kontra et al., 2015). In line with this, researchers have argued that “when the appropriate sensorimotor systems are engaged, the converging inputs can create stronger and more stable memory traces and knowledge representations” (Lindgren & Johnson-Glenberg, 2013, p. 446). In other words, learning processes that are supported by bodily activity may generate stronger and perhaps longer-lasting learning effects. This is also known as ‘embodied learning’ (Lindgren et al., 2016; Lindgren & Johnson-Glenberg, 2013).

Although embodied cognition, or embodied learning, does not necessarily require VR technology, VR is well suited to easily facilitate interactive learning through bodily actions (Bailenson et al., 2008). This brings us to the concept of ‘virtual embodiment’. Virtual embodiment refers to the substitution of an individual’s physical body by a virtual one, with the objective of generating the cognitive illusion that the virtual body is, at least temporarily, one’s own (Banakou et al., 2018; Falconer et al., 2014; Slater et al., 2019). One necessary condition for the illusion of virtual embodiment is through multisensory contingencies that correspond approximately to those employed (Slater, 2009a).

A well-known example of body ownership is the ‘rubber hand illusion’, a paradigm in which participants’ left hands are hidden out of sight and replaced by a life-sized, rubber hand (Botvinick & Cohen, 1998). Subsequently, both hands are stroked synchronously by an experimenter. As a result, participants start to experience the rubber hand as their own. If the tactile stimulation is not synchronous, then this illusion does not occur. In the case of whole body displacement, visuomotor synchrony can be established by having participants perform a series of physical movements in front of a virtual mirror using handheld controllers while viewing their avatar body synchronizing their movements (González-Franco et al., 2010; Slater, 2017). Experiencing body ownership of the avatar in virtual reality increases the likelihood that the user feels absorbed in the virtual environment, creates the illusion that the events occurring are real and this, in turn, increases the likelihood that the user responds to virtual events and situations in more realistic ways (Slater, 2009b).

An interesting example of a VR intervention program that uses virtual embodiment, is the Virtual Reality Aggression Replacement Therapy (VRAPT; Klein Tuente et al., 2018). VRAPT concerns an interactive VR intervention program in which forensic psychiatric patients are confronted with the provocative behavior of others and practice how to inhibit their aggressive responses. VRAPT is based on Aggression Replacement Therapy (ART; Goldstein et al., 1998), a widely applied intervention framework that aims to reduce aggressive behavior through a high-level of learning by doing, using role-playing exercises to practice with prosocial behavior. Although widely applied, meta-analytic research has shown that "there is an insufficient evidence-base to substantiate the hypothesis that ART has a positive impact on recidivism, self-control, social skills and moral development in adolescents and adults" (Brännström et al., 2016, p. 1). Previous meta-analytic research on correctional intervention programs has shown that studies that use role-playing were significantly more effective in diminishing (violent) re-offending than those that did not (Jolliffe & Farrington, 2007). Klein-Tuente and colleagues (2020) have argued that VRAPT could intensify/support the practice of new behavior with help of various highly-interactive role-playing exercises. Role-playing exercises do not necessarily require VR technology, though "the imagines re-created through VR may be more vivid and real than the one that most subjects are able to describe through their own imagination and their own memory" (Vincelli & Riva, 2000, p. 356). Overall, however, results from a randomized controlled trial indicate that VRAPT did not successfully decrease aggressive behavior. Still, it did temporarily improve anger control skills, impulsivity, and hostility among aggressive psychiatric patients. The results are modest and in line with previous (non-VR) aggression treatment studies (Brännström et al., 2016), but since we are at the start of exploring the potential of VR as a tool to support (embodied) learning among individuals with antisocial behavior, we believe these findings are promising.

Another example of how VR and its ability to establish virtual embodiment can be used to influence antisocial behavior, concerns a study conducted by Seinfeld et al. (2018) who used immersive VR to foster empathy skills among perpetrators of domestic violence. In this study, offenders virtually embodied a female victim of domestic abuse. In total, a group of 20 male domestic violence offenders and 19 males without a history of violence experienced a virtual scene of abuse in the first-person female perspective. After being embodied as a female victim, offenders significantly improved their ability to recognize fearful faces among females, although their overall ability to recognize emotion was still reduced compared to controls. Even though the results do not provide evidence for real-life behavioral changes among the offenders, this study does show promise for using interactive embodiment in VR to influence socio-perceptual processes.

A follow-up study (Seinfeld et al., 2021), examined the underlying brain mechanisms of these effects using fMRI to measure the impact of the same virtual abuse intervention. In this study, which was conducted among a sample of Dutch males without criminal records and without a history of physical or emotional abuse towards themselves or others but with low fear recognition sensitivity brain processes related to facial and bodily emotion perception were compared prior to and after the VR experience. Results show that the virtual abuse experience led to an enhancement of Default Mode Network (DMN) activity, specifically associated with changes in the processing of ambiguous emotional stimuli. In contrast, DMN activity was decreased when observing fully fearful expressions. Finally, the results indicate increased variability in brain activity for male versus female facial expressions. The authors conclude that taken together, these findings suggest that the first-person perspective of a virtual violent situation impacts emotion recognition through modifications in DMN activity (Seinfeld et al., 2021).

A final example of applying VR within the context of antisocial behavior stems from our own research group. In a small-scale field study, 24 young delinquents alternated between virtually embodying an avatar representing their present self and an avatar representing their 10-year older, and hence ‘future’ self (Van Gelder et al., 2022). During the interaction, participants reflected on their current lifestyle, alternating between the perspective of their present self and that of their future self. We hypothesized that virtual embodiment of the future self would ‘bring the future to life’ and would stimulate participants to think and act – at least temporally – in a more future-oriented way. Results indicated that the interaction indeed increased vividness of the future self compared to baseline and reduced self-reported self-defeating behavior, including alcohol use and overspending, one week after the experiment. The results are based on a small sample and should therefore be treated with caution. Yet again, the results are indicative of the possibilities of using a VR paradigm as an intervention tool to reduce self-defeating behavior (see also: Ganschow et al., 2021).

The aforementioned examples illustrate the use of VR to create learning environments in which users can be perceptually transported to realistic training environments (e.g., VRAPT) and virtually embody another entity (e.g., victim of crime), where they are not solely exposed to cognitive therapeutic instructions but rather use their entire body in the process of interactive learning.

4. The future of VR

In this chapter, we have illustrated the potential of VR as a tool to understand and reduce antisocial and criminal behavior. However, like any other technology, VR comes with relevant limitations and challenges. Here, we discuss three important challenges. First, working with VR requires specific knowledge. Expertise is required during the process of designing and building VR software and having knowledge of how to work responsibly and safely with VR hardware to avoid any physical or psychological discomfort among participants is critical. Furthermore, most, if not all, VR hardware systems are currently developed by private companies (e.g., HTC, Facebook), which implies that data collected with VR devices might be shared with third parties. Hence, it is important to be aware of, and communicate about privacy issues to participants as part of informed consent procedures. Finally, at this moment, there is limited information about the (long term) psychological and emotional side effects of using VR. Although research has shown that VR is a promising tool for individuals with, for example, dementia or intellectual disabilities - more research is required to better understand the impact of this technology on vulnerable groups of individuals. Also, little is known about the exact effects of VR on young children (Segovia & Bailenson, 2009). We also recommend conducting user-tests with relevant target groups as part of the development process of the VR application to tailor the application to the feedback and needs of the end-user.

Future research in the domain of antisocial behavior and offender rehabilitation could focus on improving our understanding of how behavioral skills acquired in VR translate to real-life behavior and attempt to establish long-term effects of VR-based intervention on antisocial behavior, attitudes, and thinking. Given the potential VR has demonstrated in other relevant domains – from treating PTSD in war veterans to training surgeons to perform highly complex procedures – and the existence of a VR research community, which can serve as both a source of information and inspiration for criminal justice practice, the future of VR in forensic research and practice looks promising. In our view, the fact that the application of VR in the context of criminal and antisocial behavior has seen a relatively late onset and by implication is less developed compared to other fields with more longstanding VR traditions only implies that the remaining runway is long and full of opportunity.

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