Virtual Reality Applications in Forensic Psychiatry

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ABSTRACT
Violent offending behaviours remain an important issue in particular when associated with mental illness. To prevent recidivism and protect society, investments are required to develop new tools that would provide decision makers with a better understanding of violent behaviours and ultimately improve treatment options for violent offenders. Recently, Virtual Reality (VR) is gaining recognition as promising tool in forensic psychiatry. Amongst other things, VR allows a renewal from both methodological and theoretical points of view. The aim of this paper is to introduce VR applications in the context of forensic psychiatry. After a brief introduction to the purpose of forensic psychiatry, examples will be given in order to illustrate how VR can help address some of the field’s current issues.

Categories and Subject Descriptors
A.0 [General Literature]: General - Conference proceedings.

General Terms

Keywords
Forensic psychiatry, Virtual reality, Mental health, Applications, Self-regulation, Brain-computer interface.

1. INTRODUCTION
Forensic psychiatry is the field whose expertise is the assessment and treatment of offending behaviours, in particular when offenses are related to mental illness. Main clinical areas of forensic psychiatry include 1) paraphilias and sexual offending, 2) psychotic disorders, in particular schizophrenia, and 3) psychopathy. Forensic psychiatrists are usually sought-after to perform diagnostic evaluation, to assess recidivism's risk, as well as to recommend and dispense appropriate treatment that will optimize both patient's rehabilitation and society's protection.

Many theoretical models have been proposed to understand violent behaviours. Some theories contribute to a general comprehension of violent behaviours (e.g. the General Aggression Model) [1], while others provide details on specific offence types (e.g. the Integrated Theory of Sexual Offending) [21] or diagnosis (e.g. the violence inhibition mechanism to explain psychopathy) [5]. All of these theories and models try to provide answers to the same underlying question, central to forensic psychiatry, concerning the manner in which individual’s behaviours are organized. Specifically, it becomes crucial to understand how certain individuals come to display maladaptive behaviours in a given environment, especially when considering issues such as offenders’ responsibility and their ability to change their behaviours. Thanks to its ability to generate specific environments, associated with a high experimental control on generated simulations, Virtual Reality (VR) appears as a promising tool in forensic psychiatry. Nevertheless, no important benefit should be expected from the introduction of a new tool (as innovative as VR) without any explicit and heuristic theoretical underpinnings.

1.1 Agency and self-regulation perspective
The self-regulation perspective considers humans as agents who are able to influence their own functioning as well as the course of the events they are involved in, on both physical and social levels [2]. Therefore, agency is based in part on the process of self-regulation (SR), which leads to intentional behaviours, premeditated actions, deliberation of possible choices available, and metacognitive self-observation of one’s actions [13]. For the agent, the process of choosing, maintaining, and achieving adaptive behavioural objectives is greatly influenced by the environment, particularly the social environment with whom the interaction is constant [7]. Most SR theories are based on a bimodal model, built on 1) a reactive approach–avoidance system, and 2) a reflexive control system that regulates the first system [6]. SR is essentially a dynamic process that manages potential conflicts between processing ascending information (bottom-up) and maintaining specific descending objectives (top-down) [6][16][19]. In this way, SR corresponds to the ability to change, inhibit or reorient automatic responses in order to achieve long-term objectives and thus to distance oneself from immediate environmental factors [3].

Fluctuations in SR resources have been linked to different violent behaviours. For example, in sexual offending, different SR profiles have been identified and contribute to treatment's targets and recidivism's risk [22]. In most profiles, offending appears to result from a decrease of available SR resources: it appears that in certain environmental and social contexts, sexual offenders may no longer be able to inhibit automatic answers and to exert abilities to prevent (re-)offending. In contrast, other profiles suggest high ability for self-regulation. These profiles are characteristic of offenders who are able to premeditate, develop explicit plans and execute deliberate offence-oriented actions.

Because SR is directly linked to proximal triggers and violent offending behaviours are highly context-dependent, simulating a realistic environment, with its immediate stimuli either physical, social or emotional, appears crucial. Therefore, through VR, the aim would be to simulate an environment close enough to reality to probe into the underlying SR mechanisms involved in violent offending behaviours.
1.2 Virtual reality in forensic psychiatry

During the last decade, VR applications have been increasingly popular in health and mental health settings. Contributions have greatly influenced anxiety disorders’ assessment and treatment [15]. Recently, VR has also been used in forensic settings. Amongst other things, VR allows to study the etiological factors related to violent offending behaviours as they may unfold in a dynamical environment. Precisely, gathering information on how offenders perceive their immediate environment allows the clinician to consider both decision-making and self-regulation processes.

In forensic psychiatry, as well as in social and human sciences in general, phenomenological perspective has often been criticised for its non-observable and non-objectified features. VR can help address this concern by giving us access to observable information pertaining to the offenders’ sensorimotor interaction with the environment from a first person stance. Thereby, VR grants access to an improved understanding of violent offending behaviours. In addition, combining VR with psycho-physiological measures, such as eye-tracking and/or electroencephalography, allows the subjective experiences of an individual to be objectified, observed and examined. Therefore, VR becomes the first available real-time methodology to analyse violent offending’s underlying mechanisms, while promoting highly controlled experimental designs able to integrate the ecological complexity of processes leading to violent behaviours.

2. ILLUSTRATION

To illustrate our argument, some of our works are briefly presented. Since 2006, VR is used towards the assessment of sexual offenders at the Philippe-Pinel Institute of Montréal in Canada; a psychiatric hospital specialized in forensic psychiatry. Outcomes resulting from VR applications, some of which are presented below, have been so promising that paramount investments have been made toward a new, state-of-the-art virtual reality laboratory to service most clinical areas of forensic psychiatry. To our knowledge, this is the first laboratory with high technologies (such as a Cave-type immersive vault) specifically devoted to forensic psychiatry and equipped to receive forensic patients representing different levels of security risk.

2.1 Deviant sexual arousal in child molestation

Deviant sexual interests play a central role in the development, expression, and sustainment of child sexual abuse [22]. All etiological theories have integrated the concept of deviant sexual preferences. Studies show that the presence of a deviant sexual interest is the best predictor of sexual reoffending [9]. Although there are different methods to assess deviant sexual preferences, the most efficient method to date remains penile plethysmography (PPG) [14]. However, despite its adequate specificity, with false positive rates under 10%, PPG is distinctly less reliable in terms of sensitivity, with false negative rates around 40%. This lower reliability may be explained in part by the ability of those evaluated to falsify results, mainly by way of voluntary erectile control, but also by the type of stimuli used. These stimuli are often abstract and too far from reality to activate the SR mechanisms involved in the sexual offense process [12][16][19][20].

In order to better define the role played by deviant sexual preferences in sexual offending, one of our projects aimed to increase the PPG procedure’s ecological validity in order to increase its overall psychometric qualities. To do so we combined PPG with a presentation modality comprised of 3D computer-generated stimuli presented in a virtual environment. This specific presentation modality allows the assessed individual to be immersed and present in the same virtual environment as the stimuli he is observing. The results we obtained using standardized and idiosyncratic virtual stimuli (i.e. working with the characteristics of each evaluated offender; figure 1) have allowed us to better distinguish sexual preference profiles through PPG, as compared to the standard audio stimuli most commonly used in research and clinical settings (figure 2) [18][16][19].

Figure 1. Validated 3D Computer-generated stimuli: 6-7 year-old, 10-12 year-old, 16-17 year-old and 22-25 year-old.

In order to avoid false PPG results by means of voluntary erectile control, as well as to better understand the sexual mechanisms used on an attentional level by child molesters, another research project aimed to identify result-tempering attempts by participants during the PPG assessment. Voluntary control of erectile responses poses a significant threat to the internal validity of the procedure. Results suggest that the combination of PPG and eye tracking devices allow the monitoring and identification of faking attempts by participants. Through the use of new technologies, it is possible to identify both overt and covert faking attempts by participants, resulting in an increase in the procedure’s internal validity [20]. In addition, eye-tracking during PPG assessment offers direct access to exploration patterns and intentional dynamics specific to child molesters [16][20]. These results suggest the presence of ocular dynamics specific to child molesters, and corroborate conclusions from other researchers [8]. More precisely, these oculomotor patterns seem to correlate with erectile response and therefore could be linked to the self-regulation of sexual arousal.

Figure 2. Receiver operating characteristic (ROC) analyses of PPG procedure’s sensitivity and specificity. Audio stimuli yielded an Area Under the Curve (AUC) of 0.79 (SE = 0.059) while virtual stimuli yielded an AUC of 0.90 (SE = 0.052).

Moreover, the results indicated significantly different discrimination ability between modalities $\chi^2 (1, N = 58) = 7.91, p = 0.005$, with virtual stimuli performing better than audio stimuli [19].
Again, to survive long term as a new forensic assessment and treatment modality, VR needs to be articulated within a conceptual framework able to explain precisely the factors by which it is relevant to a specific issue. To this end, the introduction of VR in the assessment of deviant sexual interests was based on an extensive theoretical work pertaining to a variant of the feeling of presence, i.e. the sexual presence [17].

2.2 Towards a brain-computer interface

Lately, advances in VR in the context of forensic psychiatry were transferred to other clinical issues such as empathy. Empathy is a complex cognitive and emotional skill, generally defined as the ability to subjectively experience the feelings of another person. This ability likely stems from a specific and valid reading of emotional reactions manifested by others [10]. Lack of empathy, as a situational or permanent symptom, appears to be particularly important in sexual offending and psychopathic behaviours. One of our current projects therefore aims to develop brain-computer interface, using immersive VR paired with quantitative electroencephalography (EEG), to study empathetic responses. Beyond the need to simulate realistic environments and to improve ecological validity, this project aims to develop an interactive system, relying on a real-time evolution of a virtual environment through participants’ psycho-physiological responses (i.e. neurofeedback mediated by virtual environment). Figure 3 introduces the system we are currently developing (see Appendix).

Neurofeedback is a technique using EEG to measure brain activity and to translate its signals into stimuli sent to a participant monitoring his answers. With training, a participant is able to learn how to modulate his own brain activity to control a specific device through real-time monitoring. It is now possible, using EEG, to mathematically locate an activation source by using a relatively small number of electrodes (64 active electrodes). To keep it simple, EEG activity corresponds to the activation of broad groups of cortical neurons activated synchronously. When a psychiatric or neurological disorder is associated with a change in the activation's pattern of a given group, this pattern may be qualified as potential marker of a given disorder. Compared to traditional methods of visual inspection of the EEG, modern techniques for analyzing quantitatively EEG can significantly expand the amount of interpretable information regarding given diagnostics and electrocortical activity as marker for neurological or psychiatric disorders [11].

In regard to empathy, we now know that mu rhythm brain waves (8-13Hz) recorded in the sensorimotor cortex react in a characteristic manner according to empathy response (Jackson et al., 2006). It is observed that the suppression of mu rhythm is related to the empathy response, and that the absence of suppression is found in clinical populations that demonstrate a lack of empathy [23].

Through our brain-computer interface, participants will be trained to improve their empathetic responses when immersed with an interactive virtual character expressing pain. It is important to note that our project is at the experimental stage, thus runs with healthy participants with normal ability for empathy. To develop a brain-computer interface based upon virtual reality is, in itself, an important innovation. If validated, significant benefits could be expected from a system able to assess and potentially treat a limited ability for empathy, which is known to have a role in violent offending.

3. CONCLUSION

Until now, VR has kept its promises in the field of forensic psychiatry. With a required and essential emphasis on theoretical underpinnings, VR applications have been able to improve assessment and tend to emerge as a promising tool of rehabilitation, in particular through development of human-computer interface. Social and human costs of violent offending behaviours require the development of new tools to better understand them, especially when associated with mental illness, and, by this mean, better treat violent offenders to prevent recidivism and protect society. Our paper aimed to introduce VR applications in forensic psychiatry to illustrate how VR offers renewal from both methodological and theoretical points of view and may help address some of the field’s current issues. An underlying aim was also to rouse an interest in VR community to our field. On the one hand, in the current political context, marketing software tools intended to ensure a better management of public safety has demonstrated to be a growing market [4]. On the other hand, forensic psychiatry offers the VR community an opportunity to contribute to the common good, while new investments are still required in forensic psychiatry.

4. REFERENCES


5. APPENDIX

Figure 3. Architecture of the proposed Brain-Computer Interface system