Combining Virtual Reality and Quantitative Electroencephalography to Search Offenders’ Minds

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A virtual reality (VR) revolution is on the horizon. While it was there for the last 30 years, particularly in the field of scientific and military research, this media is now available to the general public through better and more affordable technology vehicles. In conjunction with the increasing and diversifying effect due to its anchorage in social media, VR revolution will spread in all spheres of human activity, especially that of the sexual life. Indeed, according to Market Watch: “By 2025, such adult content (i.e. synthetic pornography) is forecast to be a $1 billion business, the third-biggest virtual-reality sector, after videogames ($1.4 billion) and NFL-related content ($1.23 billion” (Booton, 2015). We do not know yet how this will affect our lives but burning questions lurk there. For instance, Will standard and VR pornography affect their users the same way? Do VR sexual experiences contribute to the shaping of new paraphilias, especially through learning and desensitization?

On the positive side, we must ask how we can fully exploit this set of technologies to better understand and perhaps help sex offenders acquire better self-regulation skills. Significant efforts have been made to this effect in the last fifteen years by our team at the Philippe-Pinel Institute of Montreal. While continuing in the vein of a combined use of virtual reality, penile plethysmography (PPG) and oculometry, we have added in recent years quantitative electroencephalography to our measurement strategy. Quantitative electroencephalography (qEEG) is especially well suited to be used with VR. Contrary to the evoked potential method, qEEG is more adapted to complex and longer scenarios such as those used in video games and VR applications. This psychophysiological technique gives access to the spectrum of wavelengths characterizing specific responses distributed over the scalp as they are unfolding in time. QEEG meets the ecological validity of virtual reality in answering the temporal dimension of the script while adding depth and power to the understanding of the relationship to stimuli, especially those of social nature.

Our symposium comprises three presentations in line with what precedes. First, Patrice Renaud (Quebec University in Outaouais/Philippe-Pinel Institute of Montreal) and his colleagues will present research results showing how virtual agents (VA) and qEEG can be used to assess empathy responses and possibly recognize features of the psychopathic personality. Joanne-Lucine Rouleau (Montreal University/Philippe-Pinel Institute of Montreal), our second presenter, will help us better understand how real and synthetic pornography induced specific psychophysiological states and how qEEG appears to be a promising index of sexual arousal. Thirdly, Sarah Michelle Neveu (Quebec University in
Montreal/Philippe-Pinel Institute of Montreal) will give a talk on the now standard sexual preferences evaluation at Pinel Institute, combining virtual characters, eye-tracking, qEEG and penile plethysmography.

Financial Disclosure:
Dr. Patrice Renaud has financial interests in the symposium as he is in charge of BehaVR solutions, a company selling software applications in forensic mental health.

Virtual Reality and qEEG:
Probing Mu Suppression in Regards of Empathic and Psychopathic Tendencies

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The main goal of this study was to explore the possibility of using immersive virtual reality (VR) in conjunction with electroencephalography (EEG) to assess levels of empathy in healthy individuals. Alpha/mu suppression (8-13 hz) was examined with six different electrodes located in two cerebral regions (C3, Cz, C4, O1, Oz and O2, installed on a 10-20 system). Two areas were targeted: the somatosensory area (SSA) as it has often been implicated in motor and pain resonance (component of empathy), and the occipital region due to its involvement in visual attention. In total, 24 adult participants (12 females) were immersed in a CAVE-like immersive VR system. Three different animations were presented: (1) human virtual agent (VA) in pain with movement and facial animation, (2) same movement pattern as in pain without emotional component, and (3) neutral animation of the same VA. Two different instructions were given before presentation of the animations: trying to be empathic towards the VA or refrain from trying to understand him. Participants’ self-reported levels of Cognitive and Affective Empathy (IRI – Interpersonal Reactivity Index) and Psychopathy (SRP – Self-reported psychopathy) were used as independent variables. For all participants, there was a triple interaction between Regions, Animations and Instructions (p = 0.037), with alpha suppression being significantly lower in the central region for the Pain animation during the Objectification condition than during all other conditions. In regards of the self-reported empathy measure, participants with higher Affective Empathy have a stronger alpha suppression for the pain and movement animations (p = .012); they also have a stronger alpha suppression during the empathy instruction (p = .0001). For the Psychopathy factor, with qEEG occipital index as covariate, a significant triple interaction was found between Group, Instruction and Animation factors (p = .025). Contrasts reveal that mu suppression is significantly stronger during the Pain animation when compared to the Movement animation but only for the participants low in psychopathy in the Objectification condition (p = .032). Participants high in psychopathy showed a flat profile, i.e. no differences in mu suppression following
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conditions. Overall, distinct cerebral activity patterns were found among healthy individuals according to self-reported measures of empathy and psychopathy. Results will be used to build an interactive BCI that could be used to train empathy through conditioning of cerebral activity. Such BCI could be used with forensic population showing deficits in empathy, such as psychopaths and sex offenders.

Learning Goals and Objectives:
- Learn how virtual reality could be used in conjunction with EEG to evaluate empathy
- Learn how self-reported measures of empathy and psychopathy are linked to cerebral activity
- Explore the possibility to modulate mu rhythm in forensic population (e.g. psychopaths) with neurofeedback within an immersive environment
- Learn about the use of Virtual Reality in research
- Learn about how empathy and psychopathy are related

Assessing Sexual Arousal and Sexual Presence using Frontal Asymmetry as Measured with qEEG

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The aim of this study is twofold, firstly to develop a non-genital index of penile sexual arousal based on brain patterns, and secondly, to better understand the psychophysiology of sexual presence (SP) in heterosexual males by comparing how different levels of subjective SP induced by real and synthetic pornography translate into psychophysiological states. This study relies on using penile plethysmography (PPG) and quantitative electroencephalography (qEEG) as measures of sexual arousal and interest.

Renaud, Fontanessi and Benbouriche (2014) suggested the following definition of sexual presence (SP), “SP as a "second order" technologically mediated experience, is defined as a psychophysiological state of sexual arousal, including a subjective erotic perception, whose content and extent are determined by the interplay between individual psychobiological predispositions, idiosyncratic past experiences, and what is sexually afforded by a mediating technology”. SP is a particularly useful concept when it comes to assess perceived realism and involvement with synthetic sexual stimuli such as those used in virtual reality (VR).
In line with Prause and her colleagues (2014), who have shown how a preponderance of left-hemisphere activation over the right one is a potential index of cerebral sexual arousal, we compared how three levels of SP (using real and synthetic pornography) would induce specific patterns of brain activation (qEEG) and sexual arousal (PPG). Our results, based on multivariate analyses, show that frontal asymmetry in the alpha rhythm (8-13 Hz) appears to be a very promising non-genital index of sexual arousal as well as a potential marker of SP, advantageously comparable to PPG.

Furthermore, interesting correlations help us better understand these results. First, SP correlate positively with penile erection as measured with PPG (r(32) = .341, p < .05), which denotes that subjective erotic perception induced by technological means, and especially the impression of sexual realism, appears to be modulated by genital arousal. Second, cerebral sexual arousal also correlates positively with perceived sexual realism; this is so for frontal asymmetry in alpha and self-reported SP (r(30) = .458, p < .01).

Results will be discussed in the light of the potential uses of qEEG in the assessment of sexual preferences as well as how SP could help us further the use of VR with sex offenders.

**Learning Goals and Objectives:**
- Learn about the concept of sexual presence and how it can be used in better understanding virtual reality
- Understand how sexual presence might relate to the assessment and treatment of sex offenders
- Learn about the psychophysiological assessment of sexual arousal in comparing methods based respectively on standard PPG and qEEG
- Learn about synthetic pornography, how it is made and new trends
- Learn about how synthetic pornography could change how sex offenders use pornography.
fundamental understanding of deviant arousal, in order to improve the assessment of the latter, the Virtual Reality Applications in Forensic Psychology Laboratory (VRAFPL) at IPPM recently acquired specialized equipment: wireless EEG, eye-tracking glasses and an immersive vault. Men who committed different sex offences (sex crimes against children or women, or pedopornography offences) are now routinely assessed in our lab, to screen for deviant sexual arousal. This new protocol started in Fall 2015. Generally, around 75 sex offenders are evaluated yearly in our lab. Moreover, psychopathy is systematically assessed during the evaluation, with a self-reported questionnaire. The goal of the presentation is to, first, demonstrate the theoretical rational behind the use of a multimethod approach to assess deviant sexual interest in sex offenders. The Integrated theory of sex offending (Ward & Beech, 2006) will be presented to support this view. Second, the protocol of evaluation, including EEG, eye-tracking and penile plethysmography, during the viewing of virtual avatars, will be presented. Virtual avatars presented to sex offenders depict child (6-7 year old, and 10-11 year old) and adult human, in different emotional disposition (neutral, seduction and fear). Third, clinical cases will be used to illustrate the clinical plus-value of this multimethod approach, in regard to EEG, PPG and oculometry. Lastly, quantitative results with each device (penile plethysmography, EEG and eye-tracking) will be presented. For example, we will present differences in groups (sex offenders against children vs adults) on penile response and perceptual-motor processes (obtained with oculometry) but also on cerebral activity associated with sexual arousal. In conjunction with penile response, data available so far suggests patterns of cerebral activity associated with sexual arousal toward virtual avatars. In that regard, frontal asymmetry in the alpha band, as proposed by Prause & al. (2014) as a measure of sexual arousal, and alpha suppression in specific regions of the brain (e.g. parietal) will be discussed. Moreover, mu suppression in the somatosensory area during the viewing of virtual avatars will be exposed. Thus, the goal of the presentation is to illustrate the plus-value of a multimethod approach in the evaluation of deviant sexual interests of sex offenders.

Learning Goals and Objectives:

- Understand the theoretical foundation of a multimethod approach in the evaluation of deviant sexual interests
- Learn specific patterns in EEG, PPG and oculometry, with immersive displays, associated with deviant sexual arousal
- Gain a better understanding of deviant sexual interests that goes beyond penile response
- Learn how virtual reality can be used to assess deviant sexual interests
- Understand how research and clinic can be combined during the assessment of sex offenders
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Dr. Renaud is among the first researchers to have developed and tested a method to generate synthetic and animated characters to be used in the assessment of sexual offenders’ sexual preferences. Dr Renaud furthermore developed and patented a method to analyze gaze behavior and sexual response in virtual immersion. He is the director of the Virtual Reality Applications in Forensic Psychiatry (VRAFP) laboratory at the Philippe-Pinel Institute of Montreal.

Dr. Christopher Patrick is a past President of the Society for the Scientific Study of Psychopathy (SSSP). He was honored in 2013 with the Hare lifetime achievement award of SSSP. Dr. Patrick’s interests lie in the field of clinical neuroscience, which encompasses areas of personality, psychopathology, and human neuroscience. More specifically, his research applies cognitive and affective neuroscience methods to the study of psychopathy, impulse control ("externalizing") problems, and anxiety and mood ("internalizing") disorders. His work focuses on understanding these disorders in terms of individual difference characteristics such as inhibitory control and defensive reactivity that are directly linked to neurobiological systems.