EEG responses to the observation of Pain and Pleasure on self and others in immersive virtual reality

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Immersive virtual reality studies indicate that healthy people who observe a virtual body from a first-person (1PP), but not from a third-person (3PP) perspective, experience an illusory feeling of ownership over it. Moreover, people can experience vicarious sensations of pain and pleasure that can be elicited by the simple observation of a virtual needle penetrating the virtual hand or of a virtual caress over it. Markers of embodiment and vicarious feelings have been detected at both explicit (e.g. subjective ratings) and implicit (changes of autonomic reactivity) level. In the present study, we aim to expand previous knowledge by recording subjective ratings and EEG responses in twenty-four healthy participants immersed in a virtual reality scenario while observing virtual stimuli having different valence: needle penetrating (pain), caress (pleasure), or ball touching (neutral) delivered to the hand of an avatar seen from 1PP or 3PP. Behavioural results show that participants felt strong feelings of ownership over the virtual hand only in 1PP, which parallel with higher vicarious sensations for pain and pleasure with respect to neutral stimuli. Visual Potentials evoked by observation of the different stimuli indicate that their valence affected both early and late stage of the visual processing. In particular, greater amplitude of early visual potentials were evoked by pain and pleasure with respect to neutral stimuli. Moreover, at later stages amplitude was decreased for pleasure stimuli compared to pain and neutral. The perspective point of view affected the early stage of visual processing with 1PP inducing greater amplitude of brain reactivity. These results suggest that while the emotional relevance of pain and pleasure enhances the amplitude of the response at an early stage, likely reflecting attentional engagement, the decreased amplitude for pleasant stimuli in the later response could reflect a reduction in the arousal induced by the soothing function of pleasant touch. Finally, we propose that an experimental approach based on IVR can be a reliable and safety method for inducing illusory sensations of being touched or threatened, i.e. without actually delivering any stimulus to participants' real body, and could open novel ways to investigate the neural and physiological underpinnings about reactivity to pain and pleasure on self and other.