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Too busy to feel? Studying the impact of workload on visuo-tactile perception through EEG

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Introduction: Perception lies at the heart of our interaction with the environment. Users in virtual reality (VR) can develop a sense of ownership over their virtual body [2]. This sense of embodiment leads users to interact with and protect their virtual body as if it were their own. However, it remains unclear how brain activity reflects the perception of virtual interactions. Furthermore, workload is known to influence attention processes and perception [3], with these effects varying depending on the sensory modalities that are overtaxed [1]. Thus, the goal of our study was to assess neurophysiological modifications occurring during visual and visuo-tactile stimulation in VR under different workload conditions.

Material, Methods and Results: A total of 32 participants were embodied in a virtual avatar, that resembled them (e.g., in terms of gender), using an HTC Vive Cosmos and a Leap Motion. A 6-axis robotic arm (Universal Robot UR5) with a soft foam ball as end effector, delivered tactile stimulation to the participant's hand, while a replication of the virtual robot delivered visual stimulation to the avatar's hand following the movement of the real robot. Using this system, visuo-tactile touch (using real and virtual robot) or visual-only touch (using virtual robot) was delivered while the brain activity was recorded using EEG (48 active electrodes; g.USBAmp from g.tec). To assess the impact of workload, we employed a N-back task in which participants had to compare a number displayed on their hand after each stimulation, determining whether it matched the number from one stimulus ago (1-back, low workload) or three stimuli ago (3-back, high workload).
Signal was filtered using a notch filter at 50 Hz and a band-pass filter between 0.1 and 30 Hz. We applied an independant component analysis to mitigate artifacts. Epochs were realigned so that the onset of the stimulation is at time 0. We studied the impact of workload on the perception of touch by observing event-related potentials (ERP) over the sensorimotor band relative to the left hand (CP4) (Figure 1a). We found significantly lower ERP amplitudes ($F(1, 26) = 13.17$, $p = 0.001$, $\eta^2 = 0.071$) (Figure 1b) in response to the visuo-tactile touch when the workload was high (mean = $5.01(\pm 2.23)\mu V$) compared to low (mean = $3.96(\pm 1.58)\mu V$), suggesting that workload led to a reduction in ERP amplitudes in response to visuo-tactile touch. However, we didn't find any significant difference in the visual-only condition.

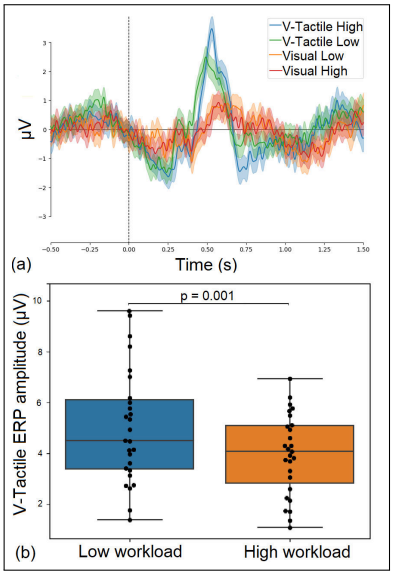

Figure 1: *(a) Grand-average event-related potential in reaction to the stimulation. (b) Amplitude of the positive potential measured between 400 ms and 700 ms after stimulus onset for the visuo-tactile touch.*

Conclusion: In this experiment, we show a direct evidence of the impact of workload on the tactile perception, consistent with findings in the literature [4], but not on the visual stimulation. Subsequent analyses will investigate the underlying reasons for the differences in the effect of workload between visual and visuo-tactile touch, as well as the potential role of embodiment in shaping these differences.

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