

Neurofeedback for increasing sense of presence in Virtual Reality

L. Botrel^{1*}, A. Kübler¹

¹ Institute of Psychology, Department of Psychology I, University of Würzburg, Würzburg, Germany;

*Marcusstr. 9-11, Würzburg, Germany. E-mail: loic.botrel@uni-wuerzburg.de

Introduction: Sense of presence in virtual reality (VR) is the subjective feeling of being there. Studies [1, 2] have found that decreased parietal alpha in scalp EEG (i.e. increased activity in the visuospatial processing areas) was related with higher spatial presence. In two studies we describe (1) a high density parietal alpha neurofeedback (NF) training and (2) its adaptation into an immersive VR neurofeedback training.

Material, Methods and Results: During the high-density study (1), 15 participants were trained in 10 parietal alpha NF sessions using 128ch EEG. The output variable used was dB transformed power spectrum density (PSD) at electrode Pz and frequency band (8.5 to 12.5Hz) after current source density spatial (CSD) filtering. Feedback was presented on a monitor as a real-time bar feedback using a 2s sliding window, normalized using a session-wise 3min baseline using 1.96 standard deviation of the mean as min and max. Artifacts detected via threshold were presented as a red bar next to the feedback. Preliminary results showed that during the last session 8 participants were above chance and 5 could be considered as “BCI efficient”. After reducing to a subset of 9 channels (3 frontal, 6 parietal), 4 participants were still “efficient”. In the VR study 10 participants were trained across 5 sessions using the reduced 9ch subset. Sponge electrodes connected to a LiveAmp (Brainproducts GmbH), were placed on the parietal area below a HTC Vive pro head mounted display (HMD). In two virtual scenes developed by VTPlus GmbH, participants respectively performed controlled NF via a classical bar feedback projected on a virtual wall, then controlled the upwards flow of a 3m vertical garden fountain, respectively baselined for 1.5 min. Preliminary results indicate less participants above chance level in alpha modulation. Results were more unstable using CSD spatial filters online and offline compared to average parietal PSD recomputed offline.

Discussion: The first study showed that parietal alpha training was achievable for most participants after only a few NF sessions. Despite mixed results in the second study, the fountain NF appear comparable to the bar feedback. The combination of HMD and EEG cap generate noise and artifacts. Using CSD with reduced and noisier channels (sponges) may also have degraded the output PSD. Hence, simply averaging parietal electrodes shows better and more consistent results despite not being trained directly. Finally, participants should have substantially more than 5 training sessions for NF learning to occur.

Significance: Our studies are meant to integrate NF experience in an immersive VR treatment protocol for patients with chronic pain. VR scenarios and quick-setup ergonomic EEG-HMD equipment may be further used for different experimental and therapeutical protocols involving different neurophysiological signals.

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[1] Kober, Silvia Erika, Jürgen Kurzman, and Christa Neuper. 2012. “Cortical Correlate of Spatial Presence in 2D and 3D Interactive Virtual Reality: An EEG Study.” *International Journal of Psychophysiology* 83 (3): 365–74. doi.org/10.1016/j.ijpsycho.2011.12.003.

[2] Baumgartner, Thomas, Lilian Valko, Michaela Esslen, and Lutz Jäncke. 2006. “Neural Correlate of Spatial Presence in an Arousing and Noninteractive Virtual Reality: An EEG and Psychophysiology Study.” *Cyberpsychology and Behavior*. Vol. 9. doi.org/10.1089/cpb.2006.9.30.