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# Single trial classification of the level of presence in VR

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*Introduction:* Virtual reality (VR) relies heavily on the sense of presence - the feeling of being physically present in a virtual environment (VE) [1]. Currently, presence is mainly assessed through subjective questionnaires, which cannot be completed while users experience VR as it would disrupt their immersion [2]. To address this limitation, we propose to explore the feasibility of using electroencephalography (EEG) to monitor users' level of presence and classify it based on the reaction to oddball stimuli.

*Material, Methods:* We immersed 24 participants in a VE using a Head-Mounted Display (HMD). Our participants experienced 2 VR conditions: 1) one where their feeling of presence was regularly disrupted by an abrupt presentation of the real environment in the HMD (i.e. breaks in presence [3]) and 2) an undisrupted one. Meanwhile, an oddball paradigm was played on loudspeakers, i.e., sequences of repetitive sounds, infrequently interrupted by a deviant sound, 20 % of the time [4].

*Results :* To assess the viability of a single-trial classification of presence levels, we used Riemannian geometry to classify the reaction to the oddball stimuli from our 2 conditions. We classified EEG data filtered between 1 and 20Hz, and tested our classifiers using the 5-fold cross validation method.

Channels	Fz Cz Pz	Fz Cz Pz	Fz Cz Pz	Fz FC1 FC2 C3 Cz C4 CP1 CP2 P3 Pz P4 POz	Fz FC1 FC2 C3 Cz C4 CP1 CP2 P3 Pz P4 POz	Fz FC1 FC2 C3 Cz C4 CP1 CP2 P3 Pz P4 POz
Epoch duration	[0, 1]s	[0, 0.5]s	[0.1, 0.4]s	[0, 1]s	[0, 0.5]s	[0.1, 0.4]s
Averaged accuracy	71.7% +-0.18	71.5% +-0.17	67% +- 0.16	80% +- 0.18	76.5% +- 0.17	70% +- 0.17

Figure 1. Accuracies of riemannian classifiers trained on different channels and epochs duration.

As expected from the literature [4], Fig1. shows that channels Fz, Cz and Pz are relevant and allow classification accuracies (between 67 and 72%) above chance level (62%), although using most electrodes produces higher accuracies (70 to 80%).

Also, reducing the epoch duration around the traditional event related potentials used in oddball paradigm (0.1 to 0.4s post stimuli) allows better than random accuracy. However, the bigger the epoch duration, the higher the accuracy, especially when using most channels.

*Discussion:* This study shows presence can be measured using an oddball paradigm. However, future work should investigate new kinds of more ecological oddball stimuli.

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