EXPLORING BRAIN ACTIVITY DURING AWE-INDUCING VIRTUAL REALITY EXPERIENCES: A MULTI-METRIC EEG FREQUENCY ANALYSIS

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Background: Virtual Reality (VR) offers the possibility to evoke awe experiences in controlled environments. Electroencephalography (EEG) is crucial for understanding transient emotional states (Liu et al., 2021). In this context, frequency-domain analysis of EEG signals allows to reveal brain activity characteristics underlying awe experiences.

Aims: This research exploits an innovative experimental setup to recreate awe experiences in controlled nature-based VR scenarios (VRs; Chirico et al., 2018) and investigate the underlying brain activity via EEG recordings. Using linear and nonlinear frequency metrics, Power Spectral Density (PSD) and PS entropy (PSE), this research aims to elucidate frequency-specific EEG responses to three different awe-inducing VRs, with respect to a reference one (not meant to induce awe).

Method: The EEG data, collected from 15 young subjects (5F, 10M, 26.5±4.3 years), were recorded using a 64-channel Geodesic EEG system at rest (baseline) and during the navigation in the VRs. For each EEG dataset, after a standard preprocessing, a 20- second window was extracted (after the maximum awe intensity in the awe-VRs). The brain activity was studied in four frequency bands, theta [4–7.5Hz], alpha [8–12.5Hz], beta [13–31.5Hz], and gamma [32–63.5Hz]. EEG signals were segmented into not overlapping 2-second epochs, and PSD and PSE features were computed for each epoch. For each channel and EEG feature (in the four frequency bands), the nonparametric Friedman test was employed to identify channel-specific significant differences ($p < 0.01$) between pairs of conditions (awe-VRs vs. reference, and reference vs. baseline).

Preliminary results: PSD and PSE captured similar patterns within the comparison reference VRs vs. baseline, mainly showing whole-brain PSD and PSE increases in the alpha band and decreases in the gamma one. Greater differences between the two methods were found in the awe-VRs vs. reference comparison, showing feature changes specific to each awe-VRs. The VR-EEG experimental setup, combined with linear and nonlinear EEG analysis methodologies, enabled us to investigate frequency-specific brain activity underlying diverse awe-inducing experimental conditions. This study allowed us to (i) provide more comprehensive, although preliminary, understanding of the brain activity underlying awe experiences, and (ii) confirm the potential of immersive VR in emotional neuroscience.

Keywords: EEG, Immersive VR, Awe experience

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