

Audio-Visual Entrainment Influence on Postural Dynamics

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ABSTRACT

The influence of multimedia on modern digital users is constantly growing. The paper describes an experimental study of audio-visual (AV) entrainment towards dynamical changes of selected human biometrics. Special wearable equipment of AV stimulation and polyphysiographic postural and brain activities recordings were accomplished for entrainment effect exploration. The obtained results demonstrated evident quantitative changes in both center-of-pressure sway and EEG of the studied subjects after the entrainment session, outlined with time-frequency spectral and multifractal measures. Practical implementation of the study results is directly applicable to the rehabilitation goals and nowadays digital world people stress relaxation, together with working capacity enlargement by multimedia applications.

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1. Introduction

The audio-visual entrainment is a well-known technique for a brain influence and possible locking into the stimulation rhythm dynamics¹. It is also used as a neurofeedback therapy approach that could be qualitatively measured from the brain cortex area².

Two key moments have to be noted for this field of study exploration: (i) the implemented stimulation modality and (ii) the stimulation series dynamics.

Both audio and visual modalities with particular applications from the psychological perspective are dating back to the early EEG studying³.

Different approaches for the time intervals of the stimulation packets variation

(isochronic, monaural or binaural) and spectrum (both audio and visual 'colouring') could be implemented, regarding the desired effect^{1,4}.

Another interesting moment of the entrainment application is the possible correlation of the brain dynamic changes and other biometric characteristics.

Several studies in this hypothesis support are addressing the similarity of fractal properties between signals reflecting brain, heart and motor activities⁵⁻⁸, but quantitative evidences for their possible joint stimulation cumulative effect are still scarce⁹.

Noting the fact that nowadays multimedia users are relying on wearable entertainment devices¹⁰, this could be a quite interesting and valuable applied research direction.

stimulation.

The experiment was organized in three stages: (i) initial measuring of EEG and COP dynamics before the AV-entrainment session, while standing with eyes-open – EO and eyes-closed – EC (two 1 min sessions each condition randomly ordered). A sensory conflict due to the absence of vision was introduced with EC condition (ii) 30 minutes AV entrainment ‘Feeling better: Mood booster -1’ mode alpha 10 Hz to beta 18 Hz; (iii) post-entrainment measuring of EEG and COP dynamics with EO and EC immediately after the AV-entrainment session and 10, 20 and 40 min after the entrainment. The studied healthy experimental subjects were instructed to stand in upright position during (i) and (iii) as quiet as possible.

The AV-entrainment session (ii) was organized in a comfortable sitting position due to its longer duration. Before the experiments all subjects are signing standard informed consent. We applied excluding and including criteria set for psychophysiological studies.

3. Analysis and Results

The recorded EEG and COP signals were processed in Matlab R2011b environment. Initial EEG artifacts and outliers removing were performed with 2SDs accuracy.

Further EEG signal filtering with Butterworth band pass (0.5-80 Hz) and 12 dB/Oct, followed by Chebishev 50 Hz notch – 18 dB/Oct were used for bandwidth limitation and hum suppression. Due to the high sharpness of the filters, an additive 3dB/Oct was stepwise applied.

In order to study the EEG signals two stages were performed: (i) We start with Relative Fourier Power Spectra (RPS) analysis¹⁴ in four different frequency bands: alpha, theta, beta and gamma. This provides a qualitative EEG evaluation by means of the stimulation in mood booster mode and is rather convenient for initial orientation for such complex signals exploration; (ii) a multifractal spectrum (MFS) calculation based on multiscale multifractal analysis for exploring the Hurst surface⁶ ($h(q, s)$ – dependence of the local Hurst exponent h on the multifractal parameter q and the scale of s observations) and understanding the entrainment EEG scaling effect.

The COP anterior/posterior sway dynamics was analyzed by using S-transform time-frequency analysis. We found it enough illustrative for the AV-entrainment and common from other physiological studies¹⁵. Direct observations of the postural sways amplitudes do not produce a clear understanding of the COP dynamics changes, or have any significance for the left-right projection.

The obtained results (see Figure 2) demonstrate a clear contralateral effect (alpha & beta frequency bands stimulated augmentation with 8-12 %) of the AV-entrainment for the EEG spectrum, regarding the central area (C3 & C4 leads) for both EO (normal) and EC (sensory-conflicted) conditions. This is combined with consecutive changes of the EEG multifractal dynamics that clearly is demonstrating a transformation by means of Hurst surface variability diminution. Additionally, the COP anterior/posterior dynamics was also correlated with the EEG changes during the non-sensory conflicted measurement – EO condition. The conflicted one showed the negative effect of the session – “disentrainment” regarding the broader S-transform spectrum of the stance.

The postural anterior-posterior sways amplitudes do not showed COP dynamics changes between series EO and EC as well between before and after series.

4. Discussion

Obviously, the obtained results are outlining both positive and negative effects of the AV-entrainment.

More concrete, the positive effects could be implemented in the rehabilitation area, working capacity augmentation, stress relaxation or different brain and stance disorders treatment.

The negative effects are opening the vast field of application, concerning the modern multimedia influence and the wearable web technologies and services progress, together with the human factor response.

This is also related and to the emotions and behavioural changes in the human lifestyle, which in the digital world could become problematic due to the increased technological impact.

Figure 2: Generalization of the results for: EEG C3 and C4 leads RPS (panel I), MFS (panel II) and COP S-transform dynamics (panel III), before (a) and 10 min after (b) the 30 min AV-entrainment session.

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