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Evaluating Virtual Reality Mood Induction Procedures with Portable EEG Devices

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Abstract. Virtual Environments (VEs) have been used as mood induction procedures. In this context, it is necessary to have instruments to analyze the emotional state during VE exposure. Objective techniques such as EEG should be evaluated for this purpose. The aim in this work was to study the changes in the brain activity with a portable EEG device during a negative mood induction based on a VE. A virtual park was used to induce a negative mood (sadness) in ten participants. Changes in the brain activity of subjects were compared between two moments (before and after emotional induction). Obtained results were in accordance with previous scientific literature regarding frontal EEG asymmetry, which supports the possibility of using the portable EEG as a reliable instrument to measure emotions in VE.

Keywords. EEG, Emotiv Epoc, Negative Mood Induction, Virtual Environment

Introduction

Virtual Environments (VEs) have been used as mood induction procedures (MIPs) in previous emotional studies. The efficacy of Virtual Reality (VR) as a MIP (VR-MIP) has been tested [1], where the results showed that VR was an excellent MIP because subjects felt more presence than in traditional MIPs during the mood induction experience.

As VEs can be used for mood induction, it is necessary to have tools that allow us to evaluate and assess mood changes of subjects during the VR experience. Currently, assessment instruments are based on subjective questionnaires that ask the subjects about the moods they felt. These questionnaires, although they have proved to be very useful, present some limitations. For example, if the questionnaires are used in combination with a VE, they may only be used before and after the experience, but can never be used during the virtual exposure without interrupting it.

Therefore, it is fundamental to have instruments to analyze emotional states while moods are being induced in subjects through VE [2]. Brain activity measures based on electroencephalogram (EEG) can be a good instrument. EEG allows us to measure the

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fluctuations in brain electrical activity associated with emotions in a non-invasive way; with a temporal resolution of milliseconds

EEG is a technique that would be easily combinable with VR-MIPs since it would not impose restrictions with the virtual stimuli that could be presented in a study. Moreover, new portable EEGs devices that are appearing on the market can be easily combined with VEs. The features of EEG measures allow us to overcome questionnaire limitations, thus complementing the information obtained by means of these instruments.

In our present work, a VE was used to induce negative emotions (sadness) in participants while a portable EEG monitored their brain activities. The main goal was to analyze if a portable EEG device was appropriate to evaluate the frontal asymmetry of the EEG [3] in the context of VE studies.

1. Materials and Methods

Ten healthy participants, 5 men and 5 women, were evaluated in this study, all of them right-handed, within the age of 23-27 years old, and with normal or corrected-to-normal vision. The subjects were university students without any psychological disorder; none of which were experts in the use of the technologies used in this study. The participants signed an informed consent allowing their data to be used in this study.

The EEG signal was monitored by means of an EEG portable device, Emotiv EPOC [4], which had 14 EEG channels using the standard 10/20 layout and 2 reference channels (CMS/DRL), Fig.1.

Figure 1. Emotiv EPOC device and Emotiv EPOC electrodes positioning on standard 10/20 layout.

EEG recordings were analyzed off-line using custom software written in MATLAB. This custom software was based on EEGLAB [5] tools, which was applied to clean the EEG-data and analyze changes in alpha-spectral power.

In the experimental session, the participants had to navigate through a VE designed to induce them into a negative mood (sadness) [2]. This VE consisted of a virtual park, already tested in previous studies, and can be used as an effective mood-induction procedure [1]. This virtual park was shown in a retro-projected screen and participants were able to navigate using a wireless pad (Logitech Rumblepad). Some pictures of the VE and the configuration of the experimental session are shown in Fig. 2.

The protocol of this study can be consulted in [2]. Participants spent approximately one hour in the laboratory and a PANAS questionnaire was completed by each; before

and after the virtual experiment. An analysis of these questionnaires allowed us to divide the subjects into two groups; subjects in whom the mood was successfully induced (sad group) and subjects who were not sad after the exposure (non-sad group).

Figure 2. Subject navigating in the VE and capture of the VE used to induce sadness

The navigation period was preceded and followed by rest periods during which participants had to watch a black screen during two minutes and thirty seconds. Between the two rest periods, the virtual mood-induction procedure started, using the same protocol as previously described [1-2]. Finally, the participants were invited to visualize a film to induce them into a positive mood before finishing the experiment.

Natural log Alpha power and asymmetric coefficient value for F3 and F4 were calculated. The asymmetric coefficient values were calculated through natural log of the ratio F4/F3 [3]. F3 and F4 were used because they are the sensors more often used in scientific literature to analyze the valence of the mood experienced by participants.

A three way ANOVA with repeated measures in two of the factors was applied for Natural log Alpha values. The factors were the moment (initial rest and final rest), the hemisphere (left/right) and the group (sad/non-sad). A two way ANOVA with repeated measure in one of the factors was applied for the asymmetric coefficient values. The factors were the moment (initial rest and final rest) and the group (sad/non-sad).

2. Results

In this section, we present the results of our current study. The PANAS questionnaire showed that a sad mood was induced in six participants (sad group) while in four subjects it was not possible to induce a sad emotion with this VE (non-sad group).

Results showed significant differences between right and left hemispheres ($F(1,8)=12.058$; $p=0.008$), a trend close to significance for the interaction factor between hemisphere, moment and group ($F(1,8)=5.267$; $p=0.051$) in the natural log alpha power.

Pair-wise comparisons only showed significant differences between hemispheres in the sad group after the virtual induction ($p=0.014$).

The mean value and standard deviation of each sensor for different moments and groups can be observed in Table 1.

Table 1. Mean and standard deviation of F3 and F4 sensors.

Group	F3 sensor				F4 sensor			
	before		*after*		*before*		*after*	
	Mean	**Std**	**Mean**	**Std**	**Mean**	**Std**	**Mean**	**Std**
Sad	3.368	1.244	1.700	1.116	2.045	1.006	3.765	1.372
Non-Sad	1.723	1.257	1.968	0.901	1.646	0.901	2.417	1.127

On the other hand, the asymmetric coefficient showed a trend for the interaction factor between moment and group ($F(1,8)=5.267$; $p=0.051$). Pair-wise comparisons showed significant differences between the moments before and after the virtual induction ($p=0.014$) for the sad group (Table 2).

Table 2. Mean and standard deviation asymmetric coefficient EEG Frontal.

Group	Asymmetric Coef.			
	before		*after*	
	Mean	**Std**	**Mean**	**Std**
Sad	2.065	1.273	1.137	7.532
Non-Sad	4.485	8.218	5.945	1.078

Figure 3 shows six topographic scalp maps, which give a visual representation about the distribution of averages natural log alpha values around scalp in before induction, after induction and the difference between them.

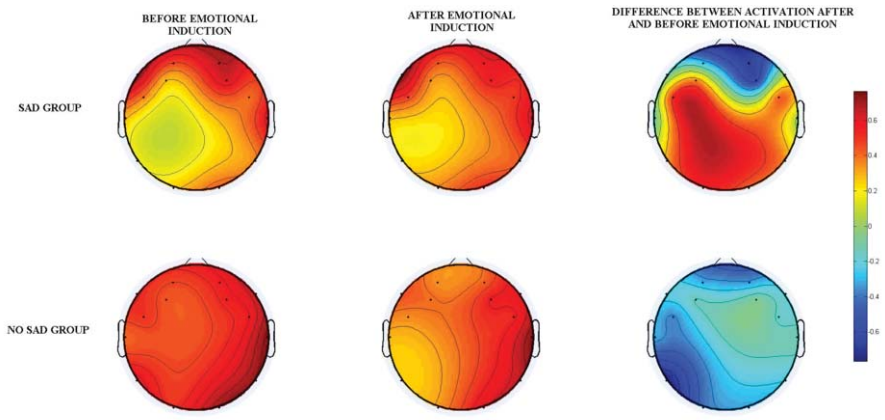

Figure 3. Topographic scalp map of average of natural log alpha values

3. Discussion and Conclusion

The goal of this study was to determine if portable EEG devices would be able to evaluate asymmetric EEG frontal theories in an emotional virtual study.

Statistical results showed greater activation, decrease of alpha power [6], in the right hemisphere after virtual mood induction for the sad group. Furthermore, the asymmetry analysis showed significant differences between the moments before and

after the virtual induction for the sad group. Finally, these results were corroborated with a visual analysis in figure 3, which shows that the activity in the right hemisphere is greater than in the left hemisphere for the group in which the sad emotion was induced to the subjects.

These results showed evidence of the asymmetry in the frontal EEG of the participants after a sad induction, which is coherent with previous results in scientific literature which indicates that the right hemisphere is activated when a subject has been induced a negative mood [3, 6].

This study demonstrates that portable EEG devices can be used as a complementary tool in emotional induction studies with virtual reality, because their flexibility and reliability allow obtaining results about the brain activation of the participants caused by the mood induction with VR-MIPs in a more objective way.

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