Variability of Frontal Alpha Wave in Response to Mood Induction via Visual Stimulus: A Quantitative Electroencephalographic (QEEG) Study

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Abstract

Background: One of the prime areas in psychiatry is concerned with assessing emotions. Assessing physiologic responses can be attained by various approaches, one of which is analyzing EEG.

Objectives: In this study, we aimed to assess Alpha wave in the frontal region after inducing specific emotion by showing evocative video clips.

Methods: After eye open recording at baseline, we showed five video clips that each induced specific emotions from the five major emotions (neutral, happiness, sadness, anger, and fear) to 66 healthy individuals, including 33 males and 33 females aged 20 - 40 years simultaneously. Then, we analyzed their brain waves. Absolute power of Alpha wave band (1, 2, total) in the frontal region (FZ, F4, F3) was analyzed via Wilcoxon test.

Results: With respect to eye open situation, all video clips significantly changed Alpha 2 in F3 and F4 (P < 0.001), but not in Fz except for sadness. The sad clip significantly increased Alpha 2 in Fz and Alpha 1 in F3 and F4 (P < 0.001). Fz had no significant variability in all other emotions.

Conclusions: The most trenchant impact with respect to Alpha band was sadness and the most exclusive finding in FZ was Alpha2. Nonetheless, in two other zones (F3, F4), Alpha1 was exclusive and Alpha2 variability was non-exclusive. It appears plausible that sadness activates neuron groups, which are involved in generating Alpha waves.

Keywords: Adult, Alpha Rhythm, Brain Physiology, Electroencephalography Method, Human, Frontal Lobe Physiology, Emotions Physiology, Young

1. Background

Neuroscientists and scholars favor the variability of the brain waves induced by various emotions or emotional disorders (1). Webster dictionary describes Emotion as a mental reaction experienced by boosted emotion, which is usually linked with specific subject and is accompanied by behavioral/physiological variability (2). Six basic emotions (sadness, anger, fear, happiness, surprise and disgust) that were discussed earlier by Ekman, has led to various studies in this area (1). Different emotions are linked with specific patterns from physiologic responses, and perhaps the causes are rooted in central nervous system (CNS) rather than the external environment (3).

FMRI studies suggest that various regions of the brain such as anterior cingulate cortex (ACC), amygdala and prefrontal cortex (PFC) play a substantial role in assessing emotional stimulus and emotion regulation (4-7). It appears plausible that pathways or specific regions are closely linked with key elements of these emotions, which can be explored by implementing various imaging techniques (6). Understanding and measuring emotional experiences have great importance on emotional assessment, and various approaches have been implemented about psychological assessment of emotion (6).

QEEG is the statistical assessment of EEG, which enables scholars to assess functional imaging of the brain (8). One of the advantages of QEEG, compared to FMRI, is maintaining timing accuracy, low price accessories, and portability (9). QEEG have been used in various areas such as diagnosis of mood disorders, choosing drug and forecasting a prognosis and efficacy of a treatment (10-12).

Some studies have been conducted on assessing emotions via EEG; for instance, categorizing emotions after audiovisual stimulation (8, 9, 13, 14). Assessing the variability of the brain waves under various circumstances such as mood variability due to sleep deprivation is one of the varied studies in this regard (15). Rest EEG is not solely enough for assessing the emotional response capacity of the individuals (16). By inducing emotions in a person and recording the brain function, electrophysiological variability can be determined. One of the methods is providing visual or auditory stimulus and subsequently recording the brain’s functional reaction (14, 17).
In this study with presenting instances of video clips (VC), we aimed to assess the induced variability in the brain waves. One of the gallant features of this study that distinguishes it from other studies in this area is that in this study indigenous videos were used to assess the brain waves’ variability. Furthermore, our study mainly focused on the absolute power of alpha rather than coherence, which have been studied mostly in other studies. Dividing alpha wave into smaller ranges (Alpha 1, Alpha 2) provide more accuracy and efficiency in diagnosis and in therapeutic methods such as neurofeedback (7,13). According to the recent literature, the malfunctioning of alpha can mainly be noticed in the frontal and prefrontal regions in mood disorders such as depressive disorders. Furthermore, assessing alpha wave in other regions (e.g., the temporal region) is under the influence of so many artifacts; hence, it is nearly impossible to assess the role of the alpha wave without considering the influences of other factors. Furthermore, strong evidence suggests that the role of frontal region in emotion regulation is undeniable (7, 14). The results of this study can be useful in clinical settings as well because of the role of impaired emotions in various disorders such as fear in panic disorders, anger in impulse control disorder and sadness in depression.

2. Methods

We used advertising and fliers to recruit our sample. The examinees, who were aged 20 - 40 years, had the minimum educational status of high school diploma. Exclusion criteria were as follows: No history of mental illness in the first and second family members; using drugs (psychotropic drugs in the past six months or other kinds of drugs in the recent month); history of head trauma, stroke, multiple sclerosis, head or brain related surgical operations; scar in the head area; headache; migraine; diabetes; seizure; cardiovascular surgery operation; neck surgery; visual/auditory impairments; history of hypertension; history of substance abuse; obtaining a score of more than 21 on GHQ (3). Finally, a psychiatrist conducted a psychiatric interview and if no problem was noticed in the interview, the individual was included in the study. Eventually, 66 (33 males, 33 females) were selected for this study.

2.1. Inducing Emotions

There was no Farsi Standardized clips with respect to inducing emotions; initially, we selected 25 short clips (with 4 minutes duration) to attain visual elements that induced neutral, sadness, happiness, anger and fear separately without inducing other emotions. Twenty candidates (10 men, 10 women) who met the inclusion criteria of this study were selected as the case group after signing a consent form. Subsequently, in the same setting in which the real test was about to happen, five clips were showed to candidates during five days. After watching the clips, the participants were asked to score the intensity of their experienced emotion (neutral, sadness, happiness, anger and fear) from 0 (minimum) to 10 (maximum). The clip, which maintained the highest mean with respect to target emotion and the lowest mean for other emotions, was considered as an exclusive clip with respect to the target emotion.

- Neutral VC: A four-minute video, which was captured from a fitness training course taught by a trainer and was confirmed after initial assessment (mean = 9.07 and SD = 2.14). The mean and SD of other emotions were as follows: Happiness (mean = 1.34 and SD = 0.94), sadness (mean = 0.00 and SD = 0.00), fear (mean = 0.5 and SD = 0.47), and anger (mean = 0.51 and SD = 0.73).

- Happy VC: A four-minute video was captured from a famous comic Persian sitcom series, which was confirmed after initial assessment (mean = 8.5 and SD = 2.06). The mean and SD of other emotions were as follows: Neutral (mean = 0.49 and SD = 0.47), sadness (mean = 0.00 and SD = 0.00), fear (mean = 0.00 and SD = 0.00), and anger (mean = 0.37 and SD = 0.45).

- Sad VC: A four-minute video was captured from the funeral of a famous Iranian singer and playing his famous musical performance simultaneously, which was confirmed after initial assessment (mean = 9.13 and SD = 2.16). The mean and SD of other emotions were as follows: Happiness (mean = 0.00 and SD = 0.00), neutral (mean = 0.00 and SD = 0.00), fear (mean = 1.53 and SD = 0.89), and anger (mean = 0.69 and SD = 0.80).

- Anger VC: A four-minute video, which had child abusing content was confirmed after initial assessment (mean = 9.44 and SD = 2.29). The mean and SD of other emotions were as follows: Happiness (mean = 0.00 and SD = 0.00), neutral (mean = 0.00 and SD = 0.00), fear (mean = 0.73 and SD = 0.62), and sadness (mean = 2.64 and SD = 1.04).

- Fear VC: A four-minute video was captured from a horror movie named Annabelle (directed by John R.Leonetti and Written by Gary Duberman in 2014), which was confirmed after initial assessment (mean = 8.60 and SD = 2.06). The mean and SD of other emotions were as follows: Happiness (mean = 0.00 and SD = 0.00), neutral (mean = 0.49 and SD = 0.47), and anger (mean = 0.44 and SD = 0.66).

2.2. Experimental Procedures

Firstly, the experiment was explained comprehensively to the participants and then the consent forms were obtained. While the test was conducted, the participants sat at a 30-centimeter distance from the computer desk.
Handedness was controlled among the participants because handedness influences the dominant hemisphere. Brain waves were recorded while the participants were in a relaxing position, with their eyes open and while watching the five inducing clips that evoked five different emotions (neutral, sadness, happiness, anger and fear), each of which lasted for four minutes. The recording procedure was conducted by the assistance of a professional technician in a semi-dark room, with a quiet atmosphere and controlled temperature between 22 - 24° and in the time frame of 05:30 pm to 07:30 pm. The interval between the video clips was five minutes, and we allocated this time to minimize the influence of video clips on each other. For the female participants, the test was conducted in the first monthly cycle and after their menstruation period. We conducted this study in the luteal phase of the menstrual cycle because in the second menstrual cycle there are unfavorable variations in the brain waves due to factors such as premenstrual syndrome and premenstrual dysphoric disorder.

2.3. Gathering QEEG Data

For recording, Mitsar 201 with 21 electrodes via international 10/20 system and electro cap were used. Symbol rate 500 and impedance quality of 5 K ohm were sustained. Low cut filter equal to 0.3, high cut filter equal to 30, and also 45 - 55 Hz filter were used. Initially, recording was conducted while the participants were in a relaxing position, with their eyes open and subsequently while they were exposed to five 4-minute emotional inducing video clips. Data were transferred into Neuroguide software, and visual and motion artifacts were deleted manually and automatically via further revisions. Subsequently, absolute power of waves in the range of 8 - 12 HZ, containing Alpha 1 (8-10HZ), Alpha 2 (10-12HZ) in FZ, F3 and F4 (Prefrontal) regions were assessed.

2.4. Statistical Evaluation

Data were analyzed using SPSS software, and Alpha absolute power (1, 2, Total) was considered as a dependent variable. With the aid of K-S Kolmogorov-Smirnov test and considering the value of P = 0, which is lower than the conventional error (0.05), the Zero hypothesis, which demonstrates the normal distribution of all variables, was rejected with respect to all variables. Furthermore, since the hypothesis of the study was assessing the differences between the two dependent variables, advising about the nonparametric nature of the variables, Wilcoxon test was used to assess the hypothesis of this study, and Alpha 1 and 2, and the absolute power of 66 healthy individuals were assessed in FZ, F3 and F4 regions.

3. Results

Lower frequencies of Alpha were more sensitive to sadness emotion in F3 and F4, but not to other emotions. As frequency elevates, sensitivity to watch video clips will be boosted as well; and consequently, power variations will become meaningful among emotions, but their exclusiveness will decrease in both electrodes.

Sadness emotion maintains the highest impact on the brain waves in Alpha 1 in F3 and F4. Furthermore, FZ electrode is linked more exclusively with this emotion, but in Alpha2 and not Alpha1. Right hemisphere dominancy of absolute power of alpha band and its subgroups were noticed rather than the left hemisphere at rest (EO) in all the participants while watching the five video clips. No significant differences were detected between male and female participants in absolute power before and while watching the clips. Furthermore, no significant difference was found between alpha 1 and 2 in F3 and F4 during emotions induction.

4. Discussion

In this study, we assessed the electroencephalography characteristics induced by evocative video clips in the prefrontal region. Kortelainen and colleagues used 20 clips for induction of different emotions, but they categorized them as pleasant, unpleasant and neutral states to study the arousal level. They found that pleasant clips were related to high frequency activities; however, the temporal region had a high pollution with regards to the activation of temporalis muscle, which is located in the high frequency region (18). It has been demonstrated that while a person is exposed to evocative video clips, environmental effects of attention and inducing emotions are reduced and the video clip maintains its prime impact (14).

In this study, we assessed a wider range of emotions. Bride and Colleagues found no variability in induced alpha wave between 2- and 3-dimensional films (19). In Cops’s study, electrophysiological responses like HRV (heart rate variability) were assessed (20). It has been demonstrated that alpha variability occurs in prefrontal regions in emotional disorders. Hence, we assessed a wider range of emotions, which was similar to Ekman categorizing model. We assessed alpha bands (Alpha 1, Alpha 2) in FZ, F3 and F4 zones of the prefrontal region. However, we did not find any similar study in the literature.

Our results revealed that the neutral video clip with open eyes state did not have a meaningful rise in the prefrontal region and with various frequencies. None of the other emotions demonstrated a meaningful rise with the neutral video clip. However, bilateral Alpha 1 and Alpha in
Table 1. Wilcoxon Test Results on Alpha Absolute Power in Respond to Emotional Inducing Video Clips (VC)

<table>
<thead>
<tr>
<th>Situation</th>
<th>Electrode Bands</th>
<th>F3</th>
<th>F4</th>
<th>FZ</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Alpha 1</td>
<td>Alpha 2</td>
<td>Alpha 1</td>
<td>Alpha 2</td>
</tr>
<tr>
<td>Eyes Open</td>
<td>Mean</td>
<td>3.83</td>
<td>2.93</td>
<td>4.50</td>
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<tr>
<td></td>
<td>SD</td>
<td>2.275</td>
<td>1.518</td>
<td>3.189</td>
</tr>
<tr>
<td></td>
<td>Sig</td>
<td>0.062</td>
<td>0.0000</td>
<td>0.068</td>
</tr>
<tr>
<td>Neutral VC</td>
<td>Mean</td>
<td>4.31</td>
<td>4.12</td>
<td>4.91</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>2.523</td>
<td>2.604</td>
<td>3.070</td>
</tr>
<tr>
<td></td>
<td>Sig</td>
<td>0.072</td>
<td>0.0000</td>
<td>0.216</td>
</tr>
<tr>
<td>Happy VC</td>
<td>Mean</td>
<td>4.41</td>
<td>4.02</td>
<td>4.92</td>
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<tr>
<td></td>
<td>SD</td>
<td>2.318</td>
<td>2.629</td>
<td>2.750</td>
</tr>
<tr>
<td></td>
<td>Sig</td>
<td>0.072</td>
<td>0.0000</td>
<td>0.216</td>
</tr>
<tr>
<td>Sad VC</td>
<td>Mean</td>
<td>5.42</td>
<td>4.72</td>
<td>5.90</td>
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<tr>
<td></td>
<td>SD</td>
<td>3.462</td>
<td>3.602</td>
<td>3.723</td>
</tr>
<tr>
<td></td>
<td>Sig</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Anger VC</td>
<td>Mean</td>
<td>4.52</td>
<td>4.25</td>
<td>4.81</td>
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<tr>
<td></td>
<td>SD</td>
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<td></td>
<td>Sig</td>
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<td>0.000</td>
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<tr>
<td>Fear VC</td>
<td>Mean</td>
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<tr>
<td></td>
<td>SD</td>
<td>3.584</td>
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<td></td>
<td>Sig</td>
<td>0.087</td>
<td>0.000</td>
<td>0.231</td>
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</tbody>
</table>

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the right hemisphere showed no meaningful increase versus eye open condition, except for sad emotion. Furthermore, bilateral Alpha2 showed variability for all emotions.

In other sense, Alpha2 variability is non-exclusive and Alpha1 variability is exclusive, with respect to sad emotion in the right and left prefrontal regions (recorded by F4 and F3 electrodes). Mid frontal region (Fz) maintained the lowest variability rate, and in other words, it was a more exclusive region. In this region, meaningful increase in Alpha2, but not Alpha1, was noticed only for sadness emotion. The meaningful increase while watching the neutral video clip, Alpha1 in F3 and Alpha2 in F4 zones may be due to processing of audiovisual data non-exclusively and not necessarily because of emotions. Additionally, the left hemisphere’s relation to positive emotion was not detected in Alpha band in this study; nevertheless, right frontal Alpha was related to negative emotion as stated by Balconi and ferrari (21). Few studies have been conducted so far with respect to mid frontal Alpha2, but we specifically assessed sadness emotion and Alpha2 in this study.

Unlike the previous studies, we selected video clips precisely to convey the exact needed emotion and we selected these movies with respect to the local sociocultural context. Overall, sad emotion induced most variability in the prefrontal region.

Perhaps the brain’s electrophysiological response to other emotions occurs in other regions and other frequencies; hence, it is vital to conduct other studies with respect to these enquiries.

Limitations of the Study: In this study, we only assessed young individuals, so conducting a study with a broader age range is advised. Secondly, we assessed women in the luteal phase of their menstrual cycle, and it would be more comprehensive if we conduct future studies considering...
the complete menstrual cycle. Finally, we excluded the left-handed individuals in this study; therefore, it is advisable to include them as well future studies.

4.1. Conclusion
Sadness induced by a video clip maintained a significant increase in the absolute power of alpha band, especially in alpha 2 in Fz, and alpha 1 in F3 and F4 regions. Other emotions induced increased Alpha 2 in F3 and F4 nonspecifically. Hence, Fz is a candidate region for investigation about sadness and also depressive disorders.

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Footnotes
Authors’ Contribution: Kolsoom Rajabi and Mani Bahrami Monajemi conceived and designed the evaluation and conducted the whole process of this study; Javad Setareh collected and interpreted the clinical data and drafted the manuscript; Sepehr Setareh and Mani Bahrami Monajemi participated in conducting statistical analyses; All authors read and approved the final manuscript.

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