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ISSN No: 2319-5886

International Journal of Medical Research & Health Sciences, 2018, 7(1): 92-97

Predicting Neuroticism Based on EEG Power Oscillations: Fearful Face as a Mediator Role

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ABSTRACT

The aim of present study was to clarify the relationships between dynamic fearful face and EEG oscillations activities to predict neuroticism in healthy people. The participants included twenty-five undergraduate students (mean age=21.36, SD=23.39) at Ferdowsi University of Mashhad that were selected as volunteers. In order to analyze the data, path analysis was applied in AMOS software. The results showed that the predictive model of neuroticism is fit respect to the mediator role of fear and the criterion role of EEG oscillations. The results revealed that EEG is a fit device for predicting fearful and neuroticism and it can be used for further pathologically researches.

Keywords: Neuroticism, EEG Power, EEG Oscillations, Fearful

INTRODUCTION

Individuals who are high in neuroticism trait experience the states associated with that trait more often and more intensely than individuals low in that trait [1]. DeYoung, et al. revealed that extraversion and neuroticism are the best understood in terms of biology underlying processes [1]. Researchers have shown that neuroticism is associated with negative emotions experiences that are associated by the amygdala, anterior and mid-cingulate cortex, medial prefrontal cortex (PFC), and hippocampus [1,2]. Additionally, in terms of behavioral results, Doty, Japee, Ingvar, and Ungerleider showed that neuroticism tends to recognize fearful and negative emotions [3].

Face processing was considered as a mediator role for predicting neuroticism. Face processing plays a major role in communication and people can infer their social relationships by perceiving people's faces [4,5]. The recognition of identity is based on the perception of aspects of facial structure that are invariant across changes in expression and other movements of the eyes and mouth [6]. Fearful facial expressions serve as cues of danger and potential punishment, and so people will demonstrate stronger inhibition and inhibited response bias in reaction to fear [7]. Researchers are seeking to identify the neural bases of face processing especially fearful, for example, Haxby, Hoffman, and Gobbini showed that the amygdala plays a central role in processing the social relevance of information gleaned from faces [8]. Additionally, Gobbini, and Haxby showed that the amygdala and the insula, structures that are involved in the representation of emotion [9].

However, it needs to clarify neural bases of neuroticism and fearful. In fact, Knyazev, et al., assumed that without a fuller understanding of the neurophysiological and biological significance of EEG activity, the study of EEG-personality relationships is bound to remain phenomenon [10]. In order to investigate neural mechanism of these factors we used EEG. EEG activity is reported in the majority of EEG frequency bands such as delta (δ: 1-3.5 Hz), theta (θ: 4-7.5 Hz), alpha (α: 8-12.5 Hz), beta (β: 13-30 Hz) and gamma (γ: above 30 Hz) [11]. Previous studies examined neural bases of personality and emotional faces separately. Gale inferred that there is a relationship between alpha band and extraversion in level of arousal [12]. Moreover, Gray's theory of personality predicts links between physiology and personality dimensions in the context of neurological systems [13]. Heller's model also revealed that all affects represented in the circumplex model of emotion are related to specific patterns of brain activity and therefore according to this framework we can predict the two big [13]. To support these models have done researches, for example, Schmidt, and Trainor showed that there are relationships between greater relative left frontal EEG activity and happy musical excerpts and greater relative right frontal EEG activity and fear and sad musical excerpts [14].

On the other hand, as regard to neuroticism factor, Schmidtke, and Heller showed that neuroticism is associated with greater relative right posterior activity, though predicted effects for neuroticism with frontal regions with brain activity was not significant [13]. However, Coleman, Barry, Karamacoska and Wilson showed that there is no significant relationship between neuroticism and intrinsic cortical activity [15]. It seems that there are incongruent studies for showing the relationships between cortical activity, emotional faces, and neuroticism. As regard to our aim, Gale, Edwards, Morris, Moore, and Forrester investigated EEG activity, neuroticism, and mood experience. They showed that positive and negative facial expressions are differentiated in frontal leads, with greater activation of the left hemisphere during negative mood experience, moreover. neuroticism is associated with greater inter-hemispheric differences in voltage [16]. However, the applicability of resting-state condition of brain activity in examining neuroticism, particularly with regard to EEG oscillations and emotions, remains a controversial issue that requires re-evaluation.

By considering research literature and lack of studies in examining the links between dynamic fearful face, neuroticism and EEG oscillations activities, the aim of present study was to clarify the relationships between dynamic fear face processing and EEG oscillations activities to predict neuroticism in healthy people.

PATIENTS AND METHODS

We used path analysis method for examining the hypotheses. The participants included twenty-five undergraduate students (mean age=21.36, SD=23.39) at Ferdowsi university of Mashhad that were selected as volunteers. All participants were right-handed and had normal or corrected-to-normal visual acuity. After completing consent letter, participants filled the big five model of personality trait and dynamic facial expression task and then entered the EEG session. This study was approved by the ethics committee of department of psychology, Ferdowsi University of Mashhad.

NEO-PI-R (Revised NEO Personality Inventory)

We used the self-report version of the Revised NEO Personality Inventory (NEO-PI-R; Costa & McCrae, 1992) to measure extraversion and neuroticism factors. The questionnaire has 60 questions with Likert point answer shit. Cronbach's alphas for the Big Five scales were high-Neuroticism: 0.92; Extraversion: 0.87; Openness: 0.89; Agreeableness: 0.91; Conscientiousness: 0.91 [1,17]. Persian version of NEO-PI-R was used.

Dynamic Face Recognition Task

In this task there are two aspects of facial expressions. First, basic emotions like anger, disgust, fear, happiness, sadness, and surprise. Second, complex emotions like contempt, embarrassment, and pride. Each of the emotions was expressed by 12 encoders; 7 males and 5 females. For each of the 120 videos from the Northern European set (12 encoders × 10 expressions) three new videos displaying three different stages of expression: low, high, and intermediate were created by extracting consecutive frame sequences starting with a neutral frame (i.e., blank stare). From the neutral expression videos, three different sequences were extracted as well to obtain an equal number of videos per category. Additionally, 10 videos were created for one encoder from the Mediterranean set of the ADFES to be used as an example display of each emotional expression included in the set. This led to a total of 370 videos. The length of each of the videos was set to 26 frames with a frame rate of 25/sec, consistent with the original ADFES [18]. For answering to the dynamic faces, we designed a five-point Likert; 0 to 4 (0 and 1 refer to negative valences, 2 refers to natural valence and 3 and 4 refer to positive valances). The task was made in psychopy in python software. In order to reach the research goal, we used fearful state.

EEG (Electroencephalography)

In order to record brain activity, Mitsar EEG-201 (Mitsar Co. Ltd. Saint Petersburg, Russia) was used. The device includes 19 main electrodes (Fp1, Fp2, F3, F4, F7, F8, Fz, C3, C4, Cz, P3, P4, Pz, T3, T4, T7, T8, O1, O2), two reference electrodes (A1 and A2) and a ground electrode (Fpz) according to the 10-20 system of electrode placement. The data were collected using a sampling rate of 250 Hz and filtered in WINEEG software with a frequency band 1 to 100 Hz. Linked Ear references were used with all EEG. Electrolytic gel was applied, and each site gently abraded until impedances were below 10 kΩ. Eye-closed and eye open conditions were used for recording signals that were 3 minutes each in duration. During eye-closed condition, we requested the participants to place their hands on the knees, half-open their mouths, and avoid blinking and opening the eyes; and during eyes open condition we requested them to additionally fixate a central point.

After recording the signals, the data were saved as EDF+ format in WINEEG and opened in Neuroguide software. Artifact-free epochs of 250 samples were extracted through Neuroguide software and submitted to Fast Fourier Transform (FFT) and the artifacts were rejected by automatic rejection. As regard to the aims of the study, the frequency bands were for delta (1-3.5 Hz), theta (4-7.5 Hz), alpha (8-12.5 Hz) and beta activity (13-25 Hz) and we used absolute power (µV2).

Statistical Analysis

After collecting the information, the data were entered in AMOS. In order to analyze the data, we used descriptive statistic and inferential statistic (path analysis).

RESULTS

The fitness of the proposed model was studied based on Chi square, CFI adaptive fitness index, GFI fitness index, GFI modulated fitness index and root mean square error of RMSEA approximation. In order to fit the pattern, it is essential that the above indicators have the required standards. If the index $\chi 2$/df is smaller than 2, the RSMEA value is smaller and closer to zero, and also the fitting indices (GFI, AGFI, and CFI) are closer than or equal to 1, indicating that the proposed pattern has been verified.

Table 1 Summary of path analysis mode

X^2	Df	X^2/df	GFI	AGFI	CFI	RMSEA
4.9`	6	0.816	0.94	0.791	1.00	0.0001

As shown in Table 1, according to the presented indicators, the predictive model of neuroticism is favorable with respect to the mediator role of fear and the criterion role of EEG oscillations.

Table 2 Effects of EEG activity and fearful face on neuroticism

Variable	Direct effect	Indirect effect	Total effect
Delta on fearful face	0.197	-	0.197
Theta on fearful face	-0.026	-	-0.026
Alpha on fearful face	-0.285	-	-0.285
Beta on fearful face	0.022	-	0.022
Fearful face on neuroticism	0.286	0.00	0.286
Delta on neuroticism	0.433	0.056	0.489
Theta on neuroticism	0.175	-0.008	0.167
Alpha on neuroticism	0.628	-0.081	0.546
Beta on neuroticism	0.192	0.006	0.198

Table 2 shows the direct, indirect, and total effects of EEG oscillations, neuroticism and fear. As seen, delta, theta, alpha and beta had a direct impact on fear of 19, -2, -28, and 2, respectively. Fear also could have a 28 percent impact on neuroticism. In addition to fearful, the Delta, Theta, Alpha and Beta bands could have 43, 17, 62, and 19 percent direct impact on neuroticism. But on the other hand, by considering the total effects, delta, theta, alpha and beta, 48%, 16%, 54% and 19%, respectively, could have significant effect on neuroticism according to fearful. The final model is visible in Figure 1.

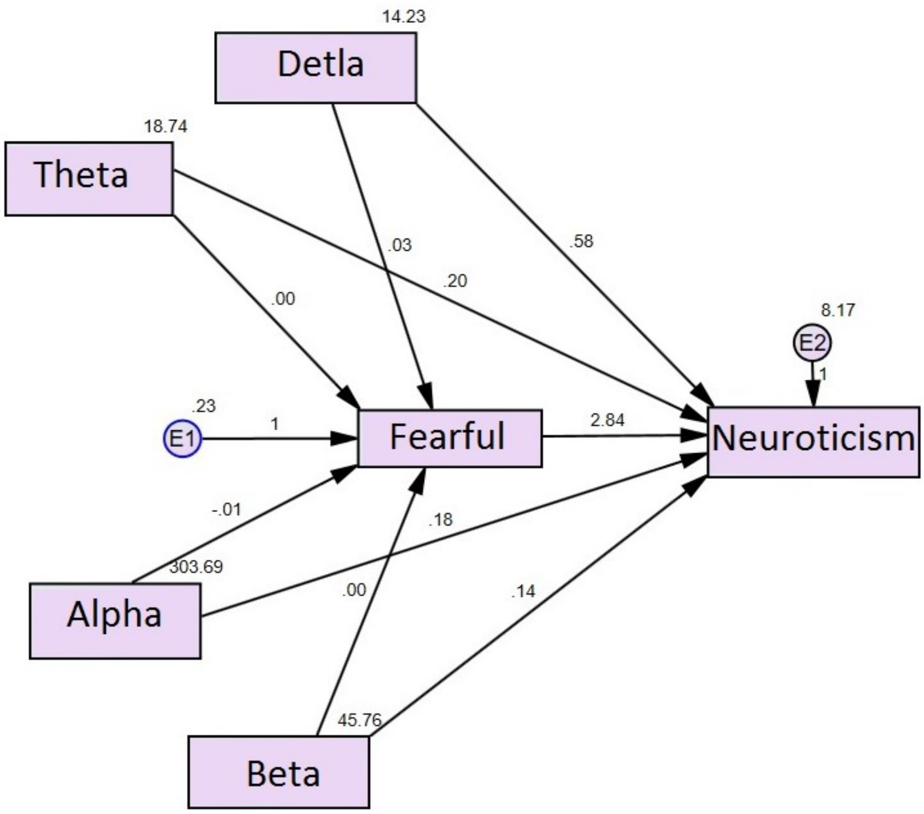

Figure 1 Path analysis model for predicting neuroticism

DISCUSSION

The purpose of present study was to examine the relationships between EEG oscillations and neuroticism considering the mediator role of fearful face. Path analysis was applied for examining the hypothesis. The results showed that alpha and delta are the fit predictors for neuroticism. Moreover, fearful could predict neuroticism; also, delta and alpha could predict neuroticism considering the mediator role of fearful. To sum up, the predictive model of neuroticism is favorable respect to the mediator role of fear and the criterion role of EEG oscillations. Though previous studies have done the same research, have paid attention to emotions as an area in brain or triggered an emotion stimulus and examined even related-potential (ERP) [13,19]. However, it seems that it is the first research that was considered resting-state brain activity, neuroticism and fearful.

Allen and Coan indicated that emotion can be examined as a mediator role. It is believed that at first the stimuli are triggered and after that a response evoked. In this research, emotion was considered as a behavioral response factor [20]; therefore, emotion variable was as a mediator variable in relation to personality and brain activity. Obviously, infants have basic emotions such as angry, fearful and sadness and their personality trait have not been shaped. biologically and environmentally, infants acquire personality traits during their development. To support the assume, De Young believed that it is important when either genes or situations have lasting effects on traits, they must do so by changing the brain; thus, personality differences are biological regardless of their heritability, in the sense that they must be proximally generated by the brain no matter whether they originated in genes or environment [1]. Therefore, based on previous studies, we considered brain as an independent variable, emotions as a mediator variable and personality as a dependent variable.

The findings revealed that delta and alpha band influence on fearful as well as neuroticism. It seems delta and alpha are common variable for neuroticism and fearful. Robinson showed that there is a negative relationship between alpha and delta band [21]. Robinson believed that delta plays a key role for brain stem and inhibitory system and alpha plays a major role for thalamocortical system [22]. The main evidence supporting this view is that direct stimulation of the brainstem ascending reticular activating system produces a low frequency cortical response in the 0-4 Hz range, whereas the frequency of cortical waves produced by stimulation of the diffuse thalamic projection system is of the order of 10 Hz [23]. Knyazev showed that there are relationships between delta oscillations with reward motivation and alpha with anxiety [24]. Enoch, et al. showed that a heritable EEG trait, the low voltage alpha, is associated with psychiatric disorders such as anxiety [25]. It is inferred that the pattern of cortical activity in individuals with a high-level of neuroticism is a risk factor for anxiety disorders.

CONCLUSION

In conclusion, considering the results, we believe that EEG is a useful device for predicting neuroticism as a personality trait and it can be used as a personality neuroscience method in order to clarify and classify emotions and personality traits. Future research is necessary to clarify EEG features of personality and emotions. Ideally, we recommend investigating the links between the big five model and EEG activity considering basic emotions for clearing these relationships.

DECLARATIONS

Conflict of Interest

The authors and planners have disclosed no potential conflicts of interest, financial or otherwise.

Acknowledgement

The article was extracted from MA thesis in General Psychology at Ferdowsi University of Mashhad.

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