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The Relation Between Affective Style Based on EEG Asymmetry and Personality on Stress

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Abstract

This study investigates the relationship of affective style based on EEG asymmetry, personality, and psychological stress on stress. The experiment consists of three sessions: rest state, landscape scene, and horror film tasks. We used a short horror film to evoke stress. We classified affective style of the individual based on EEG alpha asymmetry: negative bias, positive bias and general. The participants in the negative bias group reported higher levels of stress on the neuroticism of the Big 5 model and Cohen's Perceived Stress Scale. These results demonstrate that participants with the propensity for negative affective style have a nervous temperament and are apt to be stressed.

Key words : frontal EEG asymmetry, affective style, stress

I. INTRODUCTION

Stress always exists in everyday life and affects various fields such as happiness, health, and cognition. Many studies have been made to uncover the neuroendocrine and molecular processes mediating the cascade of reactions to a stressor[1,2]. Also, there have been studies on the central mechanism and neural correlates of psychological stress[3,4]. Indications of the fight-or-flight response under threatening situations suggest that the brain's response to stress may involve excitation of the emotion and vigilance systems. Although most stress today is due to psychosocial factors and is not threatening, this brain-activation pattern may still take place during tasks such as tests and impromptu speech[5]. Studies on brain activity patterns under stressful environments have considered stresses such as word, examination, noise, and mental tasks[6-9].

A major aspect of neurophysiological research on emotion is hemispheric specialization of emotion. These studies show that the left hemisphere is more involved in the processing of positive emotions and approach-related behaviors, whereas the right hemisphere is more involved in the processing of negative emotions and withdrawal behaviors[10,11]. The model also suggests that the frontal cortex particularly plays a key role in emotional processing. Abundant evidence supports this model, from prefrontal ElectroEncephaloGram (EEG) alpha asymmetry studies. These studies show that positive moods or reactions predict relatively greater Left preFrontal Activity (LFA), whereas, negative moods or reactions predict relatively greater Right preFrontal Activity (RFA)[12].

Recent neuroimaging studies suggest that negative affect generally elicits activation in the right prefrontal cortex, amygdala, and insula, whereas the left prefrontal cortex is associated with positive emotion[13]. The right prefrontal and cortex may be critical in the brain's response to stress, since this brain area is a primary part of both the emotion and vigilance networks. Some studies suggest that high levels of right-sided prefrontal activation have been associated with negative affective style and weakened immune function. Specifically, Davidson suggests that individual difference in asymmetric prefrontal activity indicated individual differences in affective style[14,15]. This brain area may acts as a mediator of the relationship between psychosocial stress and its effects on mental and physical health[1,2,16,17].

EEG-based personality studies have attempted to link various personality concepts with physiological measures, particularly the features of EEG activity. Eysenck claims that individual differences in cerebral arousal cause differences in personality based on scales of neuroticism and introversion-extraversion[18]. Robinson ascertained correlations between

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the individual peak amplitudes of the averaged evoked potential (AEP) components and scores on personality[19]. The Big 5 model is a purely descriptive model of personality. The neuroticism factor is the propensity to experience negative emotions, such as anger, anxiety, or depression. Neuroticism and stress are both associated with negative affects[20,21]. When people high in neuroticism are in critical stressful condition, they tend to experience them as more evasive and respond with higher levels of negative affect than those without this trait[22,23].

This study investigates the relation among personality, psychological, and EEG effects of emotions associated with stress. Many studies evaluate the stress state in stress disorder, psychological stress, and heart rate variability[24-26]. Recent studies have highlighted the role of right-sided prefrontal activation during stress[27]. Few studies consider affective style for normal stress response under natural stress. As yet, no study has been performed on the personality and psychological stress based on EEG asymmetry during stress.

Some may perceive the same sound stimulus as noise, whereas, others may not. The reception of stimulus is influenced by two kinds of cognitive characteristics; current transient influences and enduring individual qualities[28]. Stress was empirically related to the region of right prefrontal cortex[29]. For this reason, we assumed that there is an individual affective style for rest state and the stimuli inducing negative emotion results in a relatively greater RFA than that of the stimuli inducing positive emotion, especially in negative bias group. We tried to understand the relationship between the affective style according to stimuli and RFA. For that purpose, the natural log alpha relative power values of electrodes at Fp1, Fp2, F3, and F4 were calculated and alpha asymmetry was obtained in the Fp2/Fp1 and F4/F3 sites. We analyzed that this result correlates to individual's difference of stress response as usual. Also, we use a horror film stimulus to evoke naturalistic stress and compare individual's difference with the neuroticism factor and PSS. These results should reveal the relationship of an individual's affective style based on EEG asymmetry, personality, and psychological stress under a natural-like stress. It is predicted that the negative bias group will have relatively greater RFA than other groups. The negative bias group will exhibit greater neuroticism and Cohen's Perceived Stress Scale (PSS)[25] than other groups.

II. MATERIALS AND METHODS

A. Participants

36 healthy, right-handed volunteers participated in the experiment. They were all students or graduate students of Pusan national university. 7 females and 29 males aged between 20 and 30 years participated in the study. All participants had normal auditory function; none had neurological disorders. All participants gave written informed consent to completing the questionnaires and the psychophysiological protocols.

B. Procedures & EEG recording

In the first session, participants completed the Korean version of Goldberg's Big 5[30] and PSS.

Cohen's PSS consists of 14 items and assesses the frequency of feelings of anxiety regarding certain potentially stressful events. We usually analyze the neuroticism factor, because persons high in neuroticism report larger numbers of stressful events in their lives. The EEG recording procedure then followed. EEG was recorded under three different conditions (rest, landscape film, and horror film) to induce different levels of stress. We used a short horror film to induce negative emotion as stressors, and the landscape scene to induce positive emotion. The rest state lasted for five minutes with eyes closed and the movie stimuli lasted for three minutes.

We used four positions; Fp1, Fp2, F3, and F4; based on the Modified Combinatorial Nomenclature (MCN) system. These positions are chosen, in many studies on FA (Frontal Asymmetry), to detect prefrontal activity[31,32]. We usually analyzed frontal EEG alpha asymmetry at the F3, F4, Fp1, and Fp2 positions. The EEG measuring device used was QEEG-4 (LXE1104-RS232, 4Channels) developed by LAXTHA Inc. EEG was recorded using Ag-AgCl disc electrodes placed in four positions. EEG recordings from the left earlobe (A1) and back of the neck (Iz) were used to obtain the reference and ground potential, respectively. The sample rate of the EEG acquisition device was 256Hz, and the resolution of the A/D converter was 12 bits. Also, electrode impedance was kept below 5kΩ. The EEG measurement software system recorded the EEG value of participants, emitting the auditory stimulus at defined times.

C. EEG Analysis

The general analysis for the measured data was done by Complexity v2.8, software used exclusively for EEG analysis, provided by LAXTHA Inc. All EEG recordings were filtered using band-pass FFT filtering of 4 to 30Hz, to eliminate the influence of artifacts in the theta (4-8Hz), alpha (8-13Hz), and beta (13-30Hz) response components. Ocular artifacts were removed using a PCA-based procedure by Complexity v2.8.

Asymmetry scores represented the difference between log alpha density in the right hemisphere electrodes of interest,

and log alpha density in the left hemisphere electrodes of interest [33].

Right and Left means right or left alpha (8~13Hz) relative power. The difference score provides an index representing the relative activity of the right and left hemispheres. Higher scores indicate relatively greater left frontal activity. Alpha asymmetry results in lower scores in greater right frontal activity, assuming that alpha power is inversely related to activity. We performed alpha band to all band power spectrum analysis for stimuli, then, calculated frontal alpha asymmetry in the Fp1/2 and F3/4 sites.

D. Statistical analysis

To detect individual's affective style for rest state, we performed statistical analysis on EEG alpha asymmetry using k-means cluster analysis. The significant differences of rest state asymmetry among groups were examined by using Krusal-Wallis test. Also, the significant differences of stimuli type (landscape scene, and horror film) among groups were examined by using Krusal-Wallis test. All statistical analyses were performed using the statistical software package SPSS PC (version 12.0). Results were considered as significant at the level of $p<0.05$.

III. RESULTS

A. Alpha asymmetry and affective style

To detect individual's affective style for rest state, we performed statistical analysis on EEG alpha asymmetry at Fp1, Fp2, F3, and F4 sites. However, there was no significant difference at Fp1 and Fp2 sites. The subjects were divided into negative bias, positive bias and general group using k-means cluster analysis. There was significant difference among three groups, F=69.697, p=0.000, in the asymmetry of rest state at F3 and F4 sites. We repeated k-means cluster analysis varying k from 2 to 10 in order to determine initial cluster k. In the case of k=2, ANOVA showed F=50.712, p=0.000. The more k increased, the more F increased. Krusal-Wallis test revealed good results in difference of average between groups according to the type of stimulus when the number of initial group was 3. Thus, we determined initial cluster k to 3. We assign affective style to each group. Negative bias group has the lowest value of final clustering center by k-means cluster analysis and positive bias group has the highest value of final clustering center. The significant differences of rest state asymmetry among groups were examined by using Krusal-Wallis test. The result of Krusal-Wallis test did show statistically significant difference, $\chi^2=21.432$, p=0.000 in rest state asymmetry.

B. An individual's affective style of stressor

We performed Krusal-Wallis test to determine whether some detectable difference between groups according to the type of stimulus. There was no significant difference in alpha symmetry of landscape film ($\chi^2=4.501$, p=0.105). We analyzed that landscape film couldn't evoke the positive emotion. However, there was significant difference in alpha symmetry of horror film ($\chi^2=8.665$, p=0.013). The average alpha asymmetry in the negative bias group was lower than that of other groups in the horror film session. The average alpha asymmetry in the general group was lower than that of the positive bias group. These results indicated that the negative bias group was related to greater RFA compared to other groups. The negative bias group revealed a significant effect with greater right-sided activation at frontal sites. The alpha asymmetry under a stressful environment is influenced by affective style. The affective style acts as a major factor in stress response. Table 1 indicates the mean alpha asymmetry according to affective style at F3 and F4 sites. As is clear from Table 1, the mean alpha asymmetry in the negative bias group is lower than that of other groups and the average alpha asymmetry in the positive bias group is the highest among groups for both sessions.

C. Affective style, Personality, and psychological stress

Stress response varies with each individual person. Thus,

Table 1. EEG ALPHA ASYMMETRY BASED ON AFFECTIVE STYLE. Negative bias group shows greater right activity on negative stimulus than other groups.

Affective style	Alpha asymmetry of landscape film				Alpha asymmetry of horror film			
	Avg.	Std.	χ^2	p	Avg.	Std.	χ^2	p
Negative bias(N=5)	0.027	0.129	4.501	0.105	0.035	0.116	8.665	0.013
Positive bias(N=5)	0.180	0.126			0.207	0.081		
General(N=26)	0.042	0.112			0.076	0.090		

we hypothesized that the affective style is relative to personality and psychological stress. Specifically, we focused on neuroticism as personality factor relative to stress and evaluate psychological stress index. We assumed that the participants in the negative bias group may well have higher neuroticism and PSS than that of other groups. We performed Pearson's coefficient of correlation to detect relationship among alpha asymmetry, neuroticism and PSS. There was significant difference in neuroticism (Pearson's $r = -0.385$, $p = 0.042$) and not in PSS (Pearson's $r = -0.080$, $p = 0.641$). This result means that the more neuroticism increases, the more alpha asymmetry decreases (right activation). Also, we performed Krusal-Wallis test to determine whether some detectable difference between groups according to neuroticism and PSS. Table 2 shows the average of neuroticism, and PSS according to affective style. Although PSS didn't show significant correlation with alpha asymmetry, this result indicated that the average neuroticism and PSS in the negative bias group was the highest compared to other groups. Participants in the positive bias group were the lowest in neuroticism and PSS relatively to other groups. This implied that participants in the negative bias group were more sensitive to stress than those of other groups. It indicates that the affective style based on EEG alpha asymmetry was associated with personality and psychological stress.

D. Discussion

Three major results were found in the study. First, the individual's difference on EEG alpha asymmetry existed. Participants in the negative bias group demonstrated relatively greater RFA than other groups during the rest state session. Second, negative bias group demonstrated relatively lower scores than that of other groups during the horror film session. It means that negative bias group shows greater right frontal activity than other groups during the horror film session. Third, there was a relationship between the individual's affective style and an increase in reports of psychological stress and neuroticism.

The finding of the individual difference is consistent with the prior literature[15]. Numerous studies demonstrated that individual differences in electrophysiological measures of prefrontal activation asymmetry reveal some aspect of vulnerability to positive and negative emotion inducers [34]. Specifically, Davidson suggested that those individuals with more left-sided prefrontal activation at the baseline reported more positive respond to the positive film and those with more right-sided prefrontal activation reported more negative respond to the negative film[13]. The EEG enabled the relationship between brain arousal and personality dimensions to be tested. Studies of the relationship between EEG frequency bands and personality measures have been studied extensively [19,35,36,37]. Davidson presented the relationship between EEG measures of asymmetry and the score on the Behavioral Activation and Behavioral Inhibition Scales (BIS/BAS scales)[13,38]. In this sense, we investigated the relation between individual difference on frontal EEG asymmetry and personality along with previous studies. We assumed that individual difference is caused by individual temperament. This study classified individual affective style into three groups: negative bias, positive bias, general. Participants in the negative bias group demonstrated greater RFA than did other groups during stressful conditions (horror film). Also, the number of subjects included each group showed a great difference. EEG alpha asymmetry at rest state reflects somewhat the characteristics of individual such as stress and depression. Therefore, the number of subjects included each group appears that it is related to characteristics of participants. Specially, compared to general group, the number of subject in the negative bias group was small amount. We analyzed because participants were young, healthy and less stressful students. From this result we could deduce that participants in the negative bias group are apt to be stressed and may well suffer chronic stress. Although the present study presents the relationship between an individual's affective style and frontal alpha asymmetry with respect to stressor, the relationship underlying this association remains obscure. Specifically, we didn't reveal the relation between the change in frontal EEG asymmetry and the change in hormonal stress measure. Future

Table 2. NEUROTICISM AND PSS BASED ON AFFECTIVE STYLE. Negative bias group shows the higher neuroticism value than other groups.

Affective style	Neuroticism			PSS		
	Avg.	χ^2	p	Avg.	χ^2	p
Negative bias(N=5)	28.4	6.634	0.036	23.8	2.439	0.295
Positive bias(N=5)	20.2			21.8		
General(N=26)	26.44			23.6		

studies are needed to investigate these relationships. Nevertheless, this study suggests that the EEG is able to reflect personality as well as psychological stress under stressful conditions. It indicates that EEG alpha asymmetry could be a factor in stress diagnosis.

In conclusion, our study demonstrated that there was individual difference in frontal EEG asymmetry. This variation in frontal EEG alpha asymmetry was associated with an individual's affective style not stimulus type. An individual's affective style affects frontal EEG alpha asymmetry with respect to stress response. Negatively-prone people indicate higher psychological stress and neuroticism. Such men have a nervous temperament and are apt to be stressed. The present findings have an interesting implication for understanding the relationship among psychological stress, EEG alpha asymmetry, and personality relative to stress. Along with confirming the results of previous studies, the present results extend these findings to include the individual's difference of frontal EEG asymmetry and the personality field on stress.

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