EEG WAVEFORMS COMPARISON DURING RECALLING TRAUMATIC EVENTS SESSION IN POST-FLOOD DISASTER VICTIMS FROM SUBANG REGENCY

Shofa Syahidah[1], Lulu Lusianti Fitri*[2], Shanty Rahayu Kusumawardani[3]

[1,2]Biology Department, School of Life Sciences and Technology, Bandung Institute of Technology, Bandung, INDONESIA.
[3]Department of Applied Chemistry and Life Science, Toyohashi University of Technology, Toyohashi, Aichi, JAPAN
(E-mail: lfitri65@gmail.com)

ABSTRACT

Indonesia, as a tropical country, frequently experiences natural disasters such as earthquakes, tsunamis, and floods, which often lead to emotional, social, and economic repercussions. Prolonged exposure to trauma can result in mental health issues like stress-related disorders, depression, and PTSD, characterized by symptoms such as re-experiencing, avoidance, and hypervigilance. These conditions may alter brain activity, impacting areas like the prefrontal cortex and hippocampus, thereby impairing emotion regulation, memory, and decision-making. This study investigates brainwave patterns among severe flood victims in Subang Regency, Indonesia, using EEG during baseline and trauma-recalling sessions. Analysis focused on interphase, sex differences, interhemisphere dynamics, and correlations to identify connections with brain physiological activity. Findings reveal chronic stress reactions leading to PTSD symptoms, evidenced by decreased brainwave activity during stimuli and weakened synchronization in AF and TP regions, suggesting impaired information processing due to trauma. These insights may inform future neurofeedback studies in trauma recovery.

Keywords: Chronic Stress, EEG, Recalling, PTSD, Waveforms

INTRODUCTION

Indonesia is one of the tropical countries that is frequently hit by natural disasters, such as earthquakes, tsunamis, and floods. Disasters may induce emotional reactions at community scale, as well as direct social and economic repercussions. As a result, experiencing direct disaster may lead communities to face emotional, behavioral, and cognitive reactions as the mental health repercussions of trauma, such as stress-related disorders [1]. Stress can be described as the perception of personal or environmental stimuli as being more exhausting than the body's immediate mitigation capabilities, resulting in an acute stress reaction in the body [2]. These conditions may lead to several mood disorders, including depression

and post-traumatic stress disorder (PTSD) which is characterized by symptoms of re-experiencing, avoidance, and hypervigilance [3, 4, 5].

Prolonged stress and PTSD can impact brain activity by changing the brain circuitry that interprets information to trauma-related memories, thoughts, and emotions in addition to impaired prefrontal emotion regulation, decision-making, working memory, and attention modulation [6, 7]. It can also cause alterations in the hippocampus, a region that has long been linked to declarative memory and learning. These alterations can impair individual capacity to focus and recall knowledge, as well as raise one's risk of mental and physical health problems [7]. It is envisaged that the value of knowledge on the peculiarities of physiological changes in the brain of people who have experienced long-term trauma and PTSD would aid researchers in future neurofeedback studies in the context of trauma healing efforts.

EEG is one of the most frequent devices of information for researchers investigating brain activity [8]. EEG offers a flexibility administration technique that measuring activation of pyramidal neurons within the cortex that generates electrical impulses on the scalp [6]. Amount of electrode channels used in EEG may vary, though it still follows the international standard 10-20. For example, the Muse EEG contains four main channel locations: temporoparietal (TP9 and TP10) and anterofrontal (AF7 and AF8), and fifth frontal electrode (Fpz) as a reference [9]. For analyzing EEG data, many studies have used frequency-domain features by examining power spectral density (PSD) in order to determine the power distribution for a time-domain EEG signal throughout a frequency range, which gives important information regarding brain activity [5]. PSD can be measured by normalizing the total power (μV2) results of each waveform, including delta (0.5–4 Hz), theta (4–8 Hz), alpha (8–13 Hz), beta (14–30 Hz) and gamma (30–50 Hz) [5, 9]. These brain rhythms provide information about mental stress and other psychiatric diseases [5].

This study aimed to determine brain waveform patterns of the most severe victims from the flood disaster in Subang Regency in 2021 by means of EEG through interview sessions divided by baseline (BL) and recalling traumatic event session (RS) phase. In this study, we used interphase, sex difference, interhemisphere, and correlation analysis as the determining aspects for finding any interesting pattern and their connection with brain physiological activities.

MAIN RESULTS

Interphase Analysis Results

The acquisition of spectral power data from EEG waveforms based on phase differences can be seen further in Figure 1. A significant decrease in delta power was observed in channel TP9 (Sig. < 0.05) as well as a decrease in alpha and beta power in bilateral TP (Sig. < 0.01). A significant decrease in delta power may caused by lack of cognitive functioning [6] as a result of chronic fatigue in reduced sleep depth [10]. In addition, decreased bilateral alpha and beta power in temporoparietal area can be implied as a lower attentional ability during recalling session. These conditions also occur in patients who are affected by post-traumatic stress disorder and anxiety disorder which turned brain into alert state [7, 11, 12].

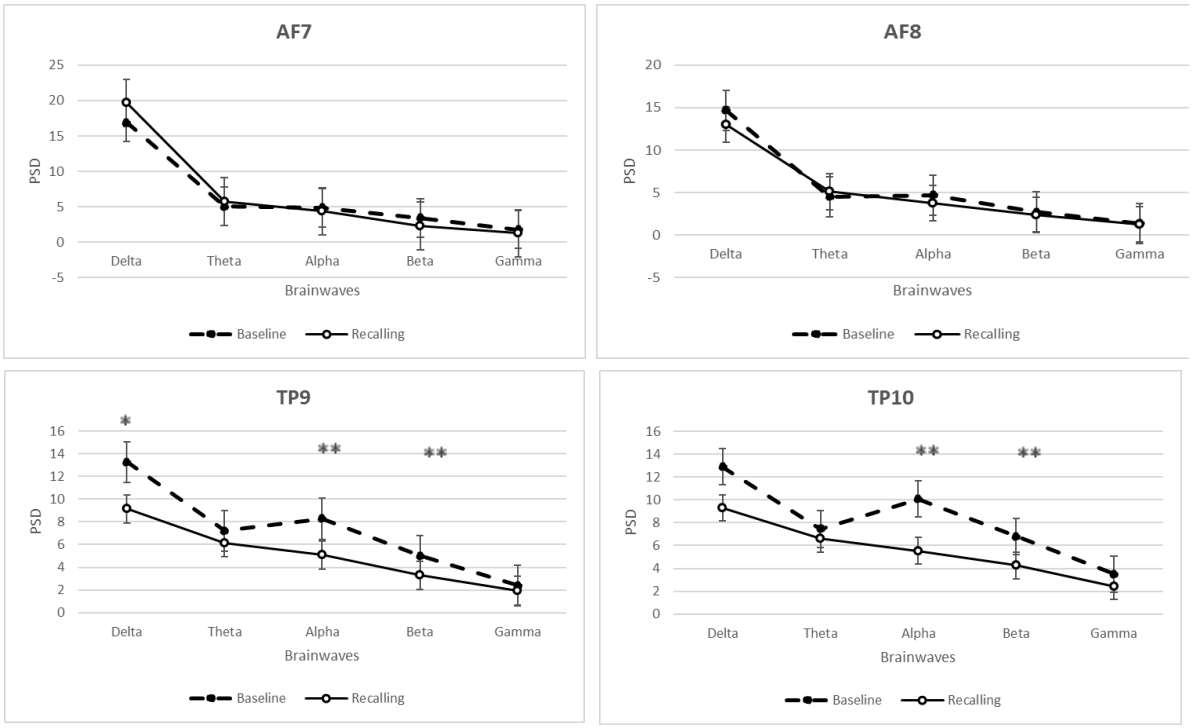

Figure 1. Interphase waveforms result comparison between channels (*Sig. < 0,05; **Sig. < 0,01).

Sex Difference Pattern Results

Analysis of spectral power differences for each waveform and phase wass also added. In Table 1, it can be seen further that significant differences in PSD values were only observed in low frequency waves, mainly in bilateral theta, delta AF7, and alpha TP10. Higher bilateral anterofrontal theta and alpha TP10 activity in male participants indicates the deeper state of memory processing carried out in that phase [13]. Meanwhile, AF7 delta activity was observed to be higher in female participants, indicating differences in cortical gray matter thickness, cranium thickness, and neuronal processing [9]. In addition, the absence of real differences in the spectral power of high-frequency waves is an indication that the induction of interviews in the context of recalling traumatic experiences does not trigger further cognitive reactions that are significantly different between male and female participants [6].

Table 1. EEG waveform comparison according to sex difference (*Sig. < 0,05; **Sig. < 0,01).

Phase	Channel	Delta (δ)		p-value	Theta (θ)		p-value	Alpha (α)		p-value	Beta (β)		p-value	Gamma (γ)		p-value
		Male	Female		Male	Female		Male	Female		Male	Female		Male	Female	
BL	AF7	13.41	22.51	0.86	4.28	6.27	0.488	4.56	5.34	0.886	3.40	3.48	1	1.87	1.68	0.996
	AF8	15.52	13.42	0.99	4.86	4.03	0.947	4.55	4.98	0.993	2.70	2.74	1	1.43	1.26	0.991
	TP9	14.25	11.67	0.89	6.20	8.80	0.863	7.70	9.21	0.986	4.48	5.84	0.763	2.32	2.51	0.989
	TP10	12.52	13.54	0.99	6.33	9.23	0.754	10.40	9.59	0.998	7.14	6.29	0.982	4.03	2.61	0.666
RS	AF7	12.87	30.440	0.012*	12.87	7.56	0.015*	4.34	5.13	0.207	2.26	2.11	0.981	1.23	1.22	0.732
	AF8	9.37	18.754	0.923	9.37	6.89	0.00**	3.74	4.56	0.174	2.00	2.75	0.638	1.21	1.07	0.973
	TP9	9.63	6.844	0.513	9.63	6.51	0.976	5.58	3.47	0.092	3.25	3.04	0.977	1.95	1.66	0.847
	TP10	9.49	7.645	0.829	9.49	5.50	0.776	6.47	3.33	0.005**	4.43	3.63	0.829	2.76	1.74	0.248

Interhemispheric Analysis Results

The results of the interhemispheric study are further explained through the laterality index (LI) parameter with the following formulation, where the notation L indicates the accumulation of power in the left area, and the notation R indicates the accumulation of power in the right area.

Based on the equation, a score for LI ranged from -1 < LI < +1, which represents a positive value implies left-hemisphere dominance and a negative value implies right-hemisphere dominance [14].

$$LI = (L-R)/(L+R)$$

The results of the LI analysis (Figure 2) show that the laterality of the anterofrontal area is very biased towards the left hemisphere as an indication of chronic stress [15]. Meanwhile, in the TP area there were changes in laterality in theta (Sig. < 0.05), as well as in beta and gamma (Sig. < 0.01). Changes in TP laterality of theta and alpha in the RS phase show inhibition of areas in the left hemisphere, while right areas tend to be activated based on the lateralization of beta and gamma power. This indicates memory processing that reflects negative emotions from the trauma experienced, a tendency commonly shown in patients with PTSD [6, 8].

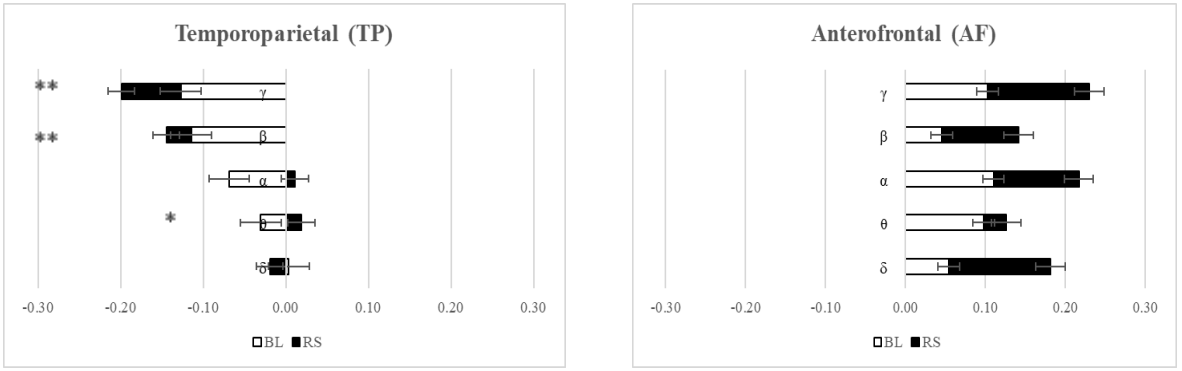

Figure 2. EEG waveforms laterality index (LI) results based on recalling session (RS).

TGC Analysis Results

Pearson's correlation-based captures linear, time-domain connections among EEG signals that may be identified over a single epoch or over numerous epochs, continuing theta-gamma coupling study. As a result, raising the Pearson correlation coefficient value from -1 to 1 suggests strong connections between brain areas [5]. Theta-gamma correlation analysis (Table 2) shows no correlation in the AF8 channel and negative correlation in AF7. Low T/G correlation in the AF area indicates a decrease in gray matter volume in the prefrontal cortex as a result of high mental stress, thereby affecting the individual's executive cognition abilities [4, 7]. Meanwhile, a positive correlation of T/G activity was observed in the TP area. However, this correlation weakened when the RS phase was carried out. This indicates that information processing involving the activation of these two waves is not running optimally, resulting in a decrease in waveforms synchronization during recalling events session.

Table 2. Theta-Gamma correlation analysis (*Sig. < 0,05 **Sig. < 0,01)

Phase	Channel	p-value	R value
Baseline	AF7	0.00**	-0.296
	AF8	0.08	0.061
	TP9	0.00**	0.334
	TP10	0.00**	0.245
Recalling	AF7	0.00**	-0.136
	AF8	0.153	-0.045

	TP9	0.00**	0.127
	TP10	0.00**	0.208

CONCLUSION

The results of our neurophysiological study of flood disaster victims in Subang district based on EEG provide an indication of a chronic stress reaction that leads to PTSD symptoms which is indicated by a decrease in brain wave activity when a stimulus is given. The results obtained also show weak AF and TP synchronization as an indication of weakened information processing due to the traumatic stress experienced.

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