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Changes in Stress Mindset and EEG through E-Healthcare Based Education

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ABSTRACT This paper presents a new approach to stress management and its effects on cognition, including brain wave analysis. An individual may have a particular mindset regarding stress, believing it to be either enhancing or debilitating. When experiencing stress, a person with an enhancing mindset responds in a healthier way and receives less negative influence from stress than a person with a debilitating mindset. Stress mindsets can be altered through education. This paper measures whether or not e-healthcare-based education can help students change their stress mindset from debilitating to enhancing. Further, it analyzes changes in electroencephalography (EEG) response when students with an enhanced mindset are stressed. Through health care education, people can acquire a stress enhancing mindset. If an individual has such a mindset, their EEG will show that they are more responsive in stress situations. Thus, educating people so that they acquire this mindset will reduce negative influences caused by stressful situations, such as health deterioration.

INDEX TERMS Stress, Stress mindset, EEG, E-healthcare.

I. INTRODUCTION

Stress is a state of tension experienced by people facing extraordinary constraints, demands, or opportunities [1]. Existing research has shed light on stress as a negative factor and described ways to reduce or manage it in various areas, including the healthcare industry, business, and psychology. Most people would agree that stress is bad for health [2]. As a result, there is a lot of research underway into the negative role of stress and ways to reduce it in various situations. However, although stress has traditionally been viewed negatively, there have been some studies on stress with a different perspective that have focused on the positive aspects and benefits that can accompany stress [3], [4].

Regarding the positive effects of stress, one of the most critical factors is stress mindset. Stress mindset refers to the extent to which one believes that stress has enhancing outgrowths for various stress-related results, such as health, performance, productivity, and learning (stress-is-enhancing mindset: SEM) or, by contrast, believes that stress has debilitating outgrowths for those results (stress-is-debilitating mindset: SDM) [3], [5].

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Depending on one's stress mindset, stressful responses can lead to an either more positive or more negative response. People who have a SEM manifest positive responses or reactions to stress. Under stressful situations, these people are more motivated and healthier, and they achieve better performance than people who have a SDM. For instance, people with a SEM have wider blood vessels, while the blood vessels of people with a SDM tend to narrow under stressful conditions [5]. In addition, people with a SEM are less likely to experience job burnout when performing stressful tasks [6]. Further addition, as compared to people with a SDM, people with a SEM have more positive attitudes toward stressful learning, experience, and task activities and achieve higher performance [3], [4], [7]. Thus, people should strive to have a SEM in order to achieve better results in a variety of settings.

Human mindsets can change [8]. Specifically, experiments have shown that an individual's stress mindset can be changed by specific interventions [5]. This study examines whether or not an intervention based on a e-health program can help change one's stress mindset from a SDM to a SEM. Existing studies have shown that mindset training can lead people to have a more positive mindset. Further, having a certain mindset internalizes and continually affects individual

behavior [5], [7]. Thus, a particular type of education should influence people to have a SEM. The mindset changed into a SEM will be internalized to the individual and the effect will be sustained, and the individual's behavior will be affected as well. As people's behaviors change positively in stressful situations, they will overcome stress and produce more positive outcomes such as improvements in health, work performance, and learning.

Furthermore, the responses to stressors of those who have a SEM will be interpreted by brain wave analysis. Brain waves reflect the state of a person's mind. Human brain waves express how someone feels or the state they are in, and the measurement and detection of brain waves can thus be used to make judgements about an individual's psychological state [9], [10]. Electro-encephalogram is a test that can be used to measure the electrical activity occurring in the brains of animals, including humans [11]. This activity can be detected and recorded by electrodes placed on the scalp [12]. An Electroencephalograph (abbreviated as EEG) is the machine that measures this brain activity, and it is used in a diverse range of contexts such as medical clinics, physiological examinations, and engineering research [13]. The test results, equipment, and methods can each be abbreviated as EEG, but in this study, the acronym EEG is used primarily to refer to the measurement results [14]. In addition, we use EEG equipment to evaluate conditions such as brain damage, and we also actively study stress-related conditions by classifying the types of brain waves according to their function and activity status [15].

Brain waves reflect the state of a person's mind. Human brain waves express how someone feels or the state they are in, and the measurement and detection of brain waves can thus be used to make judgements about an individual's psychological state [9], [10]. Electro-encephalogram is a test that can be used to measure the electrical activity occurring in the brains of animals, including humans [11]. A person performs various activities such as thinking, moving, and communication under the control of the brain. Specifically, they have the will of human activity. When a person moves their arms / legs or speaks, their brain begins to activate and their brain waves are changed. In order for the brain to do so, the surrounding information as gathered by the five senses is collected in the brain, and judged comprehensively for decisions to be made. At this time, information is transmitted between the nerve cells in the brain, and this changes the electric potential of the scalp. The human brain has a function dedicated to each region. Human brain waves change when collecting information or judging something or sending information to other organs. In particular, according to the situation, EEG appeared differently. Further, we analyze human brain waves, in order to investigate these changes in EEG so as to interpret the relative potential differences of the brain regions [12], [13]. This activity can be detected and recorded by electrodes placed on the scalp [12]. An Electroencephalograph (abbreviated as EEG) is the machine that measures this brain activity, and it is used in a diverse range of contexts such as medical clinics, physiological examinations, and engineering research [13]. The test results, equipment, and methods can each be abbreviated as EEG, but in this study, the acronym EEG is used primarily to refer to the measurement results [14]. In addition, we use EEG equipment to evaluate conditions such as brain damage, and we also actively study stress-related conditions by classifying the types of brain waves according to their function and activity status [3], [15].

In general, those with a SEM will have a more positive attitude in stressful situations, and these changes will be evidenced by brain wave activity. Ideally, the e-health program presented in this study will allow people to develop a SEM. After people achieve a SEM, they will become healthier both in stressful situations and overall. Therefore, this study highlights the importance of one's stress mindset. This paper suggests how people can change their stress mindsets. The e-healthcare program will change people's stress mindset, and they will experience positive changes, such as healthier EEG responses in stress situations. These people will be able to cope with stressful situations more positively, thus becoming healthier and achieving higher performance. These anticipated outcomes will provide guidance on how to manage stress in hospitals, schools, and businesses.

II. LITERATURE REVIEW

A. STRESS

Stress is defined as the feeling of an individual who is required to veer from standard or self-desired functioning due to opportunities, constraints, or demands related to potentially valuable work-related results in the workplace [1], [16]. Existing studies have emphasized the negative aspects of stress, such as the fact that stress is harmful to people's health and decreases work efficiency. As a result, people have tried to avoid or lessen stress and have considered it as a negative factor [2]. [5] Though appropriate levels of stress have been shown to improve performance in certain situations, people do not regard stress as positive in itself [1], [6]. Therefore, existing studies have described stress as a negative factor to be reduced.

B. STRESS MINDSET

A mindset is a mental or psychological frame that selectively organizes and encodes information [8]. A stress mindset can be conceptualized as the expectations and attributes ascribed to stress, whether one is stressed or not. It refers to the extent to which one holds the conviction that stress has enhancing outgrowths for various stress-related consequences, such as health, learning, wellbeing, performance, productivity, and growth (SEM), or the conviction that stress has debilitating outgrowths for those consequences (SDM) [3], [5]. People with a SEM and those with a SDM show different cognitive, emotional, and psychological responses to stressful situations [4]. People with a SEM perceive stress as positive by

itself, so people who have a SEM respond and react positively to stress. These people think stress can be a helpful, beneficial presence and should be actively accommodated. People with this mindset believe that stress can enhance stress-related outcomes and lead to positive results such as health benefits, higher performance, happiness, improved focus, better concentration and more effective learning, and overall stress related growth. By contrast, people with a SDM view stress as negative. These people think that they should avoid stress and eliminate it wherever possible [3], [5]. As compared to people with a SEM, they are more frustrated, energy-depleted, and more prone to job burnout in stressful situations [6]. People with a SEM are likely to handle the same stress situation more positively than people with a SDM. Therefore, we should aim to have a SEM.

C. EFFECTIVENESS OF STRESS MINDSETS

From a psychological point of view, the mindset that one has directly and indirectly affects their attitudes and behaviors [3], [8]. Specifically, one's stress mindset influences their performance or outcome while experiencing stress. A person releases particular hormones when stressed. These hormones aid in physical and mental recovery from stress. In addition, depending on one's mindset, their reactions to stressful situations also differ. When an individual experiences social stress, oxytocin increases; this hormone improves social connectivity. Hence, a person with a SEM can be more flexible in responding to stress. Such individuals tend to recover quickly without hardship or suffering due to stress [5]. In addition, those who see stress as positive achieve better results in all aspects of life satisfaction, energy levels, health, happiness, and productivity as compared to those who see stress as negative. Such people will not see overcoming a stressful situation as a problem, but rather a challenge [3], [7]. These various effects of stress mindsets can also be found in business activities in companies. Employees become stressed while doing excessive amounts of work. This stress leads to job burnout (feeling emotional exhaustion, reducing the work efficiency of workers, and making people more cynical). Hence, stress decreases job performance through job burnout. However, people with SEMs have been shown to experience less job burnout than those with SDMs who are overworked and experiencing stress [6]. This means that people with SEMs will experience less difficulty in doing their jobs. So, people with SEMs can be seen to work relatively harder or to perform better. This means that people with SEMs will be less tired or experience less difficulty in doing their jobs. Thus, people with SEMs can be seen to work relatively perform better. A positive stress mindset allows one to better cope with stressful situations and produce positive effects, such as improved health, even when stressed. Everyone will experience stress throughout their lives, and no one can live completely without stress. However, the stress mindset theory provides a new perspective on stress, suggesting ways to utilize stress and produce better results [5].

D. STRESS MINDSET CHANGE

Human mindsets can change. Stress mindsets can also be changed by various interventions such as education, training, and stimulation [8]. Individuals who have a positive mindset on a particular subject may come to have a negative mindset on that same subject after having a bad experience. By contrast, an individual who possesses a negative mindset can also be trained to have a more positive mindset. This change in mindset is internalized and affects an individual's attitude and behavior [8], [5]. Thus, after one's stress mindset changes, their attitudes and behaviors also change when they are stressed. For instance, people who have been trained to emphasize the negative aspects of a particular object will strongly establish a negative perception of the subject. Thus, they will tend to avoid work related to the object or to dislike the object itself. The results of existing studies have shown that those who are informed that stress can be positive through online training have a more positive view of stress, and may even change their stress mindset [3], [5], [7], [17]. Therefore, the stress mindset can also change from a SDM to a SEM through specific interventions, such as online education.

E. ELECTROENCEPHALOGRAM

Electroencephalography (EEG) is a phenomenon in which the electrical activity between cells generated in the brains of animals, including humans, is detected and recorded on the scalp through electrodes [18]. In this process, an electroencephalograph is used to measure electro-encephalograms, and it is used for clinical examinations, physiological examinations, and engineering research [19]. In addition, we use EEG equipment to evaluate conditions such as brain damage, and we also actively study stress-related conditions by classifying the types of brain waves according to function and activity. EEG is a continuous process in which information is exchanged between brain cells and other brain cells as well as between neurons and brain cells, and the minute currents generated cause many small activities or pulses in the form of electrical signals [20]. EEG vibrates in a very complex pattern and appears as a waveform of electrical signals that change over time [21]. Therefore, it is difficult to produce meaningful information by observing EEG waves as they occur in real time. Thus, the frequency components generated while observing the EEG are analyzed instead, and the characteristics of the waveforms are classified and judged by analyzing the distribution of the average ratio or the ratio of the EEG measured components against. In this method, the amplitude is analyzed for each frequency component in order to determine the corresponding state. The frequencies of the waves coming from the human brain are mainly in the range of 0.01Hz - 30Hz; the amplitude is mainly observed at 20-200 kV. Brain waves are divided into frequency components, as shown in Table 1 below. Among the types of brain waves, gamma waves are known to occur in a state of extreme arousal or excitement with a frequency of 30 Hz or more [22], [23]. Beta waves are also called stress waves,

TABLE 1. Types and features of brain waves recorded by an EEG [3:p94].

Indicator	Frequency Definition	State
Delta wave	0.1-3Hz	Deep Sleep
Theta wave	4-7Hz	Sleep
Alpha wave	8-12Hz	Awake
Beta wave	13-30Hz	Tension, Excitement, Stress
Gamma wave	30-50Hz	Anxiety, Nervous, Stress

and they correspond to anxiety and tension. Alpha waves are known to occur when the mind and body are in a stable state, and are excellent for facilitating learning. Theta waves occur when someone is drowsy or in the shallow stages of sleep. Finally, delta waves occur during deep sleep.

F. STRESS AND EEG

As discussed in Section E, human brain waves can be obtained by measuring the amount of electrical stimulation. It is also known that these signals can be analyzed so as to measure emotional, psychological, and mental health conditions. EEG measures the continuous minute currents flowing through the scalp, analyzes the frequency components, and then uses these values. In different parts of the brain, and in different situations, brain waves of specific frequency components can be observed. By analyzing these brain waves, we can judge changes in a person's psychological state. In a situation like stress, an EEG detects a fast frequency component of 13 Hz or more across the whole area, and the brain is very awakened and active. By analyzing brain waves subjected to the same kind of stress, the degree of stress can be estimated. Further, it is also possible to determine how to cope with stress by using changes in brain wave patterns [12], [13].

In other studies [12], [19], active frontal lobe changes were measured, and the Support Vector Machine analysis method was applied for feature extraction. The EEG was measured, with an auditory - visual external stimulus given to induce EEG. The EEG of similar condition was judged by machine learning, and an emotional judgment, such as sadness or joy, was mainly made. Prior to that, we used the ratio of beta waves above 13 Hz of EEG to analyze the excitability of the human brain. In [18], a study was conducted to determine the state of the brain based on the change of the frequency component, which is the power spectrum of the EEG. This study employed changes in the ratio of alpha and beta waves in the frontal lobe EEG. In section E, the frequency component of the EEG was measured, as shown in table 1, and the state was measured and analyzed using Cohen's PSS-10 stress questionnaires. In addition, in [20], they analyzed the differences of EEGs appearing in situations by dividing the types of stress experience by people into internal and external factors. The study also used changes in brain waves, including changes in frequency, such as gamma or theta waves, which are higher than beta waves. Gamma and theta waves change more rapidly than high beta waves, but are normally not well used because of the rapid changes in EEG and instantaneous changes. In addition, EEG was measured, and memorization and simple calculation were performed in order to analyze the differences between EEG status and test results [12], [13], [18]–[20].

III. EXPERIMENTATION DESIGN FOR STATISTICAL ANALYSIS

A. E-HEALTHCARE EDUCATION

We have developed a specific e-healthcare education to help change stress mindsets (specifically from SDM to SEM) and to illustrate the effectiveness of e-healthcare education program interventions. Previous studies have shown that specific training can change one's mindset [10], [13]. One such study focused on increased uncertainty in workers of a company. When the intervention focused on the negative impact of stress, people had a firm negative attitude about stress. By contrast, if the intervention emphasized the positive influence of stress, people thought that stress was not necessarily bad, but could be good or bad. Although these experiments measured changes in attitudes via questionnaires through a brief, three-minute intervention, they also demonstrated that people's depression and anxiety decreased [5], [4], [7].

This study developed an online-based education program based on the methodology of the previous studies in order to provide a longer time of education (15 minutes), and then measured changes the mindset over a longer period of time (16 days). The education program involves information about stress mindsets delivered through the mobile-based computer technology of an on-line video. The video covers such topics as the experiences of people with a SEM in overcoming stress along with their accomplishments, and the opportunity to acquire a SEM. The information on stress mindsets includes the effects of a SEM, which has been scientifically validated by previous studies [5], as well as objective facts about the process. Participants in the experiment will use this online e-healthcare program and a computer.

B. MEASUREMENT

Stress mindsets were measured with 10 questions [3], [5]. All measures were assessed using a 7-point Likert scale (1 = strongly have a "stress-is-debilitating mindset", 7 = strongly have a "stress-is-enhancing mindset").

C. PARTICIPANTS

In total, 618 college students in Seoul, Korea were randomly selected to measure changes in perceptions of their stress mindsets. Over approximately two weeks (16 days), students were administered two questionnaires and took part in three intervention sessions. Students who did not attend at least one intervention or failed to properly answer the questionnaire were excluded from the study. Thus, a total of 479 students ultimately participated in all interventions and measurements.

TABLE 2. Questionnaire.

	Experiencing stress	
1	is bad to me	is good to me
2	influences negative effects	influences positive effects
3	should be avoided.	should be accepted
4	should be eliminated.	should be utilized
5	inhibits my growth	facilitates my growth.
6	inhibits my learning	facilitates my learning
7	depletes my health	improves my health
8	depletes my vitality	improves my vitality
9	debilitates my performance	enhances my performance
10	debilitates my productivity	enhances my productivity
	stress-is-debilitating mindset	**stress-is-enhancing mindset**

TABLE 3. Demographics.

Gender	**Frequency**	%	**Major**	**Frequency**	%
male	289	60.3%	business administration & economics	257	53.7%
female	189	39.5%			
missing	1	.2%	engineering	197	41.1%
Age	**Frequency**	%	humanities and others	25	5.2%
18,19	78	16.3%			
20	76	15.9%	**College year**	**Frequency**	%
21	59	12.3%	freshman	44	9.2%
22	91	19%	sophomore	177	37%
23	81	16.9%	junior	151	31.5%
24	43	9%	senior	95	19.8%
older than 5	44	9.2	others	2	2.4%
others	7	1.4%	missing	10	2.1%

Demographic information about the participants is shown in the table immediately below.

D. PROCESS

The subjects were educated in the following experimental design sequence and responded to questionnaires regarding their stress mindsets.

A person's feelings and mood can change quickly. One's mindset can also be changed in a short time by specific stimuli. Compared to the time of stimulation, the mindset is internalized, and its effect can be sustained over the long term. Nonetheless, it may take several stimuli and a certain amount of time for an individual to come to have a certain mindset or the mindset opposite to their original existing position [3], [5], [8]. This study conducted three stimuli education sessions and examined the changes that occurred in mindset over 16 days. The measurement of intervention and change for the stress mindset is as follows.

1) THE FIRST MEASUREMENT

In the first measure, the respondents answered a questionnaire about which mindsets they had, without receiving any information or prior education about stress mindsets.

2) THE FIRST INTERVENTION

After the first measurement, the students were instructed about stress mindsets after a resting period of 15 minutes. The contents of the intervention included the concept and effects of the stress mindset delivered by a 15-minute computer video.

3) THE SECOND INTERVENTION

One week after the first measurement, more objective and scientific education on stress mindsets was conducted. The contents of the program included the relationship between stress responses and hormones based on stress mindsets, as well as the results and theories from previous studies in this area.

4) THE THIRD INTERVENTION

One week after the second intervention, the students were given more emotional content-based education. The content of the e-healthcare program included examples of successful people who had overcome stress and stories of people with a SEM.

5) THE SECOND MEASUREMENT

After two days of the tertiary intervention, the students had their stress mindsets measured in the same way that they took their first measurements. Participants provided their school ID, birthday, last four digits of their phone numbers, major, age, grade, and gender in both the primary and secondary measurements. Based on this information, the primary measurements of each individual could be linked.

IV. RESULT OF STATISTICAL ANALYSIS

For the statistical analysis to assess stress mindset, this study used exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) for validity, Cronbach's α for reliability, descriptive statistics, and paired samples T-test [24].

First, in the EFA, the Eigen value needs to be higher than 1.0, which refers to the number of factors that can be explained by one component. Components 1 (the first stress mindset = 7.351) and 2 (the second stress mindset = 6.601) have Eigen values above 1.0. In addition, the factor loading of the first stress mindset was .718-.832, while that of the second stress mindset was .500-.867. In the case of

the same variable, it should be connected at .4 or more and concurrently connected to other variables at less than .4. The first stress mindset is connected to component 2 at .4, but to component 1 at less than .4. By contrast, the second stress mindset is connected to the component at over .4. In addition, KMO of .919 means a higher significance value. Thus, as a result of the EFA, the measurement is considered to have gained significant validity [24]. Second, in the CFA, each of the indicators was presented at a reasonable level ($1.0 \leq [X2/df] \leq 5.0$, GFI, TLI, CFI, IFI $> .9$, PNFI, PGFI $> .6$). Further, each stress mindset has significant average variance explained (.5 or more) as well as composite reliability (.7 or more). Hence, the result of the CFA also indicates the significant validity of the measurement [25].

Third, the results of reliability show enough values of Cronbach's α (higher than .8), and the results of descriptive statistics (mean and standard deviation) were suggested [24].

Fourth, the correlation between the first stress mindset and the second stress mindset was not significant, as it was shown at .525, while significance is only valid when it is less than .5. This result means that the first and second stress mindsets are different. Thus, through the effects of education, we can observe that there was a significant change between the first and second measurements [24].

A T-test demonstrates differences between groups or specific subjects. A Paired samples T-test analyzes differences between subjects before and after a specific event. As such, if a significant difference is observed between the stress mindsets before and after education, this indicates that the education is effective. The mean of the first stress mindset was 3.378 and increased to 4.152 for the mean of the second stress mindset, indicating that the students had developed a more stress-is-enhancing mindset. The significance of this difference was demonstrated by a T-test. ($t = -9.366$, sig $= .000$)

V. EXPERIMENT DESIGN FOR BRAINWAVE

From the questionnaire, we randomly selected about 30 students who had negative attitudes toward stress. We then stressed them and measured their brain waves. After all of the online education, among the 30 students, we selected the 20 students who had a statistically significant change in the stress mindset (from SDM to SEM). They were stressed again and had their changes in brain waves measured. In the remaining 10 cases, there was either no statistically significant change or the degree of negative attitude increased. Therefore, EEGs were measured only in the students who showed significant changes, excluding these samples. Future studies will need more samples to clarify that there is no significant change in the control group.

During the course of the procedure described in Section 3.D, their brain waves were analyzed together. In addition to the results of questionnaires described from 3.D.1) and 3.D.5), coercive interviews using aggressive language and mental stress to stimulate shame were added so as to allow for the subject's brain waves to be measured in stressful situations. The degree of change was observed in the first and second measurements. We also performed two identical tests and measured the brain waves of students that did not undergo any intervention. The EEG of the groups with and without interventions were compared, and the results of the second EEG analysis of the two groups were compared with each other. In the experiment, 'neuro-harmonys' of a 2-channel dry electrode was used. The sampling rate was 512 Hz and the measurement bandwidth

TABLE 4. Exploratory and confirmatory factor analysis, reliability, mean, standard deviation, correlations.

	Component		Average Variance Explained	Composite Reliability	Cronbach's α
	1	2			
SET1_1	.183	**.832**	.573	.856	.944 (M=3.378 / S.D=1.282)
SET1_2	.262	**.817**			
SET1_3	.313	**.751**			
SET1_4	.334	**.729**			
SET1_5	.364	**.718**			
SET1_6	.291	**.754**			
SET1_7	.064	**.767**			
SET1_8	.209	**.803**			
SET1_9	.367	**.772**			
SET1_10	.336	**.750**			
SET2_1	**.855**	-.260	0.628	.857	.942 (M=4.152 / S.D=1.314)
SET2_2	**.867**	-.256			
SET2_3	**.837**	-.248			
SET2_4	**.500**	-.219			
SET2_5	**.839**	-.314			
SET2_6	**.840**	-.289			
SET2_7	**.762**	-.245			
SET2_8	**.810**	-.207			
SET2_9	**.859**	-.267			
SET2_10	**.843**	-.268			
Eigen Value	7.351	6.601			
% of Variance	36.754	33.003			
Cumulative %	36.754	69.757			
KMO=.919(sig=.000)					
X^2/df=3.131, GFI=.913, TLI=.957, CFI=.966, IFI=.966, PNFI=.751, PGFI=.652					
Pearson Correlation=.029 (sig=.525, 2-tailed)					

TABLE 5. Paired samples T- Test.

Paired Differences					t	df	Sig. (2-tailed)
Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
			Lower	Upper			
-.774	1.809	.083	-.937	-.612	-9.366	478	.000

was 45 Hz. The product is KC certified MSIP-REM-BP1-NEUROHARMONYS.

VI. RESULTS OF EXPERIMENT BRAINWAVE

In the experimental design, we proceeded with the first and second methods. Both the primary and secondary measurements were taken in a quiet meeting room. The room temperature was 22 degrees, humidity was 40%, and average noise level was 30dB. The rest was measured in the absence of environmental stress factors for 30 minutes. The EEG instrument used for the measurement was a simple but accurate instrument using dry electrodes. The results are shown as the magnitude of the frequency component over time. In Figure 1, the rightward direction of the figure is the flow of time, the length is the size, and the other axis is the component of the EEG. Figure 1 shows the results of Subject A's primary test, and is the interval during which the interview begins. In the middle part of Figure 1, the stress-inducing pressure interview, as indicated by the red arrow, was conducted. The left and right brain measurement results are shown. Figure 1 shows the left brain measurement results. Here, stimulation is started and the total EEG activity increases. In addition, in the stressful interview situation, beta waves, especially high beta waves, were displayed in the yellow circle as a ratio of EEG. It can be confirmed that stress was largely affected due to the interview.

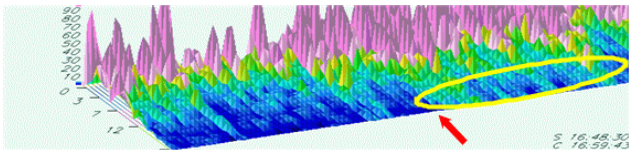

FIGURE 1. EEG result by rest and interview (Test person A, first measurement).

Figure 2 shows the results of the second test of Subject A, and the results of the interim interview after the rest, as shown in Figure 1. The EEG during rest is maintained after stimulation. As compared with the first test, it can be observed that small or high beta waves appear. In stressful situations, the brain appears to be awakened and active. However, there is a measurement result that seems to have alleviated the excited situation like high beta waves.

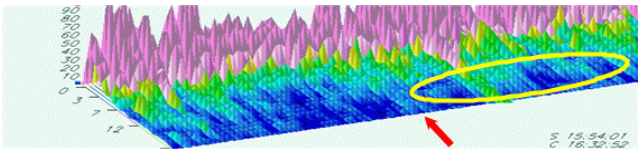

FIGURE 2. EEG result by rest and interview (Test person A, second measurement).

Figure 3 shows the results of the first measurement of Subject B. It represents the EEG of the section where the interview has been completed and a break is being taken. It was resting near the red arrow after the interview. It can be seen that the high beta wave of the yellow circle part appears.

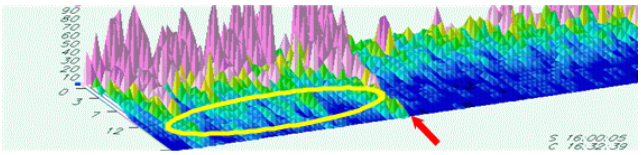

FIGURE 3. EEG result by interview and rest (Test person B, first measurement).

Figure 4 shows the results of the second measurement of Subject B. It represents the EEG of the section where the interview has been completed and a break is being taken. It was resting near the red arrow after the interview. Although the high-beta wave of the yellow circle appears, the overall measured value is high, and it can be considered that the amount of stress is smaller than the result of the first order.

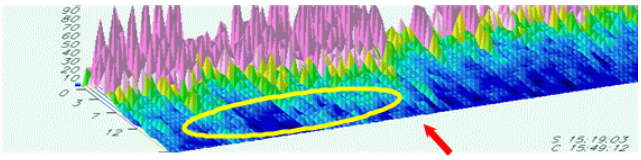

FIGURE 4. EEG result by interview and rest (Test person B, second measurement).

Figures 5 and 6 are graphs comparing the first and second mean EEG, respectively. The averages were calculated by filtering only the alpha and beta waves of interest. In Figures 5 and 6, the ratios of the upper half to the sky blue represent the percentages of the alpha waves. On the right, purple is the ratio of high beta waves, which is the high frequency of the beta waves. The two figures 5 and 6 show the averages of the EEG of the under test people. This is the EEG measured in a similar stress situation. The reason for confirming the ratio of the average EEG is that the absolute value of the EEG is different for each individual, but the ratio of the EEG component can represent the state of the brain. As shown in Fig. 5, in the first test, both the left and the right brain have fewer alpha waves and the beta waves are larger. As shown in Fig. 6, unlike in Fig. 5, the ratio of sky blue alpha waves increases. In addition, the ratio of violet high beta wave is reduced. In other words, although the brain is in a stressed state, the EEG appears to be eased.

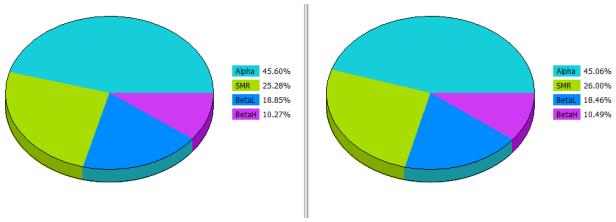

FIGURE 5. Mean EEG of time (first measure).

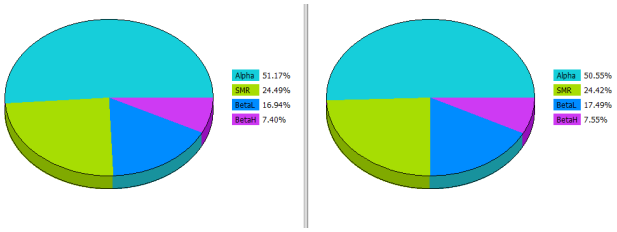

FIGURE 6. Mean EEG of time (second measure).

VII. CONCLUSION

A. RESULTS AND IMPLICATIONS

The statistical analysis and results of the EEG demonstrate that the stress mindset can be changed. Specific intervention such as the e-healthcare-based education can help people develop a SEM, and people with this stress mindset will have more positive responses to stresses. The implications of these findings are as follows.

First, the mindset can be changed through specific interventions. In particular, an e-healthcare program based on online and computer technology can change one's stress mindset. These programs have the advantage of being able to change one's stress mindset anywhere and anytime they have access to a computer. Such e-healthcare programs can be used in businesses, schools, and everyday life to help people develop a SEM. For example, medically, doctors in hospitals can suggest the role of a stress mindset as a way to manage stress for those who are stressed or struggling with stress. Doctors can use e-healthcare programs to help reduce stress, as well as help people achieve a SEM. If people achieve a SEM through the hospital's professional e-healthcare programs, that can help them address health problems that may arise from stress, such as hypertension, tension, and depression [5].

Second, when the stress mindset changed, there was a change in the EEG response to stress. When changes are made so that a person has a SEM, stress is assessed positively and considered to be an opportunity for growth. The results of the EEG analysis were confirmatory. Stress mindsets are a new approach to stress study. This theory does not claim to reduce or avoid stress, as in existing studies, but rather asserts that stress can be a positive element that can be exploited by individuals having a specific mindset called a SEM. Hence, emphasizing the importance of a SEM will help people achieve more positive outcomes in stressful situations. There is a relationship between stress and EEG: when the stress mind set is changed to the SEM, the brain waves change in stress situations. Changes in mindset also accompanied changes in EEG. Comparing figures 6 and 5 shows that the EEG changed to respond positively in stress conditions. It can be seen from the results of EEG analysis that a stress-mind set can overcome the stress of change or make good use of it.

Third, changes in mindset have an impact on stress, EEG, and behavior, leading to cognitive-psychological implications. A person's positive cognition of a particular object can change not only their brain waves but also their attitudes and behaviors. For example, when workers have a positive perception of stress, they have a positive attitude toward their hard work. These workers then have fewer negative experiences, such as emotional exhaustion and cynicism, resulting from hard work. Thus, psychological factors such as a stress mindset indirectly improve the actual performances of the workers [6]. This study suggests ways to draw real and positive results such as performance, learning, and health using these psychological factors.

Fourth, this study suggests the need to develop a technical area of education for changing people's stress mindsets. In this study, computer-based online learning was used. As technology advances, we will be able to provide even more convenient and real-time education using mobile and smart phones. In addition, education contents that can exercise more effective influence in shorter time should be developed. The development of various platforms and technologies should also consider differences in individual characteristics. Depending on personality, type of stress coping, life values, and individual orientation, the degree and method change of stress mindset may be different. Therefore, various educational programs should be developed with the influence of more psychological factors.

B. LIMITATIONS AND POTENTIAL AREAS OF FUTURE STUDY

The limitations of this research, as well as suggestions for future research, are as follows.

First, this study was specifically aimed at college students. Stress in schools, job stress, and general stress may all have different influences [6]. Thus, it is necessary to conduct studies on a variety of people (i.e. employees and seniors) and kinds of stress (i.e. job stress and life stress). Furthermore, in future studies, it is necessary to experiment with various kinds of EEG participants.

Second, the effectiveness of SEM and the possibility of changing mindsets have been proven. Future studies will need to develop more effective and diverse intervention methods based on e-healthcare. Specifically, it is necessary to search for ways to change mindsets more quickly and more appropriately based on the particular characteristics of each individual.

Third, there are limitations to the kinds of stresses measured by EEG. However, it is necessary to carry out the test in consideration of the influence of the stressed portion of the subject in advance. It is also a good idea to measure stress by other methods beyond using EEG. Fourth, if people have a new way of thinking about stress, this can be sustained through internalization [5]. Therefore, it is necessary to consider whether the change of mindset through intervention can be maintained for a certain period, or whether it will revert negatively due to specific events. Furthermore, research should also be conducted on whether people's EEG responses are sustainable. Fifth, this paper describes the effect of changing the stress mindset through the response of EEG.

In future studies, it is necessary to demonstrate other benefits of changing stress mindsets in diverse areas such as health, athletic performance, test scores, and job performance.

REFERENCES

[1] H. Selye, *The Stress of Life*. New York, NY, USA: McGraw-Hill, 1976.
[2] A. R. Subhani, W. Mumtaz, M. N. B. M. Saad, N. Kamel, and A. S. Malik, "Machine learning framework for the detection of mental stress at multiple levels," *IEEE Access*, vol. 5, pp. 13545–13556, 2017. doi: 10.1109/ACCESS.2017.2723622.
[3] A. J. Crum, S. Peter, and A. Shawn, "Rethinking stress: The role of mindsets in determining the stress response," *J. Personality Social Psychol.*, vol. 104, no. 4, pp. 716–733, Feb. 2013. doi: 10.1037/a0031201.
[4] A. J. Crum, M. Akinola, A. Martin, and S. Fath, "The role of stress mindset in shaping cognitive, emotional, and physiological responses to challenging and threatening stress," *Anxiety, Stress, Coping*, vol. 30, no. 4, pp. 379–395, Jan. 2017. doi: 10.1080/10615806.2016.1275585.
[5] K. McGonigal, *The Upside of Stress: Why Stress Is Good for You, and How to Get Good at It*. New York, NY, USA: Penguin, 2015.
[6] S. W. Hahm, "Effect of general/job stress mindset to decrease the influence of job stress to burnout," *Information*, vol. 19, no. 11B, pp. 5365–5372, Nov. 2016.
[7] A. Crum, "Evaluating a mindset training program to unleash the enhancing nature of stress," *Acad. Manage. Proc.*, vol. 2011, no. 1, pp. 1–6, 2011.
[8] C. Dweck, *Mindset: The New Psychology of Success*. New York, NY, USA: Random House, 2006.
[9] E. J. Cheon, "Electroencephalographic changes in depression," *J. Korean Soc. Biol. Therapies Psychiatry*, vol. 19, no. 2, pp. 93–100, 2013.
[10] D. H. Kyon, M. J. Bae, and J. H. Lee, "An analysis of the acoustic characteristics of forest sounds," in *Proc. 167th ASA Meetings Acoust.*, vol. 21, no. 1, May 2014, Art. no. 050005.
[11] M. J. Horowitz, "Stress-response syndromes: A review of posttraumatic and adjustment disorders," *Psychiatric Service*, vol. 37, no. 3, pp. 241–249, 1986.
[12] H.-J. Lee, D.-I. Shin, and D.-K. Shin, "The classification algorithm of users' emotion using brain-wave," *J. Korean Inst. Commun. Inf. Sci.*, vol. 39, no. 2, pp. 122–129, 2014.
[13] W. Park, S. Lee, and S. Lee, *Fundamentals of Sound Engineering*. Seoul, South Korea: Charsong, 2009.
[14] V. K. Ingle and J. G. Proakis, *Digital Signal Processing Using MATLAB: A Problem Solving Companion*. Boston, MA, USA: Cengage, 2016.
[15] Y.-S. Lee and Y.-B. Park, "An acoustic study of feeling information extracting method," *J. Inst. Internet, Broadcast. Commun.*, vol. 10, no. 1, pp. 51–55, 2010.
[16] D. F. Parker and A. D. Thomas, "Organizational determinants of job stress," *Org. Behav. Hum. Perform.*, vol. 32, no. 2, pp. 160–177, 1983.
[17] S. Mahoney, "Mindset change: Influences on student buy-in to online classes," *Quart. Rev. Distance Educ.*, vol. 10, no. 1, pp. 75–83, 2009.
[18] N. H. A. Hamid, N. Sulaiman, Z. H. Murat, and M. N. Taib, "Brainwaves stress pattern based on perceived stress scale test," in *Proc. IEEE 6th Control Syst. Graduate Res. Colloq. (ICSGRC)*, Aug. 2015, pp. 135–140. doi: 10.1109/ICSGRC.2015.7412480.
[19] C.-Y. Liao, R.-C. Chen, and S.-K. Tai, "Emotion stress detection using EEG signal and deep learning technologies," in *Proc. IEEE Int. Conf. Appl. Syst. Invention (ICASI)*, Apr. 2018, pp. 90–93.
[20] C.-T. Lin, J.-T. King, J.-W. Fan, A. Appaji, and M. Prasad, "The influence of acute stress on brain dynamics during task switching activities," *IEEE Access*, vol. 6, pp. 3249–3255, 2017.
[21] E. Cheon, "Neurofeedback treatment in adult psychiatric patient: Focusing on depressive and anxiety disorder," *J. Korean Soc. Biol. Therapies Psychiatry*, vol. 19, no. 2, pp. 85–92, 2013.
[22] H.-W. Park, S.-G. Bae, and M.-J. Bae, "Analysis of confidence and control through voice of Kim Jung-un," *Int. Inf. Inst. (Tokyo)*, vol. 19, no. 5, pp. 1469–1474, 2016.
[23] L. R. Rabiner, and R. W. Schafer, *An Introduction to Digital Speech Processing*. Hanover, MA, USA: Foundations and Trends (R) in Signal Processing, 2007.
[24] J. Cohen, *Statistical Power Analysis for the Behavioral Sciences*. New York, NY, USA: Lawrence Erlbaum Associates, 1988.
[25] B. Thompson, *Exploratory and Confirmatory Factor Analysis: Understanding Concepts and Applications*. Washington, DC, USA: American Psychological Association, 2004.

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