



CORRELATION BETWEEN PRECURSOR EMOTION AND HUMAN STRESS BY USING EEG SIGNALS

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ABSTRACT

Stress is an emergency mode of the body's reaction caused by the physical and mental pressure. Stress could also happen among teacher since they have abundance of work in school. In this experiment, the teacher has been given a task to teach students with the new developed technology. Thus, in order to identify either the teacher managed to uphold the task, we conduct an experiment to analyze the stress level of the teacher. Analyzing and understanding human stress has motivated many electroencephalograms (EEG) based studies in this area. As it has been used in many researches on human emotions before, EEG machine will be able to gather the brain signals more accurately than merely guessing the emotion state of the respondents by just looking at them. However, not many researches use EEG as a tool in understanding mental stress, even though EEG device is portable and inexpensive as compared to other devices. This research aims to understand the pattern/signatures of EEG signal for human stress. The study begins by conducting two experiments; first experiment is profiling the subject with the basic emotions - happy, calm, fear and sad, and the second experiment will be inducing stress by answering the Depression Anxiety Stress Scale (DASS21). Ten healthy participants (five males and five females) are recruited for the study. For feature extraction, Mel Frequency Cepstral Coefficients MFCC will be used in this analysis. Then, we use the features to recognize the emotion of the subjects by using multi layer perceptron (MLP) as classifier. The result shows that there is correlation between precursor emotion and human stress. Then, the subject is having stress based on DASS21 and EEG signals that has been analyzed. Research result of this study can be beneficial to draw a clearer relationship between basic emotions and stress; thereby it can develop a better healing process to tackle mental stress in future.

Keywords: human stress, MFCC, MLP, precursor emotion, DASS21.

INTRODUCTION

Life is full of frustrations, deadlines and demand. For many people, stress is so common place that it has become a way of life. In psychology, stress is a psychological and physical response of the body that occurs whenever we must adapt to changing conditions, whether those conditions be real or perceived, positive or negative [1]. In neuroscience, the primary area of the brain that deals with stress is called limbic system also referred as emotional brain. It has enormous influence on emotions and memory.

Interacting and communicating with people may be influenced by emotion. In recent studies, identifying human emotion in human computer interaction has become crucial in research area. This is due to communication that has been replaced by computer or electronic devices [21, 15, 20, 2]. Most of the time human being tends to communicate using non-verbal signs when the social aspect of interaction seems prominent. While communicating with computer, human tends to include all social aspects [14]. Thus, understanding human behavior has become vital in human computer interaction and pattern recognizing of emotion becoming popular by using brain activity [15, 3].

EEG uses electrical activities inside the brain neurons which are captured from the scalp that relates to consequence of cognitive process that approximately reveals the human response to emotional stimuli [13]. The neurons of the brain produce rhythmic signals reflecting

the brain activities through several frequency bands. However, detecting EEG signals involves some challenging issues in terms of proper position of the electrodes on scalp and extracting emotion signal instead of multiple signals. In this study, due to the excellent temporal resolution and its portability, the EEG was chosen to capture brain signal in contrast to other devices such Functional magnetic resonance imaging or functional MRI (fMRI) and positron emission tomography (PET).

In order to recognize emotion, the precursor emotion plays a vital role to ensure the exact emotion appears. Precursor emotion is important to identify the emotion that appears before the real emotion exists in people behavior. In precursor emotion, we may know the emotion that influences the people behavior especially in revealing their exact emotion. Thus, in this research study, it investigates the correlation between precursor emotion and stress itself.

UNDERSTANDING EMOTION

Based on several current research studies [22, 23, 24] that trying to understand human emotion by using Russell's model [11], the two common approaches in understanding emotion has been proposed. According to Ekman [10], commonly accepted basic emotions include happy, calm, sad, fear, anger disgust and surprise. Russell's Affective Space Model has been used in this study in which emotion is described using a two-dimensional approach which is shown in Figure- 1. It



consists of Valence and Arousal considering Sad, Happy, Calm and Fear as the four main basic emotions.



Figure-1. Russell's circumplex model of affect.

In this research study, Russell's two-dimensional Affective Space model (ASM) has been used in applying dimensional approach that consists of cognitive aspect of emotions. The brain activation in dynamic approach can be seen by analyzing and understanding the brain waves.

DASS 21

Depression, Anxiety, Stress Scales (DASS) is a set of three self-report scales designed to measure the negative emotional states of depression, anxiety and stress. The DASS was constructed not only as a scales to measure conventionally defined emotional states, but to further the process of defining, understanding, and measuring the ubiquitous emotional states usually described as depression, anxiety and stress [9]. DASS scales thus meet the needs of both researchers and clinicians who wish to measure current state or change in state over time (e.g., in the course of treatment) on the three dimensions of depression, anxiety and stress. Therefore, using DASS in understanding human stress is considered as an important means that needs to be implanted in this study. For this research work, DASS-21 is chosen which contains seven items per scale.

PRECURSOR EMOTION

According to Sroufe [18], precursor emotion is something that can form the basis of interpersonal regulation to start. Precursor emotion is the reactions appear before it is being proceeds to the real emotion. These precursor emotions are triggered by absolute physical stimulus thresholds and not by any attribution of meaning. Eyes closed data were used to identify the precursor emotion as it represents the initial emotional state [19]. In this paper, the correlation between precursor emotion and teacher learning interest were analyzed in relation to the teacher's dynamic emotions.

METHODOLOGY

Figure--2 shows the block diagram of the experiments in order to analyse the correlation of precursor emotion to subject stress. In the pre-processing stage noise and other artefacts will be removed from the raw EEG signals using the ellipord filter. Features will then be extracted using the Mel-frequency Cepstral Coefficient (MFCC) method and finally using the Multilayer perceptron (MLP) to classify the valence and arousal.

In this paper, features were extracted using MFCC to extract the low frequency EEG signals. Instead of using 40 MFCC coefficients like most feature extraction for speech, here only 10 MFCC coefficients were extracted and found to be sufficient. Thus every instance will have 160 features from 16 channels based on 256 nfft points at 83Hz sampling frequency and 20% overlap.

MLP was adopted as the classifier to investigate the precursor emotion and it's dynamic. In this analysis, one hidden layer and ten number of neuron in the hidden layer has been used. The activation function for hidden layer is using tan-sig whereas activation function for output layer is by using purelin. Learning rate is 0.01 and mean-square error goal is 0.1.

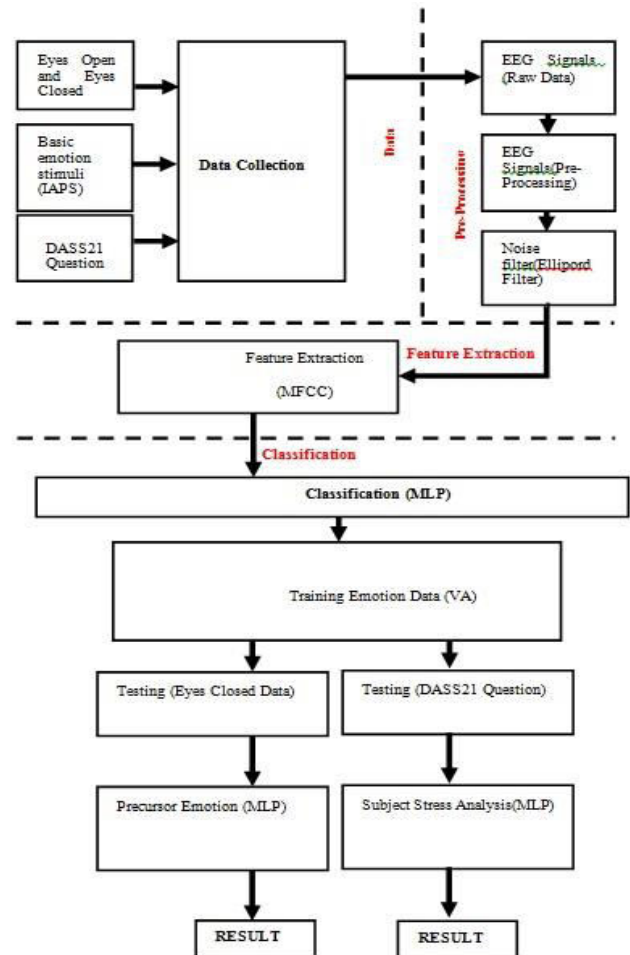


Figure-2. Block diagram of experiment.



EXPERIMENTAL SETUP

To ensure a proper connections and placement of the electrodes on the scalp of the participants, Nuprep electro-gel was used to clean the scalp surface. In order to make the sensors stick well onto the scalp, the Ten20TM conductive gel was used. The viscosity paste is needed to ensure that the gel will not flow easily and yet it can be easily remove. Besides, Ten20TM conductive also helped to further reduce the impedance on the sensors.

Data were collected and divided into two parts. Firstly in order to derive the ASM for each individual basic emotion stimuli were used while EEG signals recorded. Secondly while the subject was answering each question the EEG signals were also recorded. The experimental design flow and protocol is shown in Figure-3 as a generalize experiments.

Notice from Figure- 3 both the eyes open and eyes close will provide initial information about the emotional state of the subject. The purpose of having eyes open and eyes close is for resting state. However in this experiment, we are using eyes close to identify the precursor emotion since it represents the initial emotional state of the subject. To ensure a proper initialization of the brain activity during eyes open task, subject will be looking at a blank white screen. A movie clip which consists of four basic emotions will then be displayed for one and half minute per movie clip representing emotion happiness, fear, calmness and sadness. After each movie clip, the subject was required to fill up the Self-Assessment Manikin (SAM). Finally subject was requested to accomplish a test consisting of DASS21 questionnaire. In this paper, subject was required to answer 21 questions of depression, anxiety, and stress.

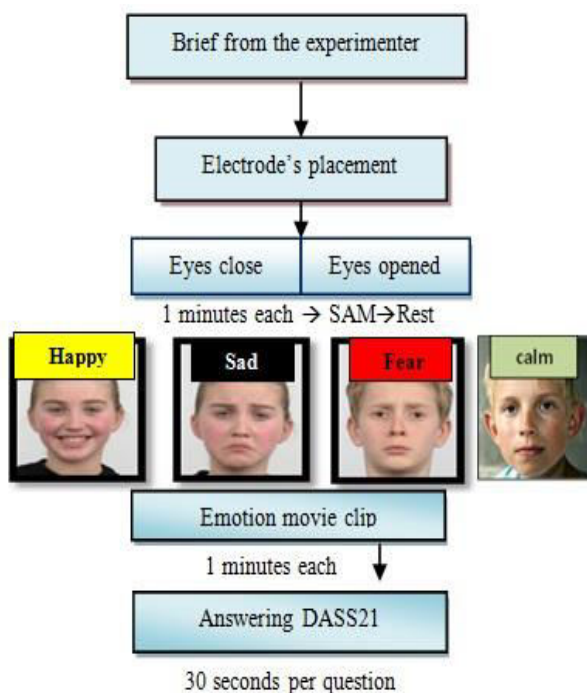


Figure-3. Experimental setup and protocol.

STIMULI

Emotional responses were obtained through emotion's movie and one set of DASS 21 test to identify the teacher stress [15]. Four basic emotions of happiness, fear, calmness and sadness from the International Affective Picture (IAPS) were used to generate the ASM references of each teacher. In order to elicit emotional responses, Gross and Levenson's movie clips and Bernard Bouchard's synthesized musical clips were used [12] prior to teacher doing the mathematics and science tests.

PARTICIPANTS

Ten healthy teachers (five female and five male) were recruited from Sekolah Kebangsaan Taman Universiti 1. Subjects were chosen from the teacher who is involved in the smart learning program in school. Since, we are providing new technology to the teacher and students, thus we tend to identify either the teacher is stressful or not when they have to teach this technology to the students. Since the school project consist of technology that based on Mathematics, Science and English. So the teacher has been selected based on the subject they are teaching.

RESULTS AND OBSERVATION

In this paper only one subject data were analyzed as a preliminary result. Eyes closed data were first analyzed to identify the precursor emotion. Precursor emotion for subject 1 is shown in Figure--4 with combination of calm and sad. Subject seems to have both positive and negative valence also positive and negative arousal while the eyes were closed. In the beginning, subject was showing positive valence and negative arousal which indicates calm emotion. This could mean that the teacher was not sure what to feel and the brain is still having low activation. Then, subject tends to have negative valence and negative arousal which indicates sad emotion. Next, subject showed positive valence and positive arousal which indicates happy emotion. This emotion lasts for 10 seconds. After 10 seconds, subjects tend to have negative valence and positive arousal which indicates fear emotion. These four emotions fluctuate every 10 seconds.

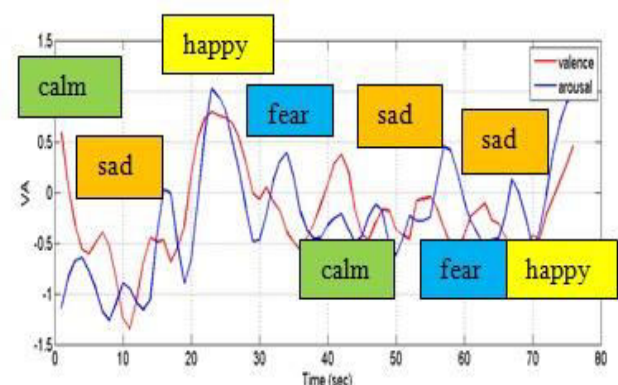
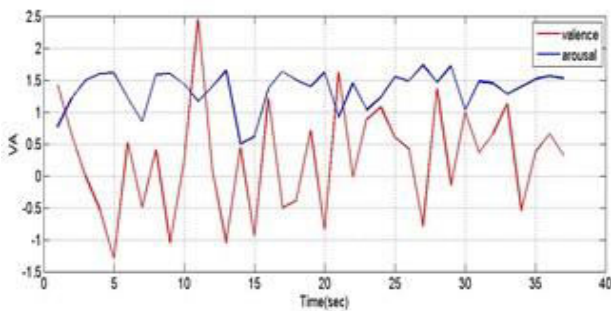


Figure-4. Precursor emotion of subject.

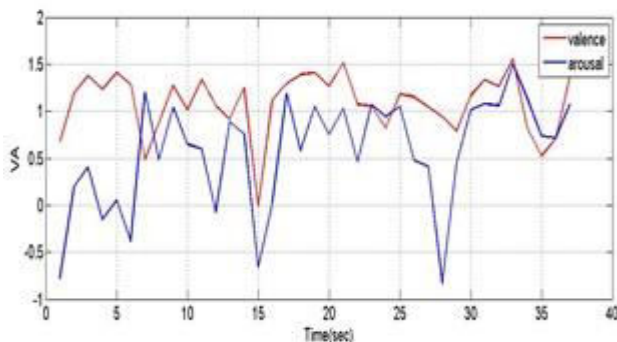
**Table-1.** DASS21 scoring table.

	Depression	Anxiety	Stress
Normal	0-4	0-3	0-7
Mild	5-6	4-5	8-9
Moderate	7-10	6-7	10-12
Severe	11-13	8-9	13-6
Extremely Severe	14+	10+	17+ (18)

Question number 1 is “I found it hard to wind down” [17]. According to question number 1, subject tends to have positive valence and positive arousal which depicts happy emotion. The subject’s emotion fluctuates between happy emotion and fear emotion which showing negative arousal and positive valence. This is shown in Figure-5.

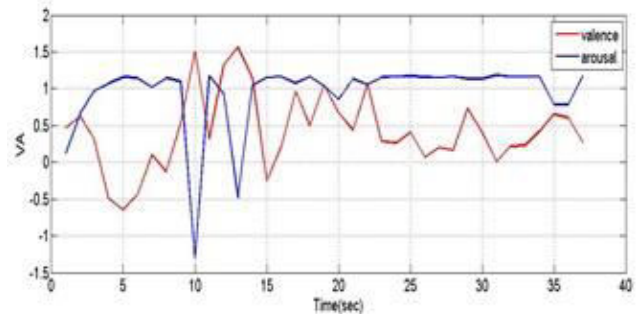
**Figure-5.** Dynamic emotion of subject for question1.

Question number 2 is “I was aware of dryness of my mouth” [17]. For this question, subject tends to have positive valence and positive arousal which depicts happy emotion. The emotion fluctuates between happy and calm emotions which shows positive valence and negative arousal. This is shown in Figure-6.

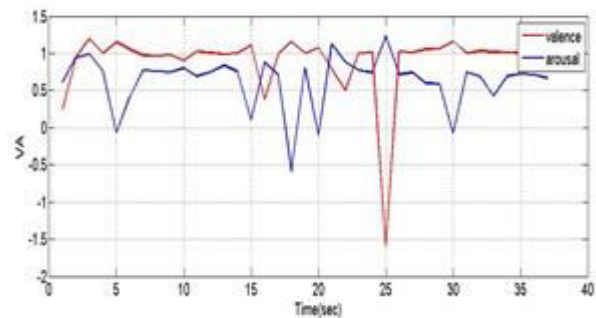
**Figure-6.** Dynamic emotion of subject for question 2.

Question number 3 is “I couldn’t seem to experience any positive feeling at all” [17]. For this question, subject tends to have positive valence and positive arousal which depicts happy emotion. The

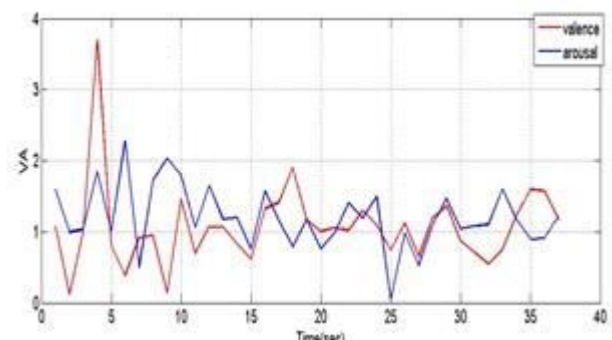
emotion fluctuates between happy, calm emotion which shows positive valence and negative arousal and fear emotion which shows negative valence and positive arousal. This is shown in Figure-7.

**Figure-7.** Dynamic emotion of subject for question 3.

Question number 4 is “I experienced breathing difficulty (eg, excessively rapid breathing, breathlessness in the absence of physical exertion)” [17]. For this question, subject tends to have positive valence and positive arousal which depicts happy emotion. The emotion fluctuates between happy, calm emotions which shows positive valence and negative arousal and fear emotion which shows negative valence and positive arousal. This is shown in Figure-8.

**Figure-8.** Dynamic emotion of subject for question 4.

Question number 5 is “I found it difficult to work up the initiative to do things” [17]. For this question, subject tends to have positive valence and positive arousal which depicts happy emotion. This is shown in Figure-9.

**Figure-9.** Dynamic emotion of subject for question 5.



Question number 6 is “I tended to over-react to situations” [17]. For this question, subject tends to have positive valence and positive arousal which depicts happy emotion. The emotion fluctuates between happy and calm emotion which shows positive valence and negative arousal. This is shown in Figure-10.

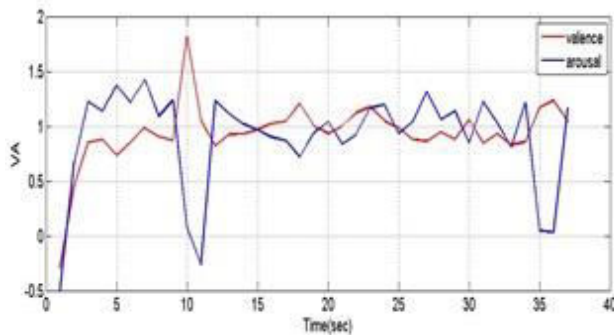


Figure-10. Dynamic emotion of subject for question 6.

Question number 7 is “I experienced trembling (eg, in the hands)” [17]. For this question, subject tends to have positive valence and negative arousal which depicts calm emotion. The emotion fluctuates between calm and sad emotion which shows negative valence and negative arousal. This is shown in Figure-11.

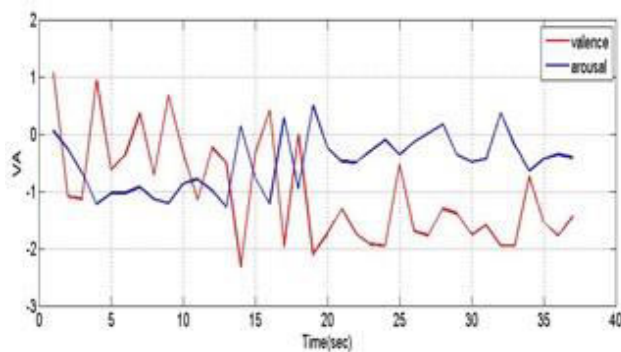


Figure-11. Dynamic emotion of subject for question 7.

Question number 8 is “I felt that I was using a lot of nervous energy” [17]. For this question, subject tends to have negative valence and negative arousal which depicts calm emotion. The emotion fluctuates between sad and calm emotions which shows positive valence and negative arousal. This is shown in Figure-12.

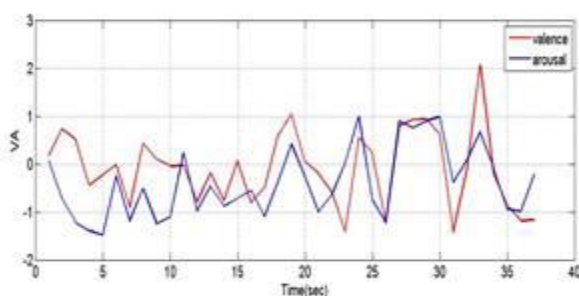


Figure-12. Dynamic emotion of subject for question 8.

Question number 9 is “I was worried about situations in which I might panic and make a fool of myself” [17]. For this question, subject tends to have negative valence and negative arousal which depicts sad emotion. The emotion fluctuates between sad and calm emotions which shows positive valence and negative arousal; and fear emotion towards the end which shows negative valence and positive arousal. This is shown in Figure-13.

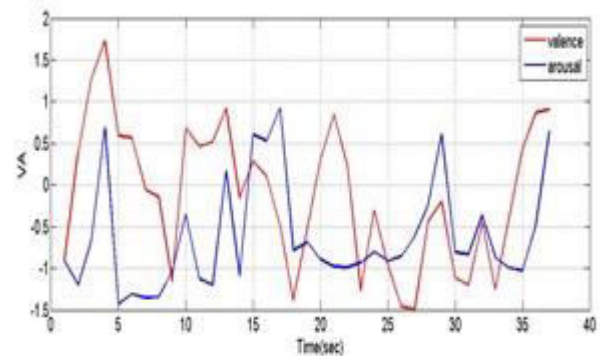


Figure-13. Dynamic emotion of subject for question 9.

Question number 10 is “I felt that I had nothing to look forward to” [17]. For this question, subject tends to have positive valence and negative arousal which depicts calm emotion. The emotion fluctuates between calm and sad emotions which shows negative valence and negative arousal; and fear towards the end which shows negative valence and positive arousal. This is shown in Figure-14.

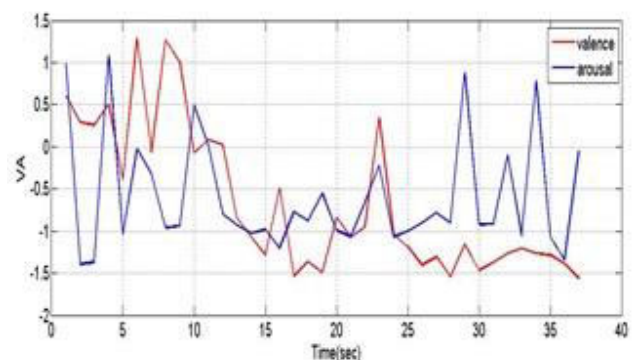


Figure-14. Dynamic emotion of subject for question 10.

Question number 11 is “I found myself getting agitated” [17]. For this question, subject tends to have positive valence and negative arousal which depicts calm emotion. The emotion fluctuates between calm and sad emotions which shows negative valence and negative arousal, and has fear towards the end which shows negative valence and positive arousal. This is shown in Figure-15.

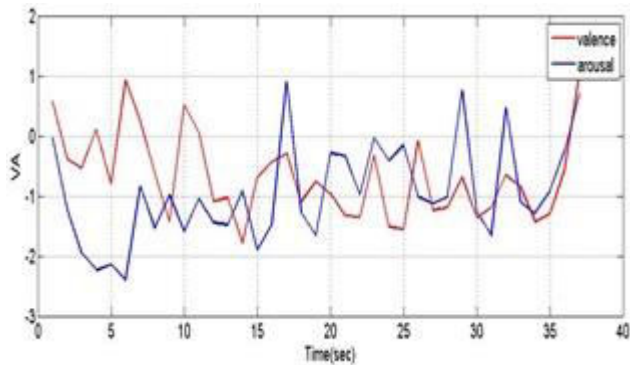


Figure-15. Dynamic emotion of subject for question 11

Question number 12 is “I found it difficult to relax” [17]. For this question, subject tends to have positive valence and negative arousal which depicts calm emotion. The emotion fluctuates between calm emotion and sad emotion which shows negative valence and negative arousal; and fear emotion towards the end which shows negative valence and positive arousal. This is shown in Figure-16.

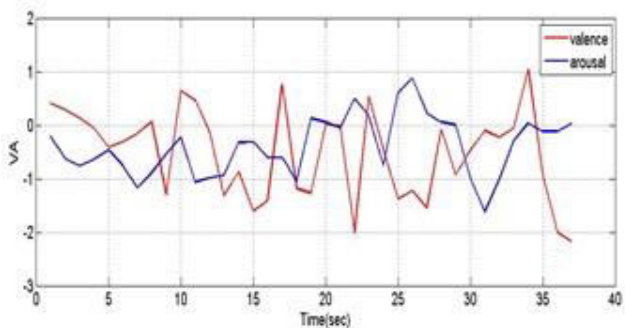


Figure-16. Dynamic emotion of subject for question 12.

Question number 13 is “I felt down-hearted and blue” [17]. For this question, subject tends to have positive valence and positive arousal which depicts happy emotion. The emotion fluctuates between happy and sad emotions which shows negative valence and negative arousal, calm emotion which shows positive valence and negative arousal; and fear emotion towards the end which shows negative valence and positive arousal. This is shown in Figure-17.

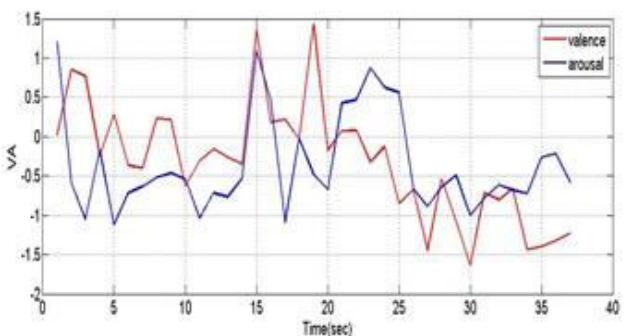


Figure-17. Dynamic emotion of subject for question 13.

Question number 14 is “I was intolerant of anything that kept me from getting on with what I was doing” [17]. For this question, subject tends to have positive valence and positive arousal which depicts happy emotion. The emotion fluctuates between happy and calm emotions which shows positive valence and negative arousal; sad which shows negative valence and negative arousal; and has fear towards the end which shows negative valence and positive arousal. This is shown in Figure-18.

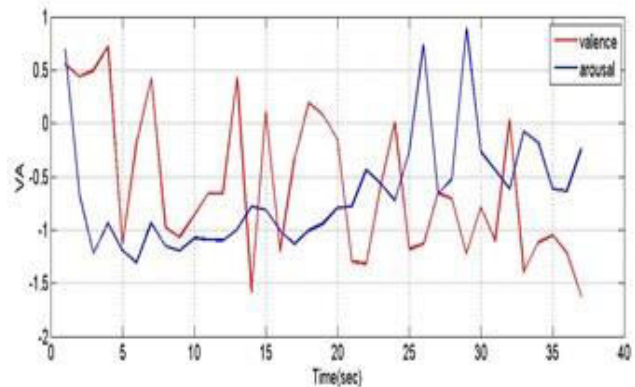


Figure-18. Dynamic emotion of subject for question 14.

Question number 15 is “I felt I was close to panic” [17]. For this question, subject tends to have positive valence and positive arousal which depicts happy emotion. The emotion fluctuates between happy and sad emotions which shows negative valence and negative arousal; and calm emotion towards the end which shows positive valence and negative arousal. This is shown in Figure-19.

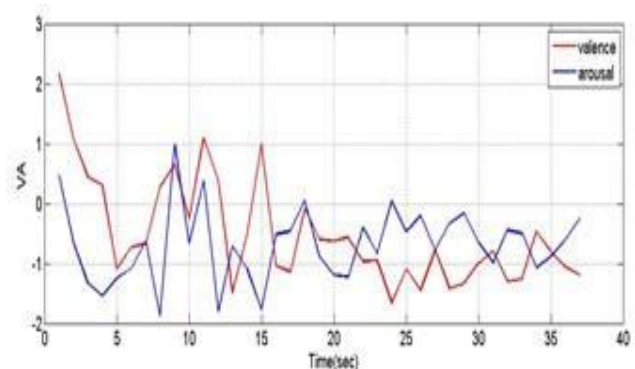


Figure-19. Dynamic emotion of subject for question 15.

Question number 16 is “I was unable to become enthusiastic about anything” [17]. For this question, subject tends to have positive valence and positive arousal which depicts happy emotion. The emotion fluctuates between happy and calm emotions which shows positive valence and negative arousal; and sad emotion towards the end which is showing negative valence and negative arousal. This is shown in Figure-20.

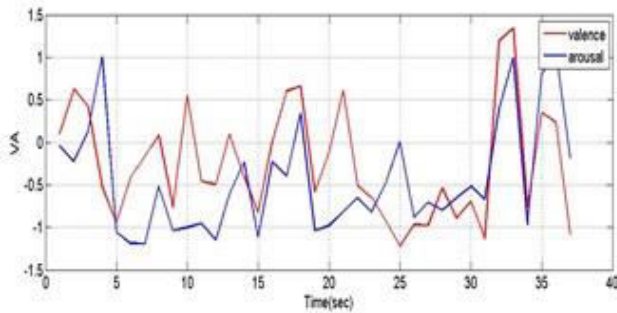


Figure-20. Dynamic emotion of subject for question 16.

Question number 17 is “I felt I wasn’t worth much as a person” [17]. For this question, subject tends to have negative valence and negative arousal which depicts sad emotion. The emotion fluctuates between sad and happy which shows positive valence and positive arousal. This is shown in Figure-21.

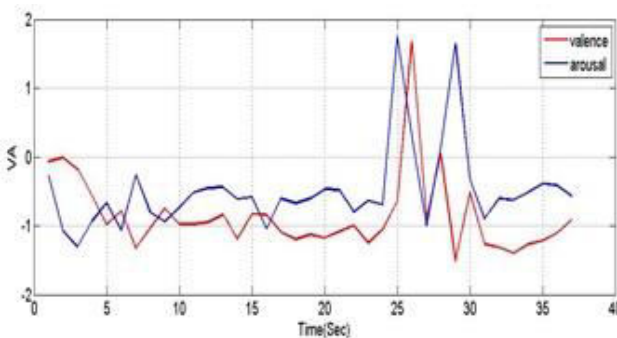


Figure-21. Dynamic emotion of subject for question 17

Question number 18 is “I felt that I was rather touchy” [17]. For this question, subject tends to have positive valence and positive arousal which depicts happy emotion. The emotion fluctuates between happy and sad emotions which shows negative valence and negative arousal; and fear emotion towards the end which shows negative valence and positive arousal. This is shown in Figure-22.

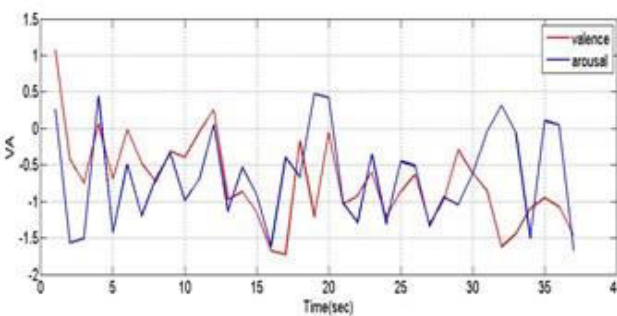


Figure-22. Dynamic emotion of subject for question 18.

Question number 19 is “I was aware of the action of my heart in the absence of physical exertion (eg, sense of heart rate increase, heart missing a beat)” [17]. For this

question, subject tends to have positive valence and negative arousal which depicts calm emotion. The emotion fluctuates between calm and sad emotions which shows negative valence and negative arousal. This is shown in Figure-23.

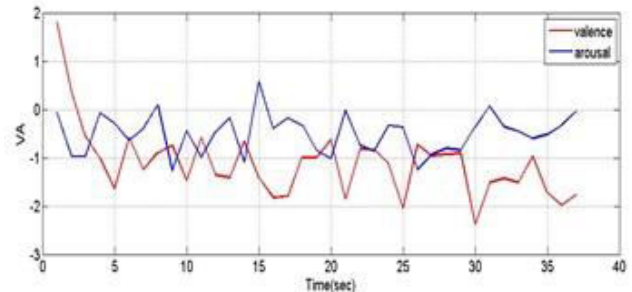


Figure-23. Dynamic emotion of subject for question 19.

Question number 20 is “I felt scared without any good reason” [17]. For this question, subject tends to have positive valence and negative arousal which depicts calm emotion. The emotion fluctuates between calm emotion and sad emotion which shows negative valence and negative arousal; and fear emotion towards the end which shows negative valence and positive arousal. This is shown in Figure-24.

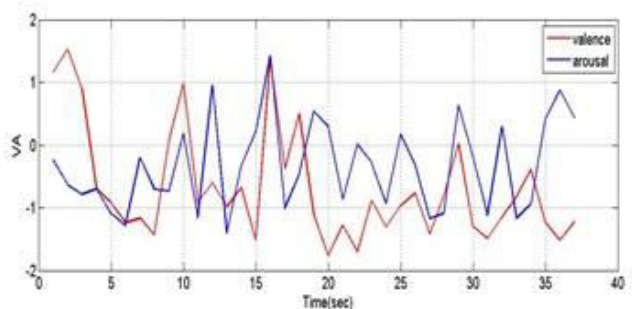


Figure-24. Dynamic emotion of subject for question 20.

Question number 21 is “I felt that life was meaningless” [17]. For this question, subject tends to have positive valence and negative arousal which depicts calm emotion. The emotion fluctuates between calm and sad emotions which shows negative valence and negative arousal. This is shown in Figure-25.

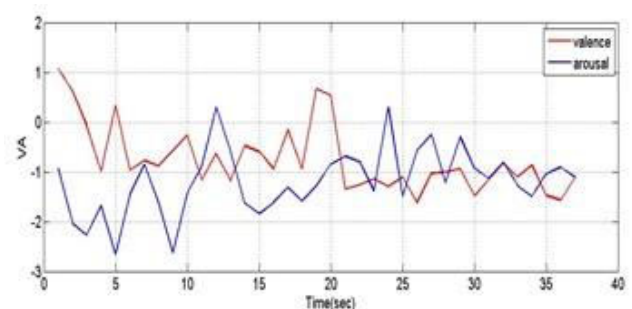


Figure-25. Dynamic emotion of subject for question 21.

**Table-2.** Dynamic emotion result.

Question	Dynamic emotion result
Question 1	Happy, Fear
Question 2	Happy, Calm
Question 3	Happy, Calm, Fear
Question 4	Happy, Calm, Fear
Question 5	Happy
Question 6	Happy, Calm
Question 7	Calm, Sad
Question 8	Calm, Sad
Question 9	Sad, Calm, Fear
Question 10	Calm, Sad, Fear
Question 11	Calm, Sad, Fear
Question 12	Calm, Sad, Fear
Question 13	Happy, Sad, Calm, Fear
Question 14	Happy, Calm, Sad, Fear
Question 15	Happy, Sad, Calm
Question 16	Happy, Calm, Sad
Question 17	Sad, Happy
Question 18	Happy, Sad, Fear
Question 19	Calm, Sad
Question 20	Calm, Sad, Fear
Question 21	Calm, Sad

DISCUSSION

Based on Figure-5 until Figure-25 and Table-2, the first six questions, positive valence and positive arousal which depicts happy emotion appears in all questions. This shows that the subject felt no stress at all. Even though, the subject is having negative valence and positive arousal which depicts fear emotion in question 1 and question 4 but still happy emotions appear in all questions. Perhaps, the first six questions do not induce any stressful thought to the subject. Question 7 and towards the end, the subject is having positive valence and negative arousal which depicts calm emotion for the rest of the questions except question number 17 and 18. However, in question 17 and 18, positive valence and positive arousal which depicts happy emotion appears in this question. Thus, this showed that positive valence appears in all questions. However, the negative valence and negative arousal which depicts sad emotion has conquered the subject's emotion starting from question number 7 to 21 even though happy and calm emotion appear to show that he is having positive valence instead of negative valence and negative arousal. This shows that the subject is in a stress condition because 70% of the emotion appear is sad. The subject might have been stressed due to work abundance in school or the difficulty to handle the new developed technology class.

In table 1, it depicts DASS21 score which the subject has scored 18 which fall into extremely severe stress.

According to precursor emotion, all emotion has appeared during eyes closed task and based on DASS21 emotion appearance, it shows that precursor emotion has also influenced the dynamic emotion of the subject. In precursor emotion, subject tends to have all emotions but sad emotion is the most dominant emotion in precursor emotion since it appears three times in almost 30 seconds. Thus, it has influenced the subject's emotion while answering DASS21 questionnaire since sad emotion is the most dominant emotion in this task.

CONCLUSIONS

In conclusion, the teacher's dynamic emotions show a dominant negative emotion towards answering the DASS21 questionnaire. This could be due to stress condition that has been occurred during the task. Also note from the results that even though the teacher was having positive emotion for the first six questions but he tends to have sad as dominant emotion from question number 7 towards the end. Subject's precursor emotion of sad is reflected throughout experiments indicating an important role of precursor emotion. Consequently, the precursor emotions have a major influence in human emotion since it has existed in our memory for a long time.

Although only one teacher EEG data was analyzed it shows the potential of correlating precursor emotion to subject stress condition. According to the result, it is possible to identify the subject stress according to precursor emotion and teacher's dynamic emotions. Thus, it could help the society especially teachers to trigger stress at the first place and it could also assist the psychologist or psychiatrist to find the best solution to cure the mental stress. In future, we are interested to classify the emotion and teacher's behavior by using fuzzy neural network.

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