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EEG Characteristics of Auditory Comfort Sensibility

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ABSTRACT

EEG(electroencephalogram) is characterized with auditory emotion in this study. Twenty university students participated in this study. The auditory stimulus was the natural sounds such as creek sound, clash, machining noise, and etc. They can cause the positive and negative emotion. EEG characteristics according to positive and negative auditory stimuli is tried to observe statistic difference. The significant difference is shown depending on the localized area. The auditory parameters of EEG variation is examined for defining human emotion qualitatively. The results shows that the alpha and the beta at temporal area may be the determinant of human auditory emotion.

1. INTRODUCTION

Human sensibility can define human comfort state. Parameterizing psycho-physiological response lead industrial product and environment to human comfort. Emotion parameter(or comfort parameter) is introduced to implement this concept to practical application. Parameter extraction in physiological response of human is able to define untangible human psychology. Their application is enormous in industry and in human life quality. Still, emotion parameters demand a lot of research devotion to be defined. Quantification and

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qualification of psychophysiology starts with EEG in this study although experimentation is not clearly standardized.

Human auditory emotion is observed in this study. Physiological response of auditory stimulus can be related to auditory emotion. It is assumed that EEG is the measure of defining auditory emotion. Psychologists showed that EEG laterality exist according to auditory emotional mode. A more positive emotional state was associated with desynchrony of alpha over the left frontal region (indicating high left frontal activation), while right frontal activity was found for a more negative emotional state (Davidson, 1979).

For the auditory observation, perceptual discrimination of music stimuli appears to be accompanied by EEG changes in the direction of alpha desynchronization (Walker, 1980). The right hemisphere is involved to a greater than the left in performance of musical tasks, whereas verbal tasks primarily involve the left hemisphere. Exception may arise, as in the case of musically trained individuals in whom the analytic information processing of music may transform music related activities into a left hemisphere function (Rugg & Dickins, 1982; Davidson, et al., 1990). Therefore, It is generally accepted that the right hemisphere is related with emotion while the left one is with analytical work.

There may be variation of EEG between positive and negative emotion, between the degrees of positive emotion, and between degrees of negative emotion. This study specially investigates the relationship between EEG response and auditory emotion. The stimuli use natural sound which we can frequently listen in our life such as creek sound, clash, machining noise, and etc. This study is to observe the behavior of EEG according to positive and negative auditory stimuli and to characterize the emotional parameters of EEG variation.

2. METHOD

The experimental system is constructed for stimulus and physiological data acquisition as shown Figure 1. The experimental system consists of two main systems such as emotion-evoked system and measurement system of physiological signal. The subject chamber is designed for preventing the interference to the subject from the environment. Its size is width 2m, length 4.5m and height 3m. Inside is floor carpeted, wall papered, deem lightened and room temperature maintained. The reclining chair is prepared and controlled according to the comfortable posture of the subject. Auditory stimulus is presented by 100KW Audio System (Inkel, AVP-8500G). The amplifier is located outside and dual speaker inside the chamber. CD player (Inkel, AVP-8500G) is used for presentation. Frequency and volume of sound is constant during the experiment. The stimulus is prepared as a negative and a positive one. The

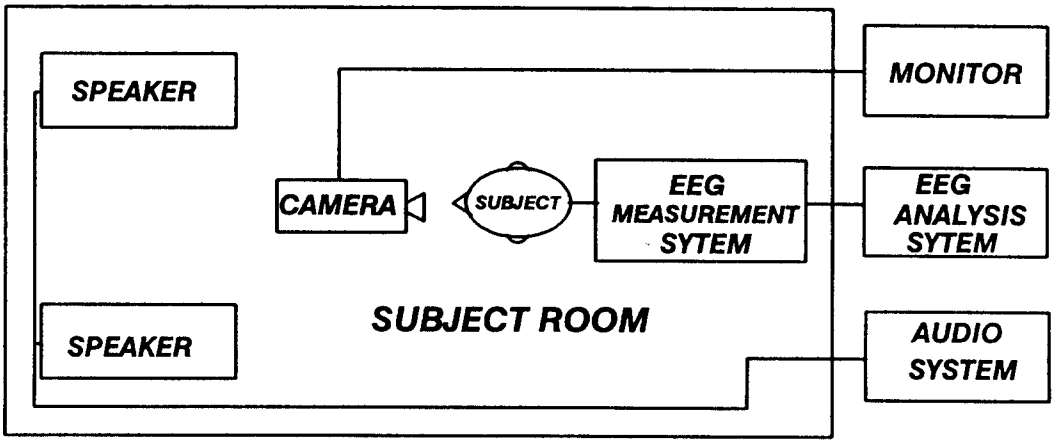

Fig 1. Experimental system.

significances of sounds are sound of creek, cathedral bell, sea wave, car crash, factory noise, and jet engine noise. The stimulus sounds are selected in sound effect CD which is commercially available.

Spectrum 32 D/P EEG measurement system is used for this study. This is modular instrument providing a full range of EEG, quantitative EEG, evoked potential, brain map function. The system is consist of amplifier, PC, 32 channel data aquisition system, A/D convertor, 650MB optical disc, and color monitor.

University students participates in this study. They are healthy and have not auditory sensory problem. They are consist of 10 males and 10 females. They are paid after the experiment.

The electrodes (SH-48, Grass) are placed on cerebrum according to International EEG nomenclature. It is 10-20 System because the various locations are either 10% or 20% of the distance between standard points used for measurement. Electrode gel (Elefix, Nihon Koheden) is used for facilitating electrical transmission. The resistance between the active and reference leads is measured by impedance meter conveniently bullit into the recording device. Recording of EEG is performed when the resistance is less than 5000 Ohms. The resistance level indicate the good attachment of electrode on a scalp.

The subject sits and relaxes on the chair in the chamber. The EEG of the unstimulus state is measured for 2 minute. Then, the stimulus is given for 30 sec. The subject is unstimulated for 2 minutes in order to recover from the previous stimulus. Another stimulus is given after recovery. The presentation of the stimulus takes turns of negative and positive sound. Subjective assessment is performed after experiment is done. The

stimulus is scaled from -5 to +5. If the stimulus is the best, it is scored +5. If the stimulus is the worst, it is scored -5.

3. ANALYSIS

EEG information recorded by each individual electrode is analyzed for its basic frequencies such as delta, theta, alpha and beta. The EEG spectrum can be segmented on both frequency or topographic structure.

The spectral analysis of the EEG requires the choice of epoch length for the EEG, which is usually 2.5 seconds per epoch. Artifacts in the EEG recording is identified and eliminated by epoch performance. The epoch length is inversely related to the width and spacing of the frequency bins, and so temporal resolution can only be obtained at the expense of frequency resolution. A fast fourier transform is used to process the data. The information gathered from each electrode is processed for relative power. Coherence measures are defined between homologuous electrode pairs.

Relative power is scaled in percentages, and ranges from 0.00 to +1.00 (100%). Therefore only the top half of the scale can be used. Relative power is an index of the power accounted for in one frequency band relative to the total amount of power (summed across all frequency bands). The sum of all power is equal to 100%.

The data analyzed in this study consists of the relative power of four frequencies in 21 electrode points on positive and negative auditory stimuli. This data includes the nonstimulus state before positive and negative stimuli. Therefore the data has 4 21 electrode relative power for four states (rest state before positive stimulus, positive stimulus state, rest state before negative stimulus, negative stimulus state). Although six auditory stimuli is presented, only two responses are selected based on the results of the subjective test, in which the results shows maximum positive score and maximum negative stimulus. A particular physiological response to a given stimulus depends on the prestimulus level. This is the law of initial value (Wilder, 1957, 1967, 1976). Therefore, the stimulus state is calculated to normalized value from the unstimulus state such as (stimulus - unstimulus)/ unstimulus. The normalized value indicates percentage change of the stimulus sate form the unstimulus state. It is noted that the unstimulus state is the state before the stimulus. It is used for statistical analysis. The negative response is compared with the positive response at individual electrode for 20 subjects by student pair t-test.

4. RESULTS

The results is described in Figure 2. Figures are mimicked the cerebral top-viewed. The triangle attached indicates the human nose. Therefore, the cerebral areas closed the nose is a frontal area

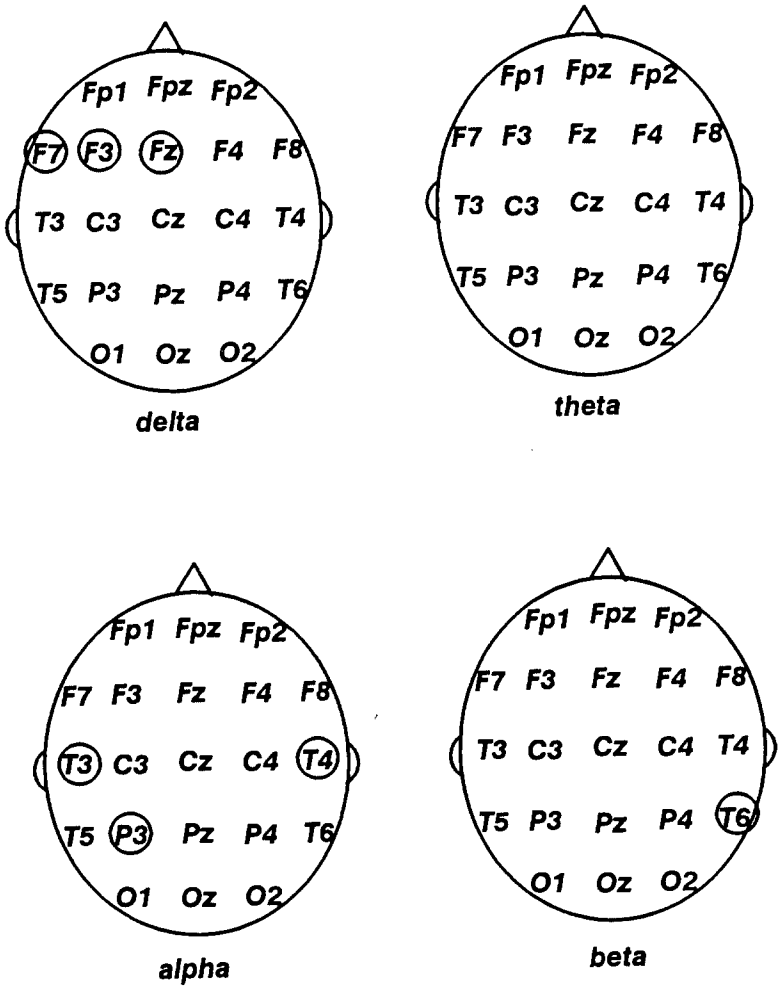

Fig 2. Shown are the top-viewed cerebriums and results of paired t-test. Circled points are less than p=0.05.

and the other side from the nose is a occipital region. The results of student t-test is shown in Figure 2. The circled symbol indicates that p value is less than 0.5. This is the comparison between positive and negative response of percentage change from baseline when negative and positive stimuli are presented respectively. Alpha wave which is dominant at rest shows the differences at T3 (p=0.04), T4(p=0.03), and P3(p=0.05). Left area which is specified by temporal and parietal regions shows significant alpha variation with positive stimulus. Also, right temporal (T4) shows significant variation. Beta wave which is dominant on mental activity shows T6 shows significant difference

between negative and positive response. Beta wave shows significant variation at right posterior region and both frontal region with negative stimulus. Theta wave does not show significant difference. Delta wave shows significant difference at F7(p=0.03), F3(p=0.04), and Fz(p=0.03). Figure 3 shows variation trend of respective EEG wave between positive and negative response. Horizontal line shows local point showing significant difference (P≤0.05) and P, N indicating positive and negative response respectively. Vertical line shows normalized sensibility defined by (stimulus-unstimulus)/unstimulus. The data points are averages(AVG) and standard deviations(STD) of 20 subjects. Therefore, positive values indicates increase from baseline and negative values does decrease. Delta decreases with positive response but increases with negative response. F7 shows relatively strong difference between negative and positive response. Alpha increase with positive response while there is some fluctuation between positive and negative response. T4 is relatively strong point showing difference. Beta increases with both positive and negative response. However, negative response causes more beta increase than positive response. It is interesting that the standard deviation shows wider variation in negative response than in positive response. This is consistent trend in delta, theta and alpha wave.

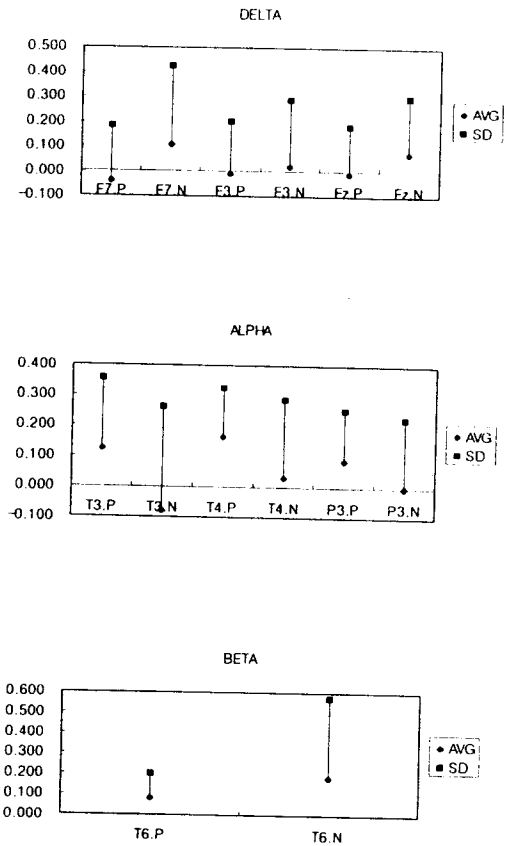

Fig 3. Shown are delta, alpha, beta variation between negative and positive response at local areas showing significant difference (P≤0.05)

5. CONCLUSION AND DISCUSSION

Human sensibility can define human emotion state. Parameterizing psycho-physiological response lead industrial product and environment to human comfort. Emotion parameter is introduced to implement this concept to practical application. Still, emotion parameters demand a lot of research devotion to be

defined. Quantification and qualification of psychophysiology starts with EEG in this study although experimentation is not clearly standardized. Specially selected auditory stimuli cause human positive and negative response. EEG is observed according to the responses. EEG is analyzed and define human emotion by its parameters such as power spectra and local point variation of brain in respective wave, delta, theta, alpha, beta.

Twenty one local point of brain is analyzed for observing difference between positive and negative emotion. Only few points shows difference in the sense of statistics as shown Figure 2. Other points indicate individual difference and emotion fluctuation among people Also, sensibility may not be strong enough to respond. Auditory modality may not be appropriate to those local area of brain. Although results of the other points showing no significance remains many speculations, the few points with significant difference could be high sensible station and could well define the human auditory emotion. The local points are different with respective wave, delta, theta, alpha and beta. Delta shows at left frontal area (F7, F3, Fz), theta at no area, alpha at temporal points of upper parts both ears (T3, T4) and left parietal area (P3) and beta at right posterior temporal area (T6).

Human brain has emotional asymmetry. This study shows frontal asymmetry is dominant in delta, not in alpha and beta. Delta and beta increase in negative emotion. Delta shows left-dominant difference while beta does right-dominant. In positive emotion, alpha increases with left-dominant difference. However, T4 has relatively large increase among local points. Davidson (1979) shows alpha desynchrony over left region with positive emotion. According to him, T3 alpha should less than T4 and so does this study results. Brain activation (beta increase) is right hemisphere with negative response, specially posterior region. P3 alpha increased region is secondary cortex region. It is intersting P3 alpha region may related the fact that the secondary cortex (planum temporale) is larger on the left in right handed people(Kolb & Whishaw, 1996).

Figure 3 shows large variance of mean value since there is individual difference. However, variation trend of standard deviation is the same as one of the mean trend between positive and negative response. Difference of individual response is larger in negative than positive response. Negative stimulus has more individual fluctuation of brain activity than positive stimulus. Positive preference is relatively stable among individuals. Also, EEG during stimulus may show different deviation from mean value between responses. This deviation could control data stability. However, this data stability according to stimulus is not studied and remains to be done.

The parameters of auditory-emotion may be the appearance amount of the alpha and the beta in the temporal area. The alpha is increased with the positive

response while the beta is increased with the negative response. However, the variation of both the alpha and the beta is not reciprocal. That is, the increase of the alpha is not accompanied with the reduction of the beta. The reduction is occurred in the delta, the theta, and the beta, of which statistical variation is not significant between the rest and the stimulus. Therefore, the positive parameter may be the alpha and the negative parameter is the beta, respectively. The alpha and the beta is observed individually for defining the positive and the negative emotion. The quantitative level of the alpha with the positive and the one of the beta with the negative is remained for the future study.

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