International Journal of Medical, Medicine and Health Sciences
ISSN: 2517-9969
Vol:6, No:6, 2012

An Investigation on the Effect of Various Noises on Human Sensibility by using EEG Signal

Wonhak Cho, Jongkwan Lee, Taeyoon Son, Hyeonki Choi

Abstract**—**Noise causes significant sensibility changes on a human. This study investigated the effect of five different noises on electroencephalogram (EEG) and subjective evaluation. Six human subjects were exposed to classic piano, ocean wave, alarm in army, ambulance, mosquito noise and EEG data were collected during the experimental session. Alpha band activity in the mosquito noise was smaller than that in the classic piano. Alpha band activity decreased 43.4 ± 8.2 % in the mosquito noise. On the other hand, Beta band activity in the mosquito noise was greater than that in the classic piano. Beta band activity increased 60.1 ± 10.7 % in the mosquito noise. The advances from this study may aid the product design process with human sensibility engineering. This result may provide useful information in designing a human-oriented product to avoid the stress.

Keywords**—**Electroencephalogram, Human sensibility, Human-oriented product design, Noise

I. Introduction

TODAY, the experiences of stress are common to all living things. And noise is one of the most widespread sources of environmental stress. The effects of noise on human health, the auditory systems, and the development of deafness have been extensively studied since the 19th century [1]. It has been found that noisy environments can cause psychological, physiological, and behavioral stress in people, as well as affect sleep, work efficiency and performance, and communication abilities [2]. The effects of noise vary depending on the characteristics of noise, such as intensity, frequency [3], exposure time [4], form [5], individual age [6], sex [7], and health condition [8]. The effects of noise stressors on the onset and through the course of cardiovascular disease as well as other disease are often suggested to be mediated by a negative emotional effect [9] leading to high physiological arousal [10]. Basic emotions utilize specific cortical and subcortical brain systems, and have been differentiated by regional brain electrical activity and cerebral metabolism activity [11, 12]. Emotionally-laden thoughts associated with stimuli that are environmentally generated are more likely related with the distinct patterns of left and right frontal and anterior temporal EEG alpha activity [13].

Hyeonki Choi is with School of Mechanical Engineering, Sungkyunkwan University, 300 Cheoncheon-dong, Jangan-gu, Suwon, Republic of Korea (phone: +82-31-290-7455; fax: +82-31-290-7455; e-mail: hkchoi@skku.edu).
Wonhak Cho is with School of Mechanical Engineering, Sungkyunkwan University, 300 Cheoncheon-dong, Jangan-gu, Suwon, Republic of Korea (e-mail: suha1976@skku.edu).
Jongkwan Lee is with School of Mechanical Engineering, Sungkyunkwan University, 300 Cheoncheon-dong, Jangan-gu, Suwon, Republic of Korea (e-mail: captainjk@skku.edu).
Taeyoon Son is with School of Mechanical Engineering, Sungkyunkwan University, 300 Cheoncheon-dong, Jangan-gu, Suwon, Republic of Korea (e-mail: sty8702@skku.edu).

Furthermore, the attentional demand of external or internal attention focus on emotional stimuli has led to different brain activation patterns. An underlying assumption in emotion EEG research is that in creased 8-12 Hz alpha activity is associated with decreased cortical activity in that cortical region, and that the relative contribution of the two hemispheres, and regions within the hemispheres, to different emotional states can be inferred by evaluating the relative power of alpha activity [14]. Higher frequency EEG activity appears in many cortical areas and may be indicative of different types of emotional, cognitive and attentional processes [15, 16]. Certain beta frequency oscillations found within specific beta frequency bands are thought to reflect states of neuronal networking of specific cortical and subcortical cell assemblies during which cognitive and sensory inputs are being processed and acted upon. Beta activity, particularly in the temporal region, has been implicated in emotional processing [17, 18].

This study investigates the effect of various noises on brain activity for designing a human-oriented product. This study may provide useful evaluation of various noise effects on physiological sensibility responses.

II. Method

A. Experimental design

The experiment involved six male subjects' aged 26–30 (average 27.2, SD 2.1) years old, whose height and weight were 165-175 (average 168.2, SD 2.5) cm and 57-71 (average 65.2, SD 4.3) free of cardiovascular disease and with normal functional hearing. The subjects were tested in a soundproof chamber. For auditory stimulation, speakers were equally spaced. Each subject remained seated in a chair during the experiment. Each subject was exposed to five noise containing noise levels from approximately 70dB while eye opened (Fig. 1). The time span of the experiment comprised of a relaxation phase in which 10 minutes lacked acoustic content. The relaxation phase was followed by 20 second noise exposure. EEG data were collected during noise exposure.

B. EEG measurement

The methods of EEG-recording and spectral analysis have been similar in the investigations that are presently described.

EEG was recorded with digital equipment (model LXC3203;LAXTHA Inc.) with 4 surface electrodes and locations (Fig. 2) according to the international 10–20 system over frontal (Fp1, Fp2) and parietal (P3, P4) areas. Linked mastoids (A1+A2) were used as reference in the calculation of the power parameters. The impedance was kept along the experiment below 50 kΩ.

Fig. 1 A picture of experimental setup

The EEG signal was sampled at 256 Hz, with cut off frequencies below 0.5 and above 50 Hz. Subjects were asked to minimize blinking, head movement, and swallowing during the experiment. Bad channels were identified by visual inspection, and their voltage values were set to zero. Trials with EEG activity greater than 100 μV were automatically eliminated. The remaining trials were visually inspected, and those with blinks and movement artifacts were eliminated. After the subjects sat quietly for 10 minutes, 20 second of data were collected during noise exposure using stress analysis software. Data were stored in a computer for subsequent review, artifact rejection, and calculation. A customized program was used to perform the review and calculation of data. Power spectra were calculated with fast Fourier transformation (FFT) with a 2.5 s time window, from which an average spectrum of each channel was obtained in each subject. The EEG signals obtained were pre-processing using band-pass filter to classify alpha and beta waves. Then the filtered signals were converted into power spectral density representation by using the LAXTHA software in order to measure the magnitude of each alpha and beta wave.

The power spectral density for alpha and beta wave was obtained by computing the average of power spectral density for alpha frequency that range between 8-13 Hz and calculating the average of power spectral density for beta frequency that range between 13-25 Hz.

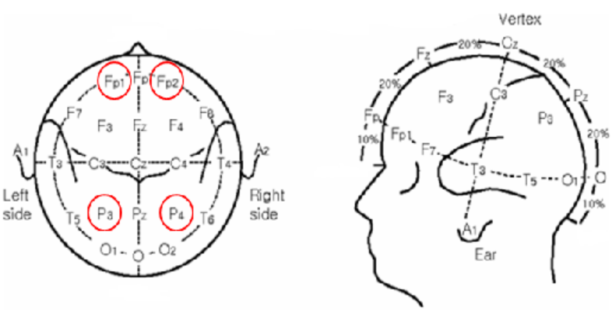

Fig. 2 Locations of surface electrodes

III. Results

In this investigation, study was focused on two types of brain wave which are alpha and beta wave. Alpha wave (8-12 Hz) is an indicator for the development of stress since it is said to be active when the subject feels more relaxed yet conscious. Meanwhile beta wave (13-30 Hz) is associated with fast brain activity caused by higher-order cognitive processing, such as analytical problem solving, judgment, decision making and executive function. EEG alpha band activity was significantly decreased under the mosquito noise as it compared to classic piano. EEG alpha band activity was significantly decreased under the ambulance and mosquito noise as it compared to the classic piano and ocean wave. Alpha band activity (Fig. 3) decreased 5.5 ± 1.2 % in the ocean wave, decreased 13.3 ± 2.7 % in alarm in army, decreased 18.6 ± 2.9% in ambulance and decreased 43.4 ± 8.2 % in mosquito noise. On the other hand, EEG beta band activity (Fig. 4) was significantly increased under the ambulance and mosquito noise as it compared to classic piano and ocean wave. Beta band activity increased 9.5 ± 2.2 % in the ocean wave, increased 29.0 ± 5.9% in alarm in army, increased 40.0 ± 6.8% in ambulance and increased 60.1 ± 10.7 % in mosquito noise.

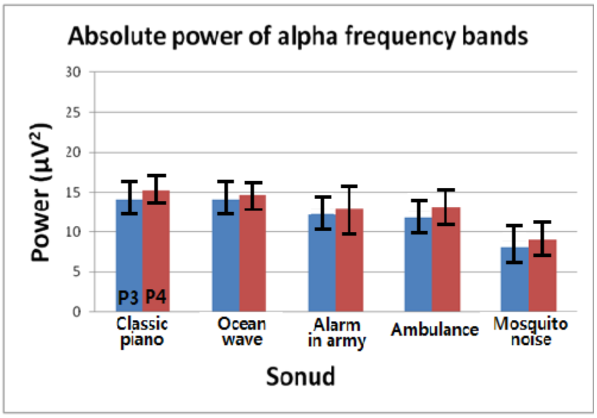

Fig. 3 Absolute power of alpha (8–13 Hz) frequency bands

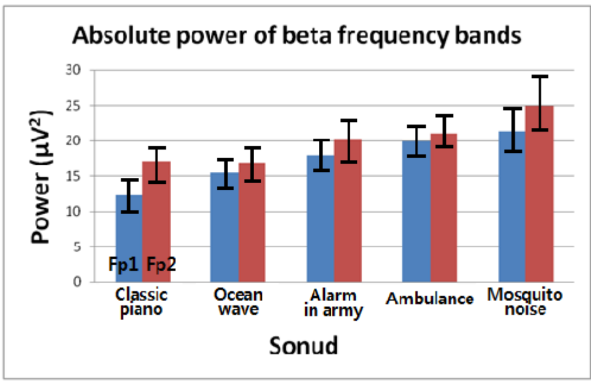

Fig. 4 Absolute power of beta (13–25 Hz) frequency bands

Fig. 5 The subjective evaluation

IV. Conclusions

The results of this study confirm that noise is a definite stressor. This study investigated the effect of five different noises on EEG and subjective evaluation (Fig. 5). Many studies have examined the influence of noise on human physiology and psychology. However, very few studies have examined the effect on human bio-signals. In this paper, we have studied the normal time-dependent variability of the human EEG and the effect of various noises on the EEG spectral components. Additionally, it can be assumed that stress induced by noise causes psychological dysfunction and negatively affects oculomotor responses. Thus, this result may provide useful information in designing a human-oriented product to avoid the stress.

Acknowledgment

This paper was supported by Hyundai-kia motor group, 2011.

References

[1] J. Wagner, M. Cik, E. Marth, B. I. Santner, E. Gallasch, A. Lackner, and R. B. Raggam, “Feasibility of testing three salivary stress biomarkers in relation to naturalistic traffic noise exposure,” Int. J. Hyg. Environ. Health, Vol. 213 No. 2 pp. 153-155, 2010.

[2] I. P. Zalikanova, “Developing vibration-damping spring steels to reduce factory noise,” Metallurgist, Vol. 52 pp. 25-329, 2008.

[3] J. H. Fang, Y. Q. Zhou, X. D. Hu, and L. Wang, “Measurement and Analysis of Exhaust Noise from Muffler on an Excavator,” International Journal of Precision Engineering and Manufacturing, Vol. 10, No. 5, pp. 59-66, 2009.

[4] A. Wallenius, “The interaction of noise stress and personal project stress on subjective health,” Journal of Environmental Psychology, Vol. 24, pp. 167–177, 2004.

[5] V. W. Vermeer, and W. F. Passchier, “Noise Exposure and Public Health” Environ Health Perspect, Vol. 108, No. 1, pp. 123-131, 2000.

[6] S. Uimonen, E. Maki-Torkko, and M. Sorri, “Hearing and occupation,” International Journal Circumpolar Health, Vol. 57, pp. 156-161, 1998.

[7] L. C. Gallo, and K. A. Matthews, “Do negative emotions mediate the association between socioeconomic status and health,” Annals of the New York Academy of Sciences, Vol. 896, pp. 226–245, 1999.

[8] J. Kiecolt-Glaser, K. L. McGuire, T. F. Robles, and R. Glaser, “Emotions, morbidity, and mortality: new perspectivesfrom psychoneuroimmunology,” Annual Review of Psychology Vol. 53, pp. 83–107, 2002.

[9] J. Smyth, M. C. Ockenfels, L. Porter, C. Kirschbaum, D. H. Hellhammer, and A. A. Stone, “Stressors and mood measured on a momentary basis are associated with salivarycortisol secretion,” International Society of Psychoneuroendocrinology, Vol. 23, pp. 353–370, 1998.

[10] Van Eck, M. Berkhof, H. Nicolson, N. and Sulon, J. “The effects of perceived stress, traits, mood states, and stressful daily events on salivary cortisol,” Psychosomatic Medicine, Vol. 58, pp. 447–458, 1996.

[11] R. J. Davidson, “Anterior cerebral asymmetry and the nature of emotion,” Brain Cognit., Vol. 20, pp. 125-151, 1992a.

[12] M. Robert, “Theory of the normal waking EEG: From single neurones to waveforms in the alpha, beta and gamma frequency ranges,” International Journal of Psychophysiology, Vol. 64, pp. 18–23, 2007.

[13] F. Vogel, Genetics and the Electroencephalogram, Springer Verlag, Berlin, Germany, 2000.

[14] L. M. Williams, E. Simms, C. R. Clark, R. H. Paul, D. Rowe, and E. Gordon, The test-retest reliability of a standardized neurocognitive and neurophysiological test battery: ‘‘neuromarker’’. International Journal of Neuroscience, Vol. 115, pp. 1605–1630, 2005.

[15] D. V. Moretti, C. Babiloni, G. Binetti, E. Cassetta, G. Dal Forno, F. Ferreric, R. Ferri, B. Lanuzza, C. Miniussi, F. Nobili, G. Rodriguez, S. Salinari, and P. M. Rossini, “Individual analysis of EEG frequency and band power in mild Alzheimer’s disease,” Clinical Neurophysiology, Vol. 115, pp. 299–308, 2004.

[16] L. K. McEvoy, E. Pellouchoud, M. E. Smith, and A. Gevins, “Neurophysiological signals of working memory in normal aging,” Brain Research: Cognitive Brain Research, Vol. 11, pp. 363–376, 2001.

[17] C. Shagass, Electrical activity of the brain. In: N.S. Greenfield and R.A. Stembach (Eds.), Handbook of Psychophysiology, Holt, Rinehart and Winston, New York, USA, pp. 263-328, 1972.

[18] E. Basar, Chaotic dynamics and resonance phenomena in brain function: Progress, perspectives and thoughts, In: E. Basar and T.H. Bullock (Eds.), Chaos in Brain Function, Springer, New York, USA, pp. l-31, 1990.