Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 06, June-2019

A Preliminary Study of Electroencephalogram during Acute Pain

Shivam Singh, Yudhveer Singh, Shiva Sharma, Kaushiki Mukherjee*
Department of Biomedical Engineering,
Shobhit Deemed University, Meerut

Abstract: **Nowadays, assessment of pain and its control is emerging task that needs to be done by measuring physio-pathological signal. Electroencephalogram (EEG) signal is found as a most reliable means to extract and assess the proper management of hypnosis state of patient including during surgery and other pain inducing for people under controlled anaesthesia, under chronic pain, epileptic seizure etc. Five health male volunteers will be studied for the pain assessment and characterization where, EEG would be recorded during different session of normal and pain induced at different stances. During the study subjects would be given pain on Lunula region of finger for 5 seconds each. EEG recording would be performed from Central region of Brain using 10-20 EEG electrode system. Four different identified EEG parameters i.e. Mobility, Complexity (Hjorth parameters) and Shannon entropy will be computed for both sessions.**

Keywords : Acute Pain, EEG, Hajorth, Shannon

INTRODUCTION:

Pain, as defined by the International Association for the Study of Pain (IASP), is "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage". [1]

There is no direct technique available to measure the pain in rodents and create a need to develop or to search out some alternative medium to quantify and evaluate it. [2] However, Pain is associated with the activation of brain areas including the somatosensory, insular, cingulate, and prefrontal cortices, the thalamus, subcortical areas, and the brainstem [3]. Oscillations of the pain can be seen in different frequency range from slow fluctuations below 0.1 Hz via theta (4–7 Hz), alpha (8–13 Hz), and beta (14–29 Hz) to gamma (30–100 Hz) oscillations [4-11].

Besides, an increase in neuronal activity and cerebral blood flow in the Pain Matrix has been reported to be associated with

pain. Moreover, some of these regions have been shown to encode pain intensity. [12] Evaluation of EEG during pain condition make it essential to analyse it frequency as well as time domain. An EEG signal has a non-stationary property and its frequency feature also varies from individual to individual. Thus, we can infer that each subject has one's own dominant timing and frequency band for extracting distinguishable features. [13] There are several techniques available to compute the parameter in frequency as well as time domain. Among the available computation method Hjorth parameter analysis is a simple computation technique to extract the information from EEG Signal in time and frequency domain both. [14-15]

Therefore, to find out the dominant frequency band and time related information, we used Hjorth and Shannon that helps in extracting the high informative features of EEG. . Then, the feature is used for classification. In this preliminary study, a comparative analysis was carried out to differentiate between normal and painful condition.

METHODOLOGY:

This study was carried out at Department of Biomedical Engineering, Shobhit University, and Meerut. Only five healthy male volunteers were selected after taking the informed consent and explaining the procedure. EEG was recorded five time for each individual to maintain the accuracy of the results during pain and normal condition then averaged. EEG was recorded using BIOPAC MP 36 system from central region of the brain. During study subjects were instructed lay down on the bed in supine position with closed eye in relaxed stage to avoid the external stimulus. Pain was induced by pinching stimulus on finger at the lunula region. Recording was started as soon as the subject received the pain stimulus.

At first, disposable EEG electrodes were connected to the central region of brain with central channel for signal acquisition and amplification using Nasion as reference. In order to find the various parameters a program in Matlab has been developed which digitized the values of all parameters, that could be further used for comparison and variation between normal and pain condition. Comparative analysis of EEG was done under normal and pain conditions. EEG was recorded for every subject in two sessions:

Pain induced through lunula region of finger
(http://darkerebus.blogspot.in/2011/04/lunula.html)

Features/Parameters for Pain Assessment:

The Hjorth parameters introduced by Hjorth (1970), of EEG signal *x(t)*are defined as follows [8]:

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 06, June-2019

$$Activity = var\ (x(t))$$

$$Mobility = \sqrt{activity(\frac{dx(t)}{dt}) / activity(x(t))}$$

$$Complexity = mobility(dx(t)/dt) / mobility(x(t))$$

Where Activity is denoted as the signal power, mobility for mean frequency and complexity as the change in frequency or bandwidth of the signal. The first parameter, i.e. activity represents squared standard deviation of the signals amplitude. Mobility is defined as the square root of the ratio of the activity of the first derivative of the signal to the activity of the original signal. The third parameter, complexity, is defined as the ratio of mobility of the first derivative of the signal to the mobility of the signal itself. The computational cost of this technique is very less as it used variance to find the three parameters [16].

The Shannon entropy can be described in terms of the temporal distribution of signal energy in a given time window. The entropy H of a discrete random variable X with possible values $\{x_1,\ldots,x_n\}$ is $H(X) = E(I(X))$, where E is the expected value and I is the information content of X.

The entropy $H(X)$ of X is defined as

$$H(X) = -\sum_{x \varepsilon X} p(x) \log_b p(x) \quad (4.13)$$

Where, b is the base of the logarithm used and p is the probability distribution function of x. The logarithm is usually taken to base 2 in which the entropy is measured in 'bits'. The entropy of a random variable reflects the degree of disorder that a variable possesses. The more uncertain the variable, the greater is its entropy [17].

The wavelet toolbox was used to determine the Shannon entropy. The **wentropy** function was used to obtain the Shannon entropy to obtain the necessary features from the pre-processed EEG signals. The total feature size obtained is 2 combining both the electrodes.

RESULTS AND DISCUSSION:

Table 1 is indicates Hjorth parameters (Activity, Complexity and Mobility) analysis for all five subjects. Results show considerable changes during pain stimulus thereby distinguishing it from the normal EEG data. For all subjects Activity decreases during pain stimulus. Mobility and Complexity changes are subject specific showing great inter-individual variability.

Table 1 Hjorth Parameter Analysis

	Activity		Mobility		Complexity	
	Normal	Pain	Normal	Pain	Normal	Pain
Subject 1	0.123939 ±0.007826	0.065864 ±0.008749	0.371953 ±0.003991	0.384816 ±0.00402	1.89924 ±0.010681	2.034493 ±0.03586
Subject 2	28.53236 ±0.303902	27.003 ±0.789881	0.340129 ±0.000371	0.338031 ±0.0006	1.44863 ±0.003982	1.424085 ±0.004384
Subject 3	0.5069 ±0.019495	0.410103 ±0.007201	0.345828 ±0.000431	0.357512 ±0.003959	1.657378 ±0.004547	1.756909 ±0.026335
Subject 4	0.025481 ±0.020845	0.016118 ±0.001664	0.219145 ±0.05876	0.195732 ±0.009914	4.413648 ±0.627863	5.241266 ±0.262479
Subject 5	0.00908 ±0.002086	0.006147 ±0.002992	0.2123 ±0.025517	0.31039 5±0.071287	6.751658 ±0.847059	4.634239 ±1.385298

Table 2 is showing the results for Shannon Entropy Analysis and indicate that for most of the subjects there is a rise in information content in the EEG signal corresponding to pain stimulus thereby indicating higher complex mental functions activity.

Table 2 Shannon Entropy Analysis

Subject 1		Subject 2		Subject 3		Subject 4		Subject 5	
Norma l	Pain	Normal	Pain	Normal	Pain	Normal	Pain	Normal	Pain
381.96 ±9.699	281.43 ±22.58	-2128 ±3330.8	-198944 ±6818.34	196.2656 ± 29.43	329.7152 ± 10.972	101.1738 ± 75.09	112.3595 ± 8.67	72.01066 ± 13.00	50.8818 ± 17.57

Our analysis shows good discriminating ability between the normal and pain groups using complexity and mobility. The higher complexity and mobility values observed in pain shows the novelty of the results that can be further helpful for the clinicians in pain analysis and to correlate it with EEG. It also reduces the complexity of the analysis. However sample size shows the limitation of our study and it further need to validate this procedure using large sample size and to record the EEG from other regions of the brain and corresponds them with EEG.

On the basis of the Results, it was observed that during acute pain the complexity of EEG increased. This EEG was distinctly different from EEG in normal individuals. Thereby, we conclude Non-linear estimation of EEG parameters is also helpful to analyse the behaviour of the signal and it can be utilized to study the difference between acute and chronic pain .

REFERENCES:

[1] Cox J. J., Reimann F., Nicholas A. K., Thornton G., Roberts E., Springell K. An SCN9Achannel opathy causes congenital inability to experiencepain.Nature; 2006; 444, 894–898. doi:10.1038/nature05413.
[2] Bennett D. L. and Woods C. G. Painful and painless channelopathies. LancetNeurol.2014; 13,587–599.doi:10.1016/s1474-4422 (14)70024-9
[3] Mogil J. S. Animal models of pain: progress and challenges. Nat. Rev. Neurosci. 2009; 10,283–294.doi:10.1038/nrn2606
[4] Zhang Z.G. Gamma-band oscillations in the primary somatosensory cortex – a direct and obligatory correlate of subjective pain intensity. J. Neurosci. 2012; 32:7429-7438.
[5] Baliki M.N. The cortical rhythms of chronic back pain. J. Neurosci. 2011;31:13981– 13990.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 06, June-2019

[6] Malinen S. Aberrant temporal and spatial brain activity during rest in patients with chronic pain. Proc. Natl. Acad. Sci. U.S.A. 2010;107:6493–6497.
[7] Napadow V. Decreased intrinsic brain connectivity is associated with reduced clinical pain infibromyalgia. Arthritis Rheum. 2012;64:2398–2403.
[8] Alshelh Z. Chronic neuropathic pain: it's about the rhythm. J. Neurosci. 2016; 36:1008–1018.
[9] Green A.L. Neural signatures in patients with neuropathic pain. Neurology. 2009; 72:569– 571.
[10] Huang Y. Characteristics of local field potentials correlate with pain relief by deep brain stimulation. Clin. Neurophysiol. 2016; 127:2573–2580.
[11] Harris R.E., Sundgren P.C., Craig A.D. et al. Elevated insular glutamate in fibromyalgia is associated with experimental pain. Arthritis Rheum. 2009; 60:3146–52.
[12] Apkarian A.V. Human brain mechanisms of pain perception and regulation in health and disease. Eur. J. Pain. 2005; 9:463–484. works. 2009. 22: 1313-1319.
[13] Oh S.H. , Lee Yu-Ri, and Hyoung-Nam. A Novel EEG Feature Extraction Method Using Hjorth Parameter. International Journal of Electronics and Electrical Engineering. 2014; 2.
[14] Kemal K. M. Comparison of STFT and wavelet transform methods in determining epileptic seizure activity in EEG signals for real-time application. Computers in Biology and Medicine. 2005; 35(7):603-616.
[15] Bo H. EEG analysis based on time domain properties. Electroencephalography and Clinical Neurophysiology. 1970; 29(3): 306-310.
[16] Hjorth B. EEG analysis based on time domain properties. Electroencephalography and Clinical Neurophysiology. 1970. 29: 306-310.
[17] Vidaurre C. Kramer N. Blankertz B. and Scholgl A. Time domain parameters as a feature for EEG-based Brain-computer interface. Neuralnet