The Use of Quantitative EEG in Creativity Study with Simple Task

Yunyong Punsawad*, Winai Chathong†, and Yodchanan Wongsawat†
*Department of Electrical Engineering, Faculty of Engineering and Industrial Technology, Silpakorn University
†Department of Biomedical Engineering, Faculty of Engineering, Mahidol University, Thailand
E-mail: yunyong_pd@hotmail.com, dear013ok@hotmail.com, yodchanan.won@mahidol.ac.th

Abstract—This paper proposes three main contributions. First contribution is on a study of brain activity during creativity task by the use of electroencephalogram (EEG). Second contribution is on a simply creativity task in art. Lastly, an information intervention for creative thinking activation is proposed. Quantitative EEG (QEEG) and brain connectivity are analytical methods for studying a phenomenon of creativity. Delta, theta, alpha and beta bands are the indicators of the brain activity. Moreover, phase of EEG is also employed. Prefrontal area of the brain is observed. Parietal area is considered to associate with the cognition. For the results, we can identify the creativity improvement in right frontal (Fp2 and F8) brain locations. Coherence analysis also reveals an effect of the intervention. We hope that this paper is useful for the neurological and cognitive science. The neurofeedback training system for creative thinking enhancement is listed as our future work.

I. INTRODUCTION

Creativity is one of the most common characteristics manifested in a human skills for impetus civilization forward. Naturally, creativity divided into four stages, preparation, incubation, illumination, and verification [1]. Essentially, these mention stages could simultaneously apply brain mechanisms and neuropsychology theory to promote knowledge, motivation, and creative thinking skills [2]. Several researches have been indicated creative ability by using a score of the Divergent Thinking (DT), Remote Associations (RAT), Creative Personality Scales (CPS), Consensual Assessment Technique (CAT), Creative Achievement Questionnaire (CAQ) [3, 4]. However, these processes may not be the most efficient way of prediction. The investigation on creativity research is very challenging research. Neuro-imaging is a research area that invents a tools and technology of medical imaging to serve the clinical and research of the neural system. A cognitive of creativity is complicated process of the brain. Physiological information of the brain such as electro, magnetic and metabolic of the brain is commonly used to study creativity processing. Electrophysiological measuring or electroencephalogram (EEG) is a famous modality for brain phenomenon investigation by using a changing of electrical activities inside the brain. EEG reveals high sensitivity in temporal resolution to the brain response. A relationship between EEG and creativity phenomenon reported useful information to support cognition creativity.

For the previous researches of creativity investigation with EEG modality, EEG modality was used to distinguish the brain localization of creativity. Event-related potential (ERP) is a one kind of EEG signal that is use to investigate the creativity. This technique was early focused on the insight events. Often, it seems associated with creativity. Divergent thinking task was employed to study insight where areas of the brain effected. At frontal and left lateral regions, researchers found P300 activation can affect the creativity, and interpret that systematic, planning, and working memory relevant to creativity. Several reports have been reviewed EEG and ERP data at the right temporoparietal regions and the superior temporal gyrus (STG) including anterior cingulate cortex which are related with creativity domains. In addition, the slow positive wave and 200 to 600ms after stimulus effect to insight in rule solve problem and solution [5].

For ERP, it particularly changes in the amplitude of the N200 during verbal creative task that frequently studied. The divergent thinking increased activity could be able to induce amplitude of N200 on the frontal and anterior frontal areas in left hemisphere. On the other hand the amplitude of N200 increased at the cerebral cortex in the temporoparieto-occipital area of the right hemisphere that creative activity was encouraged. To consider the conceptual expansion, ERP paradigm has been extensively employed to identify. This method was proposed by Kroger et al. who reported conceptual expansion as one critical aspect of creative thinking. ERP components, unusualness and appropriateness, induce conceptual expansion by word pairs which design in the experiment for instance common uses, nonsensical uses, and creative uses. Additionally, stimulation the N400 component responds to function of nonsense or creative uses greater than common uses. Furthermore, ERP later phase (500-900ms) is more activated with nonsensical uses than creative and common uses. There are some researches investigate the relationship between both creativity and intelligence. The difference in ERP parameters (entropy, peak latencies and amplitude) was employed for this study. The regular ERP waveforms showed an intelligent individual while less intelligent individuals presented increased P300 latencies and reduced amplitudes [5].

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Normally, the brain can be anatomically divided into left and right sides. Prefrontal area of brain was observed to identify a logical thinking and creativity. Left prefrontal of the brain reported a logical thinking. Right prefrontal presented emotional and arts cognitive. ERP and QEEG are famous techniques to observe a brain potential development. This paper proposed a study of creativity in art by using QEEG. Amplitude and phase of EEG signal were employed for localization and investigation on response of creativity phenomenon. A QEEG is an analytical tool for brain potential study. We used the brain connectivity for exploration of a pathway of the creativity phenomenon. Besides, this paper has to study of the data intervention or distraction that might be affected to the output by imitation shown in Fig. 1. We aim that this paper can be beneficial to many fields such as art, neuroeducation, neuropsychology, neuromarketing and so on.

II. PROPOSED METHOD

A. A Simple creativity task for Art

For the design of creativity task, a painting of geometric picture was used for activate a creative thinking for art shown as Fig.1 (a). First is calibration part to record the baseline of brain in 10 second. Second is an information intervention activation part. Two interventions are gray and color picture for increasing information before performing a painting task. Each intervention has five pictures. Each picture was presented in 5 second. Last part is the painting task in Fig.1 (b). Subject must paint a color to the assignment in 30 second. In each part, we have to record the EEG in the same time. These EEG signals were process to qualitative of EEG (QEEG) for identification of creativity phenomenon in human brain.

B. Electroencephalogram (EEG)

Electroencephalography (EEG) is a non-invasive tool for the neurobiology investigation by using brain electrical activity. EEG is the most favorable and competent way to collect, process, and analyze brain signals that will employ inferences concerning the brain activity and function. The application of EEG, for clinical use to symptom or disorder diagnose and observation. Moreover, neuropsychological and cognitive science researches were employed EEG for theory and behavioral improvement. Brain-computer interface (BCI) system is a popular application in real-time processing with EEG by connecting between brain and computer. For the observation of creative cognition, it is possible to investigate the creativity of human by employing EEG. EEG-based cognitive neuroscience has been applied, mainly based on event related potentials (ERPs) signal [5]. That is processes during creative tasks which associated with creativity [6]. The study of alpha/theta ratio in neurofeedback training can enhance a performance of creativity [7]. Currently, the literature reviews of qualitative of EEG (QEEG) methods to widespread assist for identifying brain activity and function.

C. Quantitative EEG

QEEG brain mapping [8] is an interpretation of electrical activity within the brain [9]. This technique presents the dynamic changes of brain during processing tasks. In addition, the data from the QEEG is able to assist determining which the processing efficiently brain areas was fully engaged [10]. Commonly, the QEEG recording are compared with the normative statistics of healthy group in an individual’s EEG. Clinical and cognitive research has been applied this tools for investigation the brain phenomena [11]. To consider the depth brain function particular in term of creativity, the features of brain connectivity extremely need to be analyzed.

Fig. 1 Diagram of creativity process with intervention

Fig. 2 (a) A simple task of creativity (Gray color)
(b) Painting task [http://mandalas.coloringcrew.com]
D. Brain Connectivity

QEEG analysis is divided into power and brain connectivity analysis. Power analysis is a measure of the amount of electrical activity at a specific scalp location. This information explains quantity where there are areas in the cortex in order to predict the brain activity in a range of different frequencies. Normally, brain connectivity analysis composes of the coherence and phase lag. Coherence analysis is a measure of the nature brain’s cortex connections between different locations which indicate a capability different area are communicating with each other. Phase lag relates to the speed of shared information between different locations or two sites on the brain’s cortex. These two measures alone provide a wealth of useful information for the brain connectivity analysis [12].

E. EEG Acquiring and Processing

EEG signals were recorded by following 10-20 standard system of electrode placement. The use of Brainmaster discovery 24 for EEG measuring system was performed. The impedance was ranging on 5 to 15 kΩ. For software analysis, we used NeuroGuide software. More than 90% reliable of EEG signal is a requirement. The software can select a clean EEG signal. It can reduce the eye blink and drowsiness period. After that EEG signal will be transformed to frequency domain in EEG bands as Delta (0.5-3 Hz), Theta (4-7 Hz), Alpha (8-13 Hz), Beta (14-25 Hz) and High Beta (26-30 Hz) bands. The powers of EEG bands were used to calculate a quantitative of EEG. The two powers of EEG methods are absolute and relative powers have to present the electrical activity in topographic brain mapping. Moreover, brain connectivity is calculated by both the correlation between each location of the brain and by using a phase of EEG. The investigation of creativity phenomenon employed the absolute power, coherence and phase lag. These are the methods of analytical that can be summarized on a creativity phenomenon for art.

III. EXPERIMENTS

For experiment, 7 healthy volunteer subjects were performed for studying the electrical activity of brain during creativity. There are 4 males and 3 females. They are 22-25 years old. All subjects were record EEG before performing the paradigm. The baseline of EEG used for reference normal state. The brain activity evaluation of creativity is the comparison between power of baseline EEG and creative activation EEG. The changing of power is brain response representation. According to the creativity task Fig. 1 (a), two conditions of data activation were gray and color pictures by the following Table I. We do not consider the detail of picture. We just insert the color information of picture for activation, then study the effect of intervention to creativity phenomenon.

This paper would like to improve the location of brain that response during perform the proposed task. The right side of prefrontal was mainly area of exploration. The brain mapping showed the high and low power of EEG band for each channel. We can observe by a coloring on brain mask. Color definition of EEG band power, green color is a normal range of EEG band power. Yellow and red colors are a higher power than normal range. Blue color is a lower power than normal range. The connectivity line can divide into two features. For coherence, blue line is a lower than normal connection between location. Red line is a higher than normal range. For phase of EEG, blue line is a lower than normal speed for data transfer. Red line is a higher than normal range. Normal speed and connection are non line link to other area. We can explore location, response and the cognitive process of the brain during creative activity.

IV. RESULTS AND DISCUSSIONS

According to the experiment, Fig 4 is the art work during creativity of each intervention condition. Fig. 3 was presented the brain mapping of creativity without intervention and creativity with information intervention. We consider the delta, theta, alpha, and beta EEG bands by focusing on power, coherence and phase lag. We can summarize as follows:

1) According to the results, Fig. 3 (a) is brain mapping of creativity without intervention. Powers in theta and alpha bands have high ranges that mean the power increase during creativity. The location of response is the right frontal area F8. For the brain connectivity, left side of the brain has a low connection. For phase lag, alpha band at parietal area shows a slow rate for data transfer.

2) Fig. 3 (b) is the brain mapping of creativity with gray picture intervention. Power in theta at the right side of frontal and parietal areas showed a high range of power. Power of alpha at parietal area presented a low power that is an anxiety or confusion. This phenomenon may be affected from the intervention. For the brain connectivity, it yields a low connection at left side of theta. For phase lag, it has a slow rate for data transfer in alpha band at the parietal area.

3) Fig. 3 (c) is the brain mapping of creativity with color picture intervention. Power of theta at the right side of frontal and parietal showed a high range of power. Power of alpha at parietal area is similar to gray intervention. Moreover, beta band power at the right side of frontal area has a high power that is the activity of the brain with respect to the intervention. Coherence of theta represents a high connection between each location of the brain that reveals confusion.

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<tr>
<th>Experiment</th>
<th>Information Intervention</th>
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<tbody>
<tr>
<td>1</td>
<td>Non</td>
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<tr>
<td>2</td>
<td>Gray picture</td>
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<tr>
<td>3</td>
<td>Color picture</td>
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The results reported an electrical activity of the brain during perform the creativity task. This result is from one subject that was selected to report shown in Figs. 3 and 4.
In this paper, we have proposed the simple creativity task in art work as well as an information intervention for creative thinking activation. Creativity phenomenon can be analyzed using the QEEG. The results showed that the brain location on the right prefrontal (Fp2) was improved [5]. Besides, the effect of intervention is the confusion or anxiety reported by the power of alpha and beta band at parietal, coherence of alpha, and phase lag of alpha. We hope that this paper will be useful for the neurological and cognitive science. In the future work, we would also like to invent a training system of creative thinking enhancement.

**REFERENCES**


