International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 01 | Jan 2020 www.irjet.net p-ISSN: 2395-0072

Investigation of electroencephalogram signals in different posture during observation of clinical images in angiographic room

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Abstract - *During interventional radiology procedure, radiologists need to observe various images. In that case, radiologists cannot operate the console directly. Therefore, radiological technologists and/or nurses have to manipulate the console instead of radiologists. However, since communication error often occur, optimal images cannot be displayed. Thus, we developed an image manipulation system by use of electroencephalogram signals without touching the console directly in previous study. In that study, that image manipulation system was not verified to be usable in clinical situation. Moreover, examinations in most previous study had never been conducted in clinical situation although brain machine interface is expected to be applies in medical fields. In this study, we conducted the observer study in clinical situation. Moreover, we investigated whether there was difference between the trend of EEG signals in standing and sitting position. As the result of observer study, there were no significant between standing and sitting position at Attention and beta value. However, there were significant differences in standing and sitting position (alpha value at 8 seconds; the ratio of beta and alpha at 3.8, 4.0, 6.2, 6.6, 6.8, 13.2 and 14.8 second). It was possible that the image display system was manipulated in both standing and sitting position by use of EEG signals such as attention which would not be influenced by other brain activity. Moreover, we demonstrated that the image manipulation system developed in previous study could be used in clinical situation.*

Key Words: Brain machine interface, Image manipulation, Electroencephalogram, Angiography, Image display system

1.INTRODUCTION

Radiologists need to observe various clinical images during Interventional radiology (IVR) procedure. Clinical images which is CT images and MRI images and angiography images is obtained by past study. In addition, they have to observe images just obtained by the current examination. Moreover, they have to manipulate catheter minutely. Besides, post traumatic internal organs bleeding must be stopped bleeding as soon as possible. Thus, IVR procedure demands high speed of treatment time in addition to observe various images. Since physicians' hands may not be sanitary throughout the surgical procedure, they cannot handle the console of the image display system directly. In many cases, therefore, technologists and/or nurses manipulate the console instead of physicians. However, communication errors can occur between physicians and technologists. Communication errors can occur even if technical staffs have a lot of experience. Alternatively, radiologists continue the examination without displaying the optimal image when the shortest examination time was needed. Therefore, in previous studies, we had developed an image manipulation system that uses a electroencephalogram (EEG) signals [1]. In previous study, we developed a new manipulation system by use of electroencephalogram signals from observer's head. From this result, we can initiate paging by detect of intentional eye-blink and zooming by intentional mental concentration by use of this system. Experimental conditions in the study room are different from clinical situations in IVR rooms. In previous study, EEG signals have been measured in experiment room and that have never been measured in clinical situation. In future, measurement of EEG signals in clinical situation is needed in order to apply Brain-machine Interface (BMI) technique to clinical situations. Therefore, we conducted this experiment in angiographic room. Moreover, most IVR was operated in standing position. On the other side, in some cases, orthopaedic surgery was operated in sitting position. Thus, investigation of EEG signals in standing and sitting position in clinical situation is needed to apply various operations. In this study, we investigated alpha wave, beta wave and attention value which indicates operator's mental concentration in angiographic room.

2. Material and methods

In this study, we used the MindWave Mobile headset (Neurosky Ltd., CA, US) as the EEG sensor (Fig. 1). The EEG maximum signal input range of this EEG sensor was 3 Hz to 100 Hz, with a sampling rate of 512 Hz [2]. With this device, data can be sent by a Bluetooth connection to a MouseComputer NEXTGEAR-NOTE i420 series W230SS (Windows 8.1, Intel(R) Core(TM) i7-

4910MQ CPU, GeForce GTX 860M). The Raw data obtained as proper value, this value may range from -32768 to 32767. Proper value can be converted to voltage value by using following equation; Raw data * (1.8/4096)) / 2000 [3]. EEG data were obtained in the form of raw EEG data with delta power, theta power, low alpha power, high alpha power, low beta power, high beta power, low gamma power, and high gamma power. eSense was provided by MindWave Mobile. Attention value corresponding to the operator's mental concentration was included in eSense. That value may range of 1-100. However, these values were obtained every one second. Thus, alpha and beta values were derived from raw data by use of fast Fourier analysis, where time window was 512. Therefore, time resolution was improved with every 0.2 seconds. In this study, we focused attention value included in eSense, alpha and beta value derived from fast Fourier analysis. We measured attention value which was used in previous study at standing and sitting position. Moreover, we also measured alpha and beta value corresponding to mental concentration and the state of thought and the ratio of beta and alpha value corresponding to mental concentration. eSense indicates the mental condition such as attention, meditation, blinkstrength, mental effort, familiarity, appreciation, emotional spectrum, cognitive preparedness, creativity and alertness value. Attention value was used in this study to manipulate zooming function. Mental concentration was derived by various method by use of alpha and beta value, e.g., machine learning [4-6]. It was possible that image display system would be manipulate by attention value which could be increased by mental concentration. Therefore, we investigated attention, alpha, beta, the ratio of beta and alpha value in different positions to obtain EEG signals in IVR room. In observer study, observers were in front of the hanging type display (Alphenix INFX-8000C: CANON MEDICAL SYSTEMS CORPORATION, Tochigi, Japan) (Fig. 2a,b). We conducted the observer study in angiographic room by the emergency rescue room at the japan red cross society of Maebashi hospital. There were various sounds from emergency rescue room such as electrocardiograms and doctor's instructions. One case of abdominal computed tomography images was employed in this study, and that images were displayed on the hanging type monitor. Radiologists would not observe an image constantly because they could see other pages when they finish interpretation the image. Thus, Computed tomography image was changed to another page if observer needed to observe another page. Five radiological technologists (3 male and 2 female with 24 to 42 years: mean 29.8±7.2 years, Clinical experience with 2 to 21 years: mean 7.4±7.9 years) participated as observers in this study. We separated observers into two groups, i.e., three observers in group A (2 male and 1 female: Observer 1,2,4) observed in standing position with intensity mental concentration first and then sitting position to obtain EEG signals in IVR room during intensity mental concentration which used in the system of previous study, whereas group B (1 male and 1 female: Observer 3,5) observed in sitting position with intensity mental concentration first and then standing position. Before this observer study, each participant received a 5-minute explanation for this experiment. Moreover, we confirmed whether this device was fitted properly. We measured EEG signals when observers started interpretation with starting signal. EEG signals for each observer were measured ten times for 15 s.

Fig -1: Overview of MindWave Mobile.

Fig -2a: The actual condition of the experiment in standing position.

Fig -2b: The actual condition of the experiment in sitting position.

3. Results

The average attention values in standing and sitting position were shown Fig. 3a,b. Attention values were above the threshold of 65 determined in previous study until 6 seconds in standing position and sitting position. The average attention values in standing and sitting position were compared. Standard deviation of attention values in sitting position were larger than that in standing position. Attention values in standing position were slightly larger than that in sitting position until 14 seconds. Moreover, there was no significant between standing and sitting position at each second ($p > 0.05$: paired two-sample t-test).

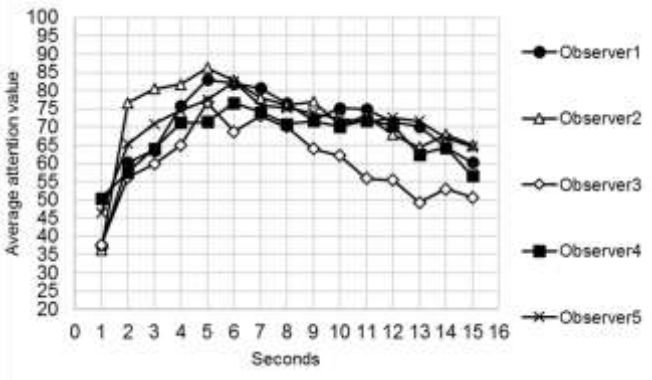

Fig -3a: Variation in average attention values by each observe in standing position for 15 seconds from the start (zero seconds on the horizontal axis) of mental concentration.

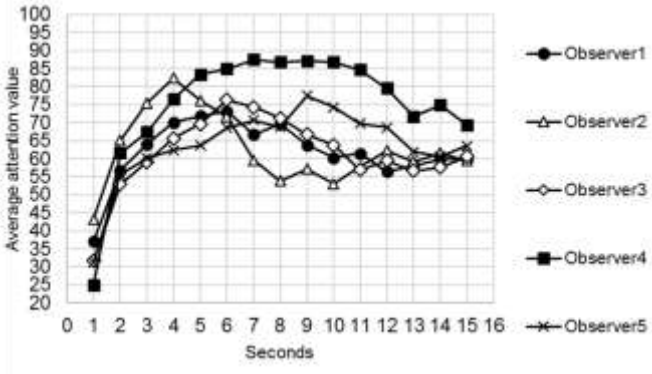

Fig -3b: Variation in average attention values by each observer in sitting position for 15 seconds from the start (zero seconds on the horizontal axis) of mental concentration.

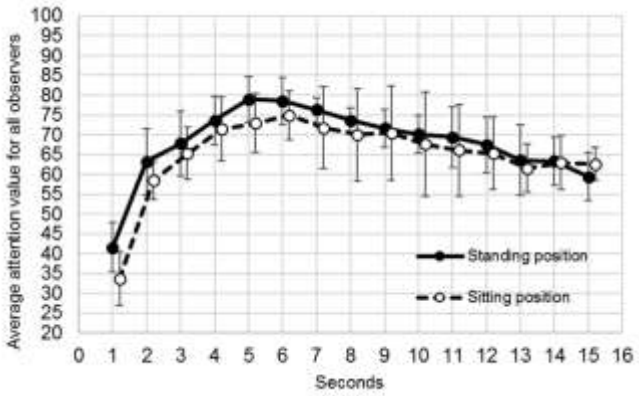

Fig -3c: Average attention value for all observers. There were no significant difference in the average attention value for each seconds between standing and sitting position ($p > 0.05$: paired two-sample t-test).

The average alpha value in standing and sitting position were also compared as shown in Fig. 4a,b. There was quite large individual difference among each observer. Some observers had large difference between standing position and sitting position at alpha value. The average alpha values in standing and sitting position were compared as shown in Fig. 4c. There was no significant between standing and sitting position for almost all seconds ($p > 0.05$: paired two-sample t-test) at alpha value. However, alpha value at 8 seconds in standing position was significantly higher than that in sitting position.

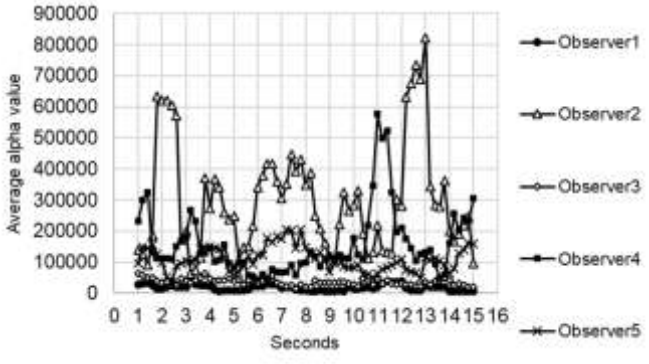

Fig -4a: Variation in average alpha values by each observer in standing position for 15 seconds from the start (zero seconds on the horizontal axis) of mental concentration.

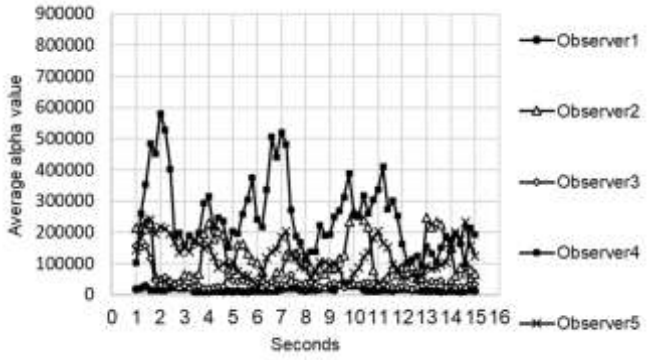

Fig -4b: Variation in average alpha values by each observer in sitting position for 15 seconds from the start (zero seconds on the horizontal axis) of mental concentration.

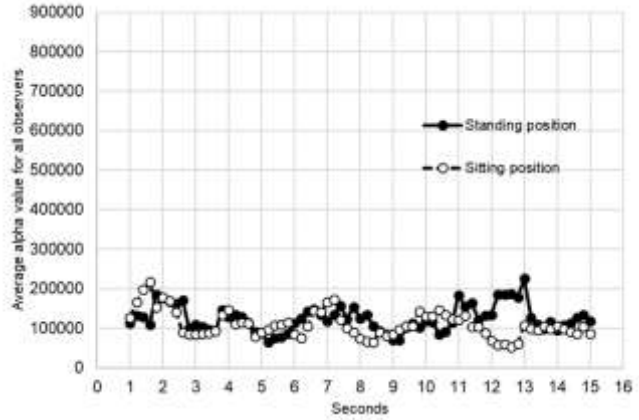

Fig -4c: Average alpha value for all observers. There were no significant difference in the average attention value for each seconds except for 8 second between standing and sitting position ($p > 0.05$: paired two-sample t-test; 8 seconds: $p < 0.05$: paired two-sample t-test) .

The average beta value in standing and sitting position were also compared as shown in Fig. 5a,b. Similar to alpha value, there was quite large individual difference among each observer. Some observers had large difference between standing position and sitting position at beta value. The average beta values in standing and sitting position were compared as shown in Fig. 5c. There was no significant between standing and sitting position each second ($p > 0.05$: paired two-sample t-test) at beta value.

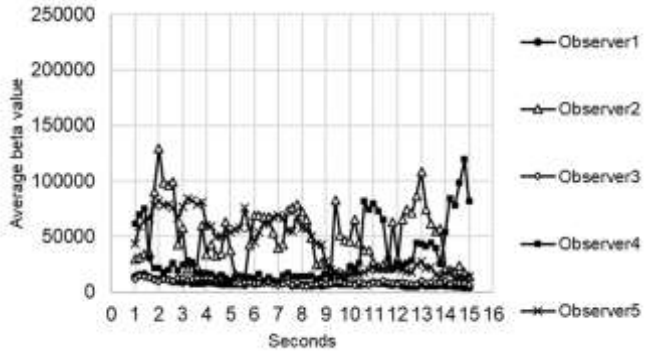

Fig -5a: Variation in average beta values by each observer in standing position for 15 seconds from the start (zero seconds on the horizontal axis) of mental concentration.

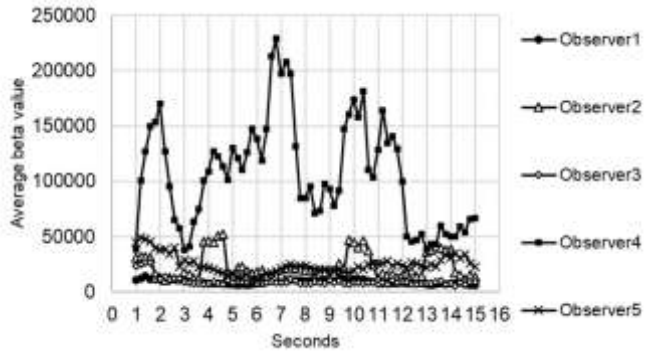

Fig -5b: Variation in average beta values by each observer in sitting position for 15 seconds from the start (zero seconds on the horizontal axis) of mental concentration.

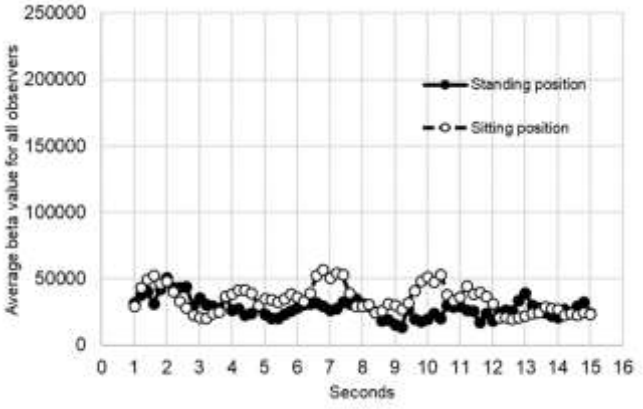

Fig -5c: Average beta value for all observers. There was no significant difference in the average attention value for each seconds between standing and sitting position ($p > 0.05$: paired two-sample t-test).

The ratio of beta and alpha values were derived from alpha values and beta values. The average ratio of beta and alpha value in standing and sitting

position were shown in Fig. 6a,b. Similar to alpha and beta value, there were individual difference among each observer. However, the difference between standing and sitting position of the ratio of beta and alpha value were smaller than that of alpha and beta value (Fig. 4-c,5a-c vs Fig. 6a-c). The average ratio of beta and alpha values in standing and sitting position were compared as shown in Fig. 6c. The amplitude in standing and sitting position was large until 7 seconds. Subsequently, that had random variations. Fig. 3c indicates that attention value continued to rise until 6 seconds. When the amplitude of average ratio of beta and alpha value were large, there might have trend to rise the attention values. There were significant differences in standing and sitting position at 3.8, 4.0, 6.2, 6.6, 6.8, 13.2 and 14.8 second. Although both attention value and the ratio of beta and alpha indicates mental concentration, thus there was large difference between trend of these values.

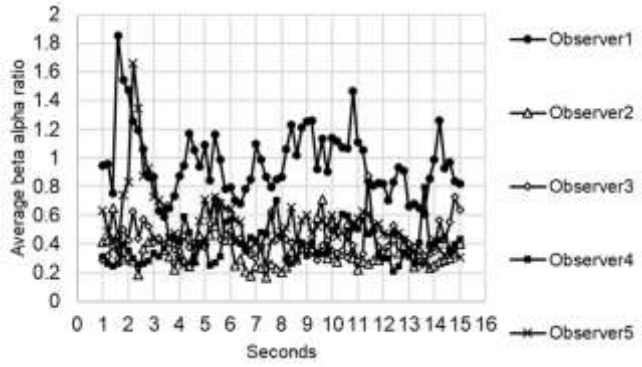

Fig -6a: Variation in average ratio of beta wave and alpha values by each observer in standing position for 15 seconds from the start (zero seconds on the horizontal axis) of mental concentration.

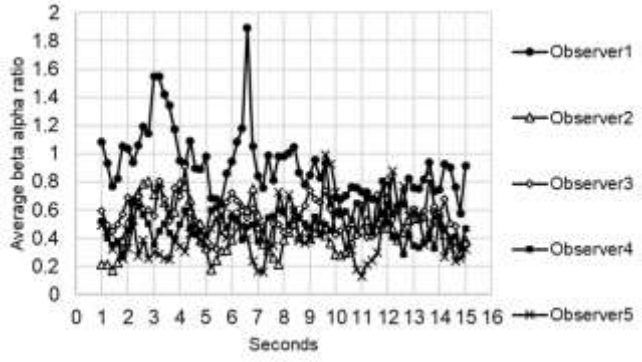

Fig -6b: Variation in average ratio of beta wave and alpha values by each observer in sitting position for 15 seconds from the start (zero seconds on the horizontal axis) of mental concentration.

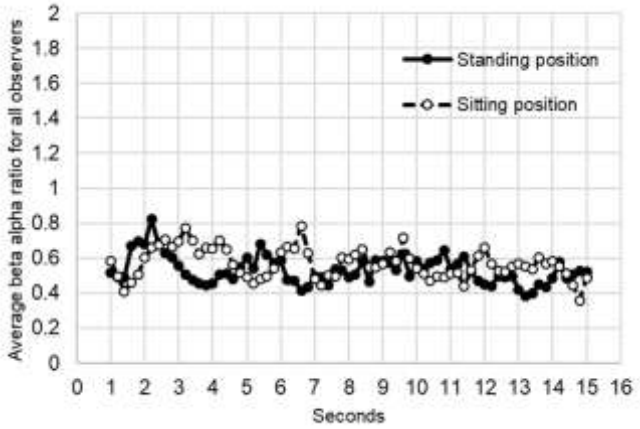

Fig -6c: Average ratio of beta wave and alpha value for all observers. There were no significant difference in the average attention value for each seconds except for 3.8, 4, 6.2, 6.6, 6.8, 13.2 and 14.8 seconds between standing and sitting position ($p > 0.05$: paired two-sample t-test; 3.8, 4, 6.2, 6.6, 6.8, 13.2 and 14.8 seconds: $p < 0.05$: paired two-sample t-test).

3. Discussion

Since there were various sounds in clinical situation in angiography room, observers' mental influence was similar to clinical situation. Moreover, experimental geometric configuration was similar to clinical situation although angiography room was not under examination. Therefore, it is possible to manipulate the system by use of EEG signals developed in previous study in clinical situation. As shown in Fig. 3a,b, although there was individual difference, it is possible to distinguish mental concentration in standing and sitting position by use of threshold of 65 determined in previous study. Moreover, as shown in Fig. 3c, because there was no significant at each second, there was no large difference of attention value between standing and sitting position. Therefore, it is possible to manipulate a computer by use of the threshold of 65 in previous study both standing and sitting position. However, as shown in Fig.4a,b, Fig. 5a,b, Fig. 6a,b, it was quite difficult for understand EEG signal since the variations in individual alpha and beta were very large, moreover, trend of mental concentration was difficult to understand. Because EEG signals could be affected by other kind of brain activities, the trend of mental concentration would be mixed with another trend. Therefore, mentioned in previous study, image display system could not be manipulated by using raw data and/or alpha value and/or beta value. Moreover, because these trends of EEG signals during mental concentration would not be extracted immediately, image display system could not be manipulated by alpha value and beta value. There was no significant difference between standing and sitting position in almost all seconds regarding to alpha, beta and the ratio of beta and alpha value. Therefore, it is possible that trend of EEG signals in standing position

were similar to that in sitting position. However, there was significant in some seconds differ to attention value. The reason of this difference, we considered that brain activities can influence simultaneously EEG signals rather than difference of position. We cannot deny that EEG signals could be easily influenced by other brain activity due to low number of observers with 5 observers. Thus, the value such as attention value derived by trend extraction would not be influenced by other brain activity than raw data and alpha and beta value obtained by frequency analysis. Moreover, that value is simple and comprehensible because that value indicates only operator's mental concentration. The experiment in clinical situation would be needed in future work, although the experimental conditions in the study was similar to clinical situation but the mental concentration in clinical situation was slightly different from that during operation.

3. CONCLUSIONS

Our study highlighted that it was possible to utilize the image manipulation system by use of EEG signals in clinical situation as well as experimental condition. In that previous study, we developed the image manipulation system. Paging which can be controlled by operator's eye blink and zooming which can be controlled by operator's mental concentration could be able to initiate. We would conduct this experiment in IVR room. There was no significant at attention value during observation for clinical images and mental concentration used for manipulating the computer between standing and sitting position. We used the attention value which indicates operator's mental concentration to manipulate image display system. There was no significant difference between standing and sitting position at attention value during observation of clinical images. It was possible that the trend of alpha and beta and the ration of beta and alpha were similar between standing and sitting position. There were no trends either of standing and sitting position. Moreover, the value which would not be influenced by other brain activity such as attention value should be used for simple manipulation of image display system. Therefore, it was possible that the computer was manipulated by use of EEG signals in both standing and sitting position.

ACKNOWLEDGEMENT

The authors wish to thank the students at Gunma Prefectural College of Health Sciences who were participant observers for their assistance in the measurements, members of the Department of Radiology and Clinical Laboratory at Japan Red Cross Society Maebashi Hospital for their helpful assistance, and Mr. Toshinori Watanabe and Mr. Junichi Sato for their useful advice.

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