Study on Synchronization of Brain Waves and Injection Technology

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Keywords: Synchronization, α Wave Band Content, Mean Power Frequency.

Abstract: In recent years, the inheritance to the next generation the skills and know-how which the skilled technician has have become problems. In this paper, we focused the inheritance of technology that nurse injected into the patient among that problems. Compared to rookie nurses, it is often said that a skilled nurse's injection is less degree of pain. It is thought that the reason is that a skilled nurse make a patient relaxed state and reduces the pain of injection. In order to relax the patient state, the authors believe that nurses make themselves relaxed and synchronize their states to the patients. In this paper, we stated the relationship between synchronous and relaxed state in between nurse-patient. In particular, we paid attention to the alpha waves of brain waves to evaluate the state of relaxation, and discussed synchronization of brain waves.

1 INTRODUCTION

In recent years, the difficulty of inheriting the skills trained technician has to the next generation become a problem. We focused on the fact that when rookie nurses and skilled nurses give an injection to patients in clinical setting, skilled nurses can give an injection with less degree of pain (Jung, 2012). Then we have regarded the skill as tacit knowledge and done a study on how to inherit the skill to rookie nurses (Murase, 2000). Figure 1 and 2 show that the conceptual diagrams of failure and success in injection.

The authors believe that there is an effect that the state of relaxation during the injection can relieve pain. Patient's relaxed state could be brought by the state that nurses being relaxed themselves. However, sufficient verification whether a relaxed state can reduce pain or not has not been made.

Also, we are thinking that not only brain wave synchronization phenomena but also α wave is important. For example, if the speaker and the hearer talk with face-to-face in conversation, the former can occur synchronization will be occurred by attracting of the breathing of each other compared with non-face-to-face and communication will become smoothly in many cases (Watanabe, 1998) (Shimizu, 2007).

When the nurses give an injection to the patients, it is inferred that, injection is smoothly done without the pain in that state which the synchronization phenomenon of brain waves, so-called breath-matched occurs. In other words, skilled nurses attract α wave to the patients by giving α wave themselves and using the synchronization phenomena. So we consider "α wave and synchronization phenomena can reduce the pain of injection".

Therefore, it is considered that (1) To clarify the relationship of α waves and synchronization phenomena and pain, (2) To review of technology inheritance technique are necessary to inherit the injection technology.

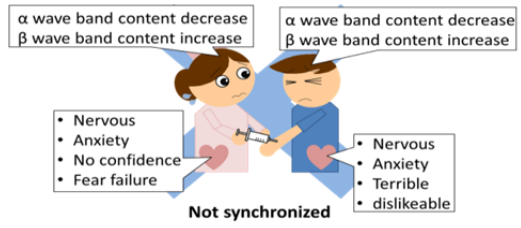

Figure 1: Conceptual diagram (failure).

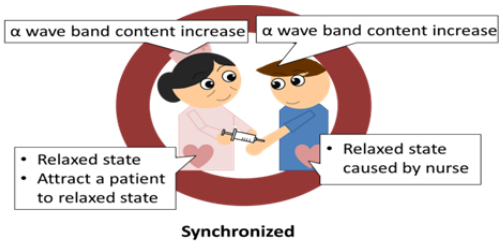

Figure 2: Conceptual diagram (success).

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For the purpose of conducting the verification of (1), we analysed with experiments on brain wave synchronization and injection in this paper.

2 SYNCHRONIZATION PHENOMENA

Human society is made up to take the communication people who had the personality involved in complex. In the communication, such as the rhythm of speech and behavior of each person is unsynchronized in the same way as personality, but gesture or nod during a conversation evokes "synchronization" which attracts each other unconsciously. Previous psychological studies have shown that this synchronization can improve the efficiency of the collaborative work and increase empathy with others (Shiga, 2004). However it is not clear that the mechanism which causes the synchronization and the synchronization is specific between people communication (or bio together). On the other hand, as well as the synchronization of the visible behavioral rhythm such as gestures, in order to realize the cognitive functions such as thinking and memory, the human brain has also been active in synchronization with a rhythm of a certain nerve cell population. These synchronizations are detected as a brain wave rhythm. In recent years, advances in measurement technology of brain wave rhythm, the study of social related to communication is also progressing. But to analyze the brain activity of one individual is still the main research issue. What synchronization of the brain between individuals of more than one brain is and mostly the relationship actually remains unknown.

In this paper, we focused on synchronization in power system. In the power system defining synchronizations that multiple synchronous generator kept at a constant value of the frequency of the alternating electric, and they are running with maintaining the synchronization. We thought the idea of synchronization of the power system can be applied for the synchronization of the multiple brains of human beings. Therefore, about the synchronization between individuals of multiple human brains we regarded a brain wave's rhythm as a synchronous generator. And we defined the synchronization of brain wave rhythm as the consistency of the value of the frequency values shown in Chapter 3.

3 VERIFICATION EXPERIMENT OF THE SYNCHRONIZATION OF BRAIN WAVES

3.1 Experimental Outline

As described in the previous section, the authors believe that there are two points involved in the difference of failure and success in injection. That is, a synchronization of brain waves and relaxed state. Also, we believe this synchronization to be implemented in a relaxed state. To verify the hypothesis, a pseudo clinical setting and three subjects who obtained their consent to the experiment are provided. However, a practice arm model was used on a desk, instead of the actual arm, for ethical issues. And the injection was carried out at the model. At that time, the patients were indicated to look at the model as their arm. Thus, classification wasn't done by pain but the success or failure of injection. Here success means that the needle is properly inserted into a blood vessel of the model. Failure means that a case it is not.– And we measured changes in the brain waves both of nurse and patient with setting the electrode of electroencephalogram measurement system on their occiput in two places and both earlobe when they perform the procedure of the injection. We show a conceptual diagram of the experiments in Figure 3.

3.2 Used Equipment and Measuring Method

The used instruments were as follows.
-Electroencephalogram measurement system
-Syringe
-Practice arm model

We were decided that two of the three persons of the subject were the nurses, and made a combination of three sets in the patient part and nurses. Then we conducted an experiment for this combination to do injection into the practice arm model. The procedure was performed for 5 times for each combination.

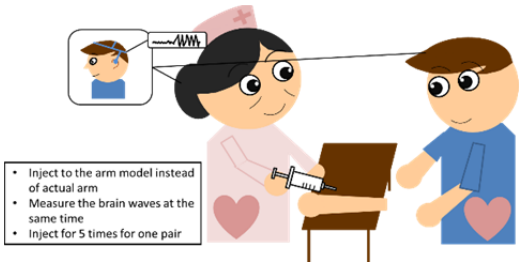

Figure 3: Conceptual diagram of the experiments.

Then it was analyzed by the method described below for the measured brain waves.

-α wave band content (Kawakami, 2008)

To evaluate the relaxed state of the subject, we determined the content of the α wave band. The brain waves are different in each frequency of brain waves. α wave band (8 ~ 13Hz) content is a percentage of component of α wave of brain wave.

-MPF(Mean Power Frequency) method (Matsuda, 1997)

We broke down the measured brain waves into frequency components with performing a Fast Fourier Transform (FFT) to 25 (Hz) in the 1 (Hz) distance. At that time, a value obtained by averaging the spectra of each frequency is called Mean Power Frequency. In this paper, we represented the state of the brain and brain wave frequency value which is determined by this equation.

The equation of MPF was shown in the following.

$$\mathrm{MPF} = \frac{\sum_{f=fl}^{fh} f * p(f)}{\sum_{f=fl}^{fh} p(f)} \quad (1)$$

Here, *fl*, *fh* represents the frequency analysis section and *fl* is minimum interval, *fh* is maximum interval, *p* represents the power spectrum.

4 EXPERIMENTAL RESULT

2 nurses is as N-1, N-2 , 3 patients is as P-1, P-2, P-3, we show the measurement results for each combination (N-1:P-1 、 N-1:P-2 、 N-2:P-3). We show the results of the injection and combination of nurses and patients in Table 1.

Table 1: The results and combination.

	N-1:P-1	N-1:P-2	N-2:P-3
1st	Failure	Success	Success
2nd	Failure	Failure	Success
3rd	Failure	Failure	Failure
4th	Success	Success	Success
5th	Success	Success	Success

4.1 Case N-1: P-1

In the procedures of five times trial, it succeeded twice, failed three times in the combination of N-1:P-1. We show an example of the time change of MPF below during the procedure of each of the success and failure at the time. In addition, we show the average value of α wave content in each of the case.

4.1.1 Injection Success

Figure 4 shows an example of a time change of the MPF of the brain waves when the procedures of injection were successful in combination N-1: P-1. Red line represents the P-1, blue line represents N-1 in the figure.

4.1.2 Injection Failure

Figure 5 shows an example of a time change of the MPF of the brain waves when the procedures of injection were failure in combination N-1: P-1. Red line represents the P-1; blue line represents N-1 in the figure.

4.1.3 A Wave Band Content

Figure 6 and 7 show the average value of α wave band content of N-1 and P-1 during the procedure of injection in twice succeeded attempts and three failed attempts.

4.2 Case N-1: P-2

In the procedures of five times, succeeded three times, failed twice in the combination of N-1:P-2. We show an example of the time change of MPF during the procedure of each of the success and failure at the time below. In addition, we show the average value of α wave content in each of the case.

4.2.1 Injection Success

Figure 8 shows an example of a time change of the MPF of the brain waves when the procedures of injection were successful in combination N-1: P-2. Red line represents the P-2; blue line represents N-1 in the figure.

4.2.2 Injection Failure

Figure 9 shows an example of a time change of the MPF of the brain waves when the procedures of injection were failure in combination N-1: P-2. Red line represents the P-2, blue line represents N-1 in the figure.

4.2.3 A Wave Band Content

Figure 10 and 11 show the average value of α wave band content of N-1 and P-2 during the procedure of injection in three times succeeded attempts and

twice failed attempts.

4.3 Case N-2: P-3

In the procedures of five times, succeeded four times, failed once in the combination of N-2: P-3. We show an example of the time change of MPF during the procedure of each of the success and failure at the time below. In addition, we show the average value of α wave content in the each of the case.

4.3.1 Injection Success

Figure 12 shows an example of a time change of the MPF of the brain waves when the procedures of injection were successful in combination N-2: P-3. Red line represents the P-3, blue line represents N-2 in the figure.

4.3.2 Injection Failure

Figure 13 shows an example of a time change of the MPF of the brain waves when the procedures of injection were failure in combination N-2: P-3. Red line represents the P-3, blue line represents N-2 in the figure.

4.3.3 A Wave Band Content

Figure 14 and 15 show the average value of α wave band content of N-2 and P-3 during the procedure of injection in four times succeeded attempts and once failed attempts.

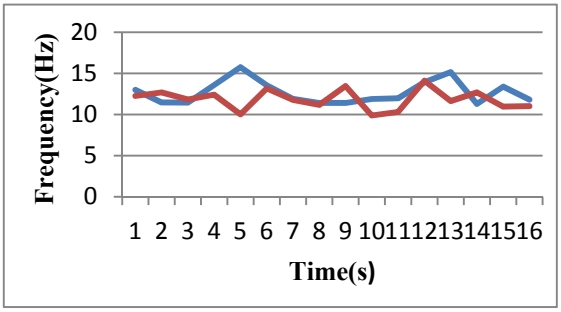

Figure 4: Time transition of MPF (N-1: P-1: success).

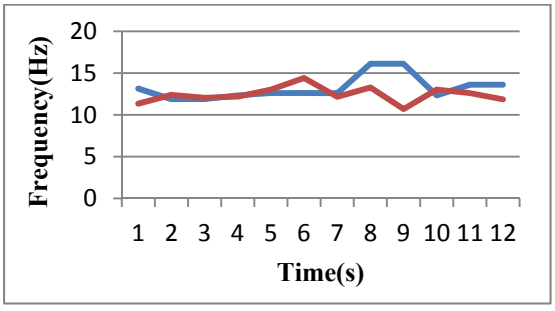

Figure 5: Time transition of MPF (N-1: P-1: failure).

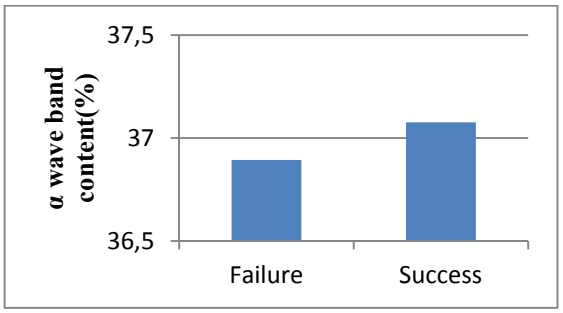

Figure 6: Average value of α wave band content (N-1).

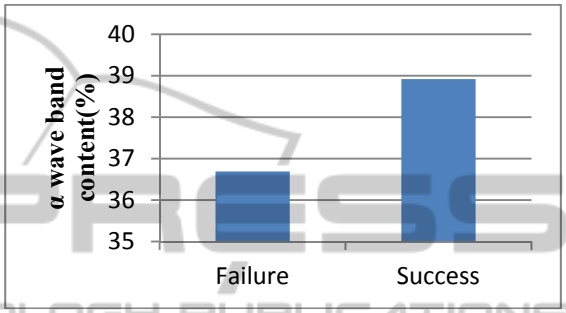

Figure 7: Average value of α wave band content (P-1).

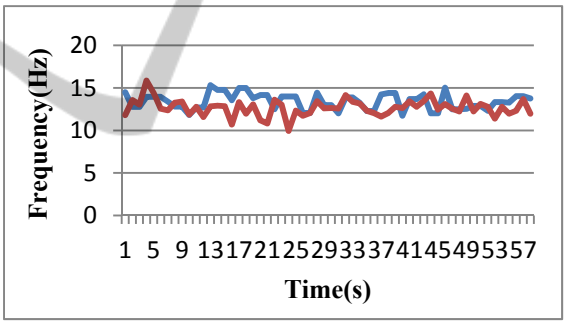

Figure 8: Time transition of MPF (N-1: P-2: success).

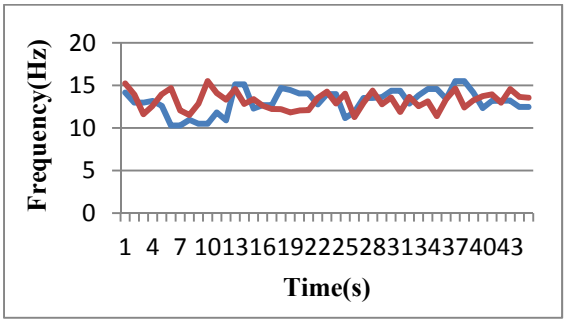

Figure 9: Time transition of MPF (N-1: P-2: failure).

4.4 Discussion

We showed the time change of MPF of the brain wave of nurses and patients in the success and failure of the injection in Figure 4 and 5, 8 and 9, 12

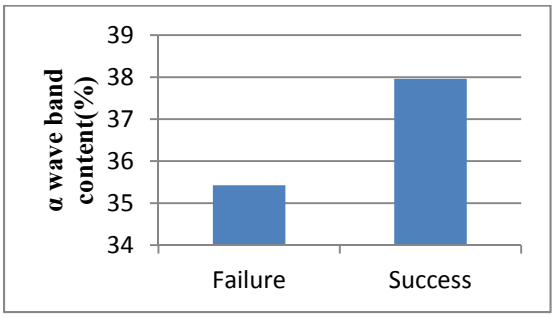

Figure 10: Average value of α wave band content (N-1).

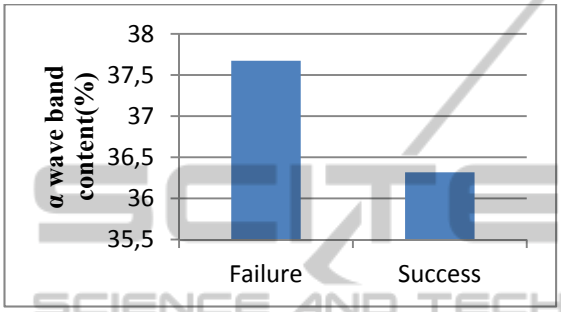

Figure 11: Average value of α wave band content (P-2).

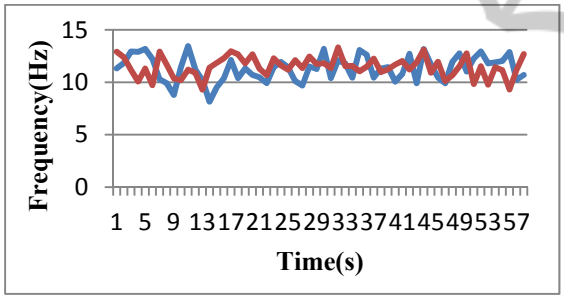

Figure 12: Time transition of MPF (N-2: P-3: success).

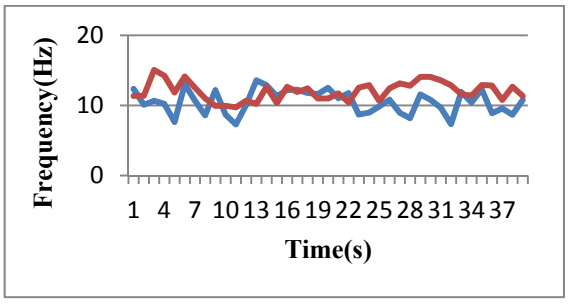

Figure 13: Time transition of MPF (N-2: P-3: failure).

and 13. However, a regular trend such as the consistency of the value (definition of synchronization in this paper) was not seen at the time of the success and failure. That is, it is considered that synchronization phenomenon wasn't going in the case where it has been successful since the value of MPF didn't change with the value

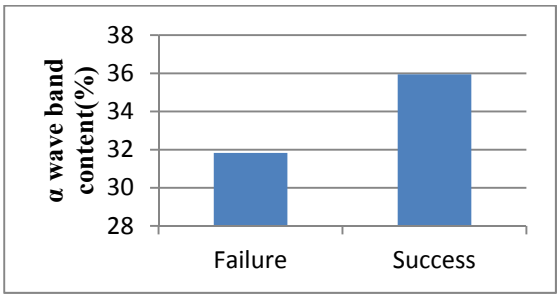

Figure 14: Average value of α wave band content (N-2).

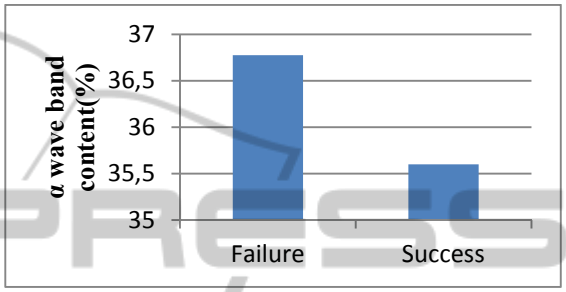

Figure 15: Average value of α wave band content (P-3).

matching between nurses and patients. Two points are considered as the reason. The first is that because the definition of synchronization in human brain wave is different from the definition of synchronization in power system. In this experiment, we have defined synchronization between brain waves referring to the power system, but we thought that there is a need to consider the definition of synchronization to suit the characteristics of the human brain waves. The second is that the synchronization between brain waves has not occurred in the successful injection. In this paper, we conducted the experiment assumed that the success or failure is related to the synchronization of brain waves. However, it is considered that the synchronization of brain waves is not always related to the success or failure of injection. As the reason, it is considered that the procedure was carried out at the arm model instead of the actual patient's arm. Therefore, less influence of the patient's feelings didn't bring synchronization phenomenon. For the same reason, regular trend of patients wasn't seen in this experiment. Next, α wave band content of subjects are shown in Figure 6 and 7, Figure 10 and 11, Figure 14 and 15. When the procedure is successful, a trend that α wave band content of nurses are higher is seen compared to the failure. From this result, it is considered that nurses can give injection successful when they are relaxed and the success or failure of the injection is affected by the mental state of the nurses.

5 CONCLUSIONS

In this paper, we examined the relationship synchronization of brain waves and injection technology. Experiments were performed for the injection to the arm model, and we defined the synchronization of brain waves by reference to synchronization of power system. Then we analyzed for the α wave band content and synchronization of brain waves. As a result, we found that the nurses those who had high α wave band content leads to the success of the injection. So we will establish the definition of the synchronization of brain waves considering the characteristics of the brain waves of humans and explore the trend of brain waves for a patient upon injection in the future.

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