Inter-brain Synchronization between Nurse and Patient During Drawing Blood

Tsuneo Kawano[1], Yukie Majima[2], Yasuko Maekawa[3], Mako Katagiri[4] and Atsushi Ishigame[2]
[1]*Faculty of Science and Engineering, Setsunan University, Ikeda-Nakamachi, Neyagawa, Osaka, Japan*
[2]*Graduate School of Engineering, Osaka Prefecture University, Naka-ku Gakuencho, Sakai, Osaka, Japan*
[3]*Faculty of Nursing, Kansai University of Social Welfare, Shinden, Ako, Hyogo, Japan*
[4]*Technology Research Institute of Osaka Prefecture, Ayumino, Izumi, Osaka, Japan*

Keywords: Nursing Skills, Tacit Knowledge, Blood Drawing, Nurse and Patient, EEG, Alpha Wave Band, Synchronization.

Abstract: Tacit knowledge such as "proficient skills" and "knacks" in nursing skills seems not to be applied by nurse alone but by the interaction between nurse and patient. The purpose of this study is to analyze their interaction from the point of interbrain synchrony. In this study blood drawing technique was adopted as nursing skills and experiments of drawing blood were carried out in nurse-patient pairs. Experimental participants were 4 nurses and 6 patients. The brain waves in the occipital portion of nurse and patient were simultaneously measured using portable EEG devices during drawing blood. The ratios of alpha-band power were calculated for each of the nurse and patient, and the cross-correlations were obtained between every pairs of them. The results indicated that the brain waves of patient were synchronized with those of nurse by several seconds behind. Furthermore the synchronization was not recognized in abnormal circumstances that nurses failed in the drawing blood.

1 INTRODUCTION

Tacit knowledge such as "proficient skills" and "knacks" in nursing skills seems not to be applied by nurse alone but by the interaction between nurse and patient. Evaluation of nursing skills is assumed to depend on the interaction. Therefore, it is important to reveal the interaction between nurse and patient in order to build a learning support system for the nursing skills. The purpose of this study is to analyze their interaction from the point of interbrain synchrony.

The perfect nursing skills could ease patient's pain or fears by the proficient technique and good communications with the patient. If the relations between the perfect nursing skills and interbrain synchrony of nurse and patient are successfully quantified, proficiency level of beginning nurse can be evaluated by the interbrain synchrony. It means that quantification of the interbrain synchrony between nurse and patient could contribute to establish entirely-new learning support system for beginning nurses. Thereby decrease of medical errors and increase of patient's safety are also expected.

Recently the research regarding "inter-brain synchronization" came to be conducted. Dumas et al. discovered that states of interactional synchrony correlate with the emergence of an interbrain synchronizing network between two persons who are engaged in spontaneous imitation of hand movements (Dumas et al., 2010). Regarding the persons who are watching a movie, Kauppi et al., suggested that several regions within the frontal and temporal lobes showed inter-subject correlation predominant-ly at low frequency bands, whereas visual cortical areas exhibited inter-subject correlation also at higher frequencies (Kauppi et al., 2010). Hari et al. introduced the synchrony of brains and bodies during implicit interpersonal face-to-face interaction (Hari et al., 2013).

Neurobehavioral studies of interaction of nurse and patient are few because of difficulties to measure brain waves during working. Our previous study has successfully attempted to measure the brain waves of nurse and patient simultaneously

Kawano, T., Majima, Y., Maekawa, Y., Katagiri, M. and Ishigame, A.
Inter-brain Synchronization between Nurse and Patient During Drawing Blood.
DOI: 10.5220/0005825605070511
In *Proceedings of the 9th International Joint Conference on Biomedical Engineering Systems and Technologies (BIOSTEC 2016) - Volume 5: HEALTHINF*, pages 507-511
ISBN: 978-989-758-170-0

during blood drawing task (Maekawa et al., 2013). The differences in the changing state of tension or concentration between nurses and beginners from the EEG data were discussed. One of the remarks was that nurses were in a state of concentration with calm during the injection performance. In another study it concluded that the increase of alpha-band power had to do with the successful injection operation (Kishida et al., 2015).

In this study blood drawing technique was adopted as nursing skills and experiments of drawing blood were carried out in nurse-patient pairs. The brain waves in the occipital portion of nurse and patient were simultaneously measured using portable EEG devices during drawing blood. The ratios of alpha-band power were calculated for each of the nurse and patient, and the cross-correlations were obtained between every pairs of them.

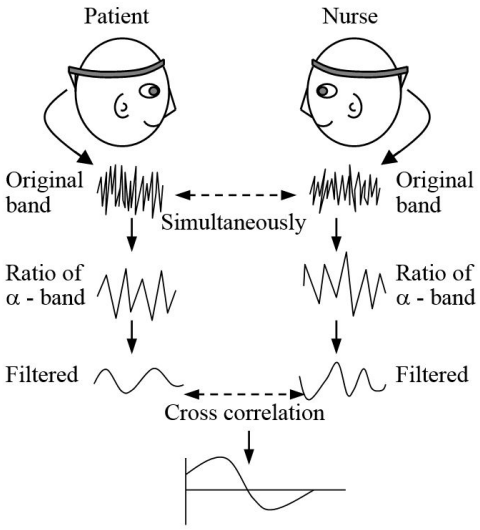


Figure 1: General concept of inter-brain synchronization between nurse and patient.

2 EXPERIMENTAL METHODS

Participants for nurses were 4 women in their thirties and forties. They have over 8 years of nursing experience. Participants for patients (5 men and 1 woman) were in their twenties.

After the ethical committee of the institute reviewed the study protocol, the authors explained ethical considerations to participants and obtained written consent before the study.

Blood drawing was actually conducted using three kind of intravenous injection trainers (Adam,Rouilly Limited) instead of actual arm of the patients. One of them was a type of arm shape. It was an easy trainer model A to draw the blood because a blood vessel had come to the surface of the skin. Another one was a same type but it was a difficulty trainer model B because of invisible vein. The other one C was a fit-on type of wrapping human arm, which had a realistic feeling. These types of arm model were employed to investigate the effect of the nurse's performance to the synchronization between nurse and patient.

There were 14 pairs in combinations of nurse and patient. The trials of drawing blood were repeated 5 times with each pair. Muse Brain System (Digital Medic, Inc.) was used to measure the brain waves. This was a portable EEG device with a single electrode for occipital cortex. The electrode was set at the midoccipital point (Oz in the International 10-20 System) (Teplan, 2002).

Figure 1 shows general concept of inter-brain synchronization between nurse and patient. Firstly, original brain waves were measured simultaneously for the nurse and patient during drawing blood. The original data were transformed into a frequency domain signal by Fourier transform every second. Secondly, the ratios of alpha, beta, delta band power were calculated every second. Thirdly, the ratio data were smoothed by a second-order Butterworth filter to distinguish the trend. The cut off frequency was set to 0.1Hz. Finally, the relation of the alpha-band between nurse and patient was evaluated by using the following cross-correlation function $C(\tau)$ in every pair (Watanabe et al., 2004).

$$C(\tau) = \frac{\sum_{i=1}^{n-\tau} \{x(i) - \mu_x\}\{y(i+\tau) - \mu_y\}}{\sqrt{\sum_{i=1}^{n} \{x(i) - \mu_x\}^2} \sqrt{\sum_{i=1}^{n} \{y(i) - \mu_y\}^2}} \quad (1)$$

Where μ_x and μ_y are the mean values of x and y, respectively, x and y is for nurse and patient, respectively, n is the number of data, and τ is time delay.

In general the changes of ratios of alpha and beta band power are in opposite phases like a seesaw. Therefore human state of tension or relax can be investigated with either of the alpha or beta band power. In this study alpha band power is taken into consideration. Actual measured data of alpha band power are discussed in the next chapter.

Figure 2 shows experimental appearance. The nurse is going to prick with a needle to the arm model. The patient gazes at the arm model.

3 RESULTS AND DISCUSSION

Figure 3 shows the changes of ratio of the alpha and beta band power measured from a nurse n1 during drawing blood. As mentioned before, it is found that their changes have mutually reverse-phase relations.

Figure 4 shows an example of time variation of ratio of alpha band power in pairs of nurse n2 and patient p2. In this case time delay τ is 9 seconds, and cross correlation coefficient becomes maximum 0.326. The graph indicates that the ratio of alpha band power (component of relaxation) of patient is almost synchronized with that of nurse by 9 seconds behind.

Figure 5 shows examples of cross correlation function. Figure (a) is the successful case in drawing blood. The functions become largest at τ =2, 3, 7, respectively. It means that alpha band of the brain waves is synchronized between nurse and patient at that delay. Figure (b) is the case of the first trial in a pair of nurse and patient and the failure case in drawing blood. In these cases large plus cross-correlation values do not exist. Due to the nerves of nurse and patient at first trial and the failure of drawing blood with repeated insertion of the needle, it is assumed that the brain rhythms are disturbed.

Table 1 shows the results of all trials in pairs of nurse and patient. In the table success or failure of the drawing blood, synchronization or non-synchronization, and time delay are listed. Synchronization or non-synchronization is decided by 5% significance level. In table 1 on the trials of synchronization due to the success, the marks of the double circle are displayed. On the trials of non-synchronization due to the failure, the marks of the single circle are displayed. The marks of dotted circle are displayed in case of the first trial and non-synchronization in spite of the success. In the 9 trials synchronizations do not occur due to the failure of drawing blood. In the first trials in pairs of nurse and patient, synchronizations do not often occur even if the trials are successful. It is considered that it is caused by the tension of nurse and patient because of the first combination. The percentage of non-synchronization in case of the first trials or failure drawing blood is 76.5%.

In the case of the 32 trials, synchronizations occur due to the success of drawing blood. When the patient felt anxious or fearful, synchronization did not occur even if the drawing blood was successful. The marks of “anxious” or “fearful” are displayed on the table. The patients tend to feel fearful when using a fit-on type arm model C because of the realistic feeling. The percentage of synchronization

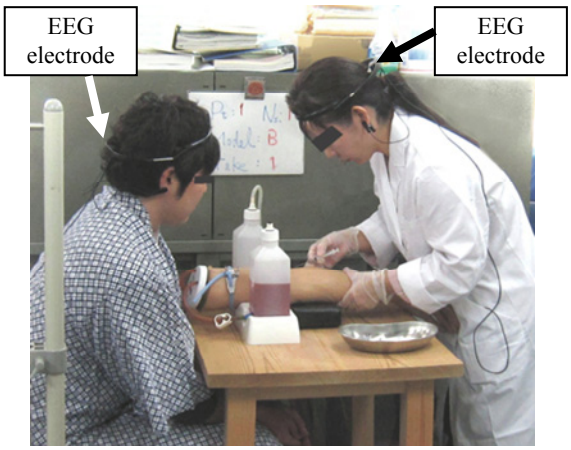


Figure 2: Simultaneous measurement of brain waves for nurse and patient during drawing blood.

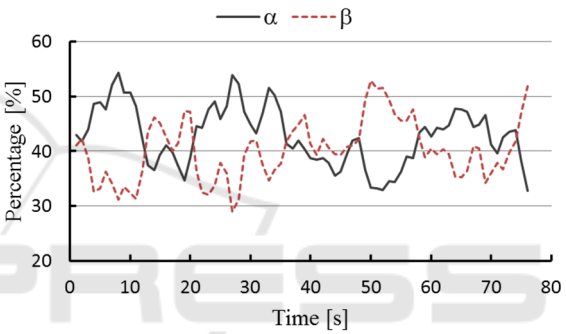


Figure 3: Changes of ratio of the alpha and beta band power measured from a nurse n1 during drawing blood.

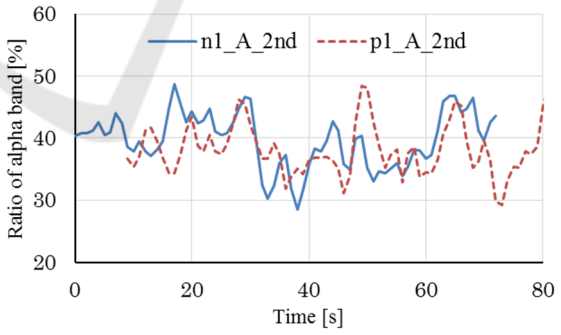
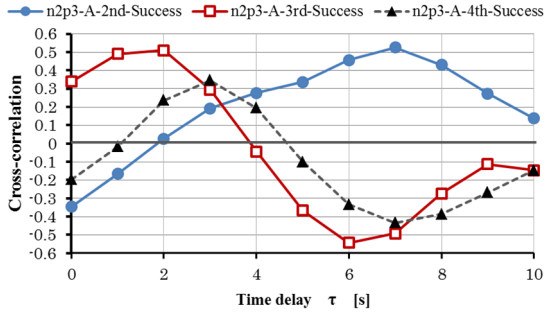


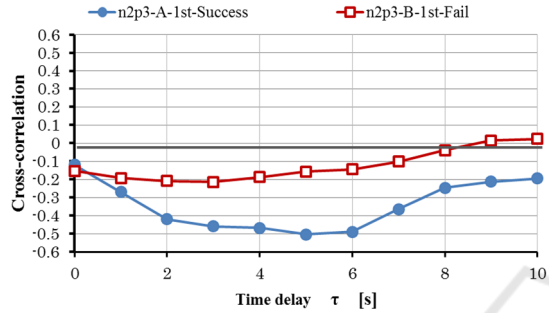
Figure 4: Example of time variation of ratio of alpha band power in pairs of nurse n1 and patient p1 (τ = 9).

in case of the successful drawing blood without the first trials and the case of anxious or fearful feeling is 69.0%.

The time delay of cross correlation was 6.18 seconds in average. Therefore, the brain waves of patient are synchronized with those of nurse by about 6 seconds behind.



(a) Example of successful case in drawing blood



(b) Example of failure in drawing blood

Figure 5: Cross-correlation of alpha band power between nurse and patient.

4 CONCLUSIONS

In order to analyze nurse-patient interaction from the point of interbrain synchrony, in this study blood drawing technique was adopted as nursing skills and experiments of drawing blood were carried out in nurse-patient pairs. The brain waves in the occipital portion of nurse and patient were simultaneously measured using portable EEG devices during drawing blood. The ratios of alpha-band power were calculated for each of the nurse and patient, and the cross-correlations were obtained between every pairs of them. The results indicated that the brain waves of patient were synchronized with those of nurse by several seconds behind. Furthermore the synchronization was not recognized in abnormal circumstances that nurses failed in the drawing blood. It is suggested that the proficiency level of beginning nurse can be evaluated by the interbrain synchrony. In the future data accumulation for more experimental participants will be an issue to validate the findings.

Table 1: Relation between success of drawing blood and inter-brain synchronization.

		First trial	2nd	3rd	4th	5th
n1p1-A	Success / Failure	Success	Success	Success	Success	Success
	Syncronization	Non	Sync	Non	Non	Sync
	Time delay [s]	–	10	–	–	8
n1p1-B	Success / Failure	Failure	Failure	Failure	Success	Success
	Syncronization	Non	Non	Non	Sync	Sync
	Time delay [s]	–	–	–	10	9
n1p2-A	Success / Failure	Success	Success	Success	Success	Success
	Syncronization	Sync	Sync	Non	Non	Sync
	Time delay [s]	10	8	–	–	8
n1p2-B	Success / Failure	Failure	Success	Success	Success	Success
	Syncronization	Non	Non	Sync	Sync	Sync
	Time delay [s]	–	–	10	4	4
n2p3-A	Success / Failure	Success	Success	Success	Success	Success
	Syncronization	Non	Sync	Sync	Sync	Sync
	Time delay [s]	–	8	3	3	10
n2p3-B	Success / Failure	Failure	Success	Success	Success	Success
	Sync	Non	Non	Non	Sync	Non
	Time delay [s]	–	–	–	5	–
n2p4-A	Success / Failure	Failure	Success	Success	Success	Success
	Syncronization	Non	Non	Sync	Sync	Sync
	Time delay [s]	–	–	6	6	5
n2p4-B	Success / Failure	Failure	Success	Success	Success	Success
	Syncronization	Sync	Sync	Sync	Sync	Sync
	Time delay [s]	2	9	9	4	4
n3p5-A	Success / Failure	Failure	Success	Success	Success	Success
	Syncronization	Non	Non	Non	Sync	Non
	Time delay [s]	–	anxious	anxious	2	anxious
n3p5-C	Success / Failure	Success	Success	Success	Success	Success
	Syncronization	Sync	Non	Non	Non	Non
	Time delay [s]	0	fearful	fearful	fearful	fearful
n3p6-B	Success / Failure	Success	Failure	Success	Success	Success
	Syncronization	Non	Non	Sync	Sync	Sync
	Time delay [s]	–	–	3	10	10
n4p5-A	Success / Failure	Success	Success	Success	Success	Success
	Syncronization	Sync	Non	Sync	Non	Sync
	Time delay [s]	5	–	1	–	6
n4p6-B	Success / Failure	Failure	Success	Success	Success	Success
	Syncronization	Non	Non	Non	Non	Sync
	Time delay [s]	–	anxious	anxious	anxious	9
n4p6-C	Success / Failure	Success	Success	Success	Success	Success
	Syncronization	Non	Non	Non	Non	Sync
	Time delay [s]	fearful	fearful	–	–	3

Synchronization due to the success of drawing blood

Non-synchronization due to the failure of drawing blood

Non-synchronization due to the first trials in pairs of nurse and patient

anxious fearful Patient felt anxious or fearful

REFERENCES

Dumas, G., Nadel, J., Soussignan, R., Martinerie, J., Garnero, L., 2010. Inter-Brain Synchronization during Social Interaction, PLoS ONE, Vol.5, Issue 8, e12166, pp.1-10.

Hari, S., Himberg, T., Nummenmaa, L., et al., 2013. Synchrony of brains and bodies during implicit

interpersonal interaction, Trends in Cognitive Sciences, Vol.17, No.3, pp.105-106.

Kauppi, J.P., Jääskeläinen, I.P., Sams, M., Tohka, J., 2010. Inter-subject correlation of brain hemodynamic responses during watching a movie: localization in space and frequency, Frontiers in Neuroinformatics, Volume 4, Article 5, pp.1-10.

Kishida, N., Ishigame, A. Majima, Y., 2015. Study on Synchronization of Brain Waves and Injection Technology, HEALTHINF 2015 - International Conference on Health Informatics, pp.592-597.

Maekawa, Y., Majima, Y., Kawano, T., Katagiri, M., 2013. Characteristics of Practical Nursing Knowledge from Biological Data Analyses of EEG in Performing Blood Collection, Proceedings of 6th International Conference on Intelligent Interactive Multimedia Systems and Services on Knowledge-Based and Intelligent Information & Engineering Systems, pp.251-260.

Teplan, M., 2002. Fundamentals of EEG measurement, Measurement Science Review, Volume 2, Section 2, pp.1-11.

Watanabe, T., Ogikubo, M., Ishii, Y., 2004. Visualization of respiration in the embodied virtual communication system and its evaluation, International Journal of Human-Computer Interaction Vol.17, No.1, pp.89-102.