FEASIBILITY OF MEASURING THE VOLITION LEVEL IN ELDERLY PATIENTS WHEN USING AUDIO ENCOURAGEMENT DURING GAIT TRAINING PHYSICAL THERAPY

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Abstract-**The purpose of this study is to find a method for measuring the volition level in elderly patients during gait training physical therapy. First, both the walking speed and tempo of the elderly patients were experimentally measured with a video camera under musical stimulation, however, neither walking speed nor tempo was directly related to the subjects' will or level of enthusiasm to undergo the gait training physical therapy. Second, the Fmθ activities of EEG signals were experimentally measured while performing a psychological task at a desk. These Fmθ activities seemed to be related to the subjects' enthusiasm, however, their high level of deviation and the influence of artifacts minimized their usefulness for this purpose.**
Keywords - **EEG, virtual reality, music therapy, aroma therapy**

I. INTRODUCTION

As locomotive capability is one of the most fundamental functional requirements for living independently, gait training physical therapy is especially important for elderly patients. However, these patients are often apathetic with regard to their future and lack hope in their prospects for recovery. If they are unwilling to fight to improve the quality of their lives, then any therapeutic training programs will prove ineffective for their rehabilitation. For example, due to its monotonous nature, elderly patients rarely show any enthusiasm for undergoing parallel bar assisted gait training.

Several studies using virtual reality technology have been carried out to solve this problem[1][2]. However, none of these studies have clarified at all precisely what kind of stimulative presentation content of was most effective in overcoming the patients' apathy. For example, Hitachi Ltd. has developed a gait training machine incorporating a video monitor and has tried to use many different kinds of video images, such as an image of a famous shrine where many elderly people liked to go, to positively motivate the users. It was reported that most of the elderly patients enjoyed watching the video images for the first time. However, they lost interest the second time they viewed the image.

Our final goal is to develop a gait training system that encourages the elderly patients with audio stimulation, such as the cheery voice of a patient's grandchild, the scolding of a therapist and the cheerful music. In our previous study [3], we found that verbal encouragement should be given according to the patients' volition level; Verbal encouragement might produce a contrary result when it was given to the patient who already had enough will to perform the training. The purpose of this study was to find a method for objectively measuring the volition level of the elderly during their gait training.

II. METHODOLOGY

A. Measurement by Walking Speed

The subjects would listen to one of two popular Japanese songs, 'Mago' or 'Furusato', while undergoing their parallel bar assisted gait training. During the course of the training, these songs would be suddenly switched between a version with lyrics (condition WL) and a Karaoke-like version without lyrics (condition KR). As the second experiment, the two songs would be switched between their normal tempo of 90 /min (condition NT) and a 15% accelerated, faster tempo of 103.5 /min (condition FT). The tempo changes were accomplished with a CDJ-100s CD player, which kept a fixed pitch while accelerating the tempo. The subjects' efforts were recorded with a video camera both before and after the changes. Their mean speeds were calculated from the time they required to walk three meters. Informed consent was obtained from all of the participants; however, they were not informed of the planned changes of music tempo and style before the experiments began. The eleven subjects were from 63 to 90 years of age with various difficulties in walking and possessed sufficient communication skills. After the experiments, the subjects were interviewed about their impressions and their favorite music. Each experiment was performed on a different day in order to avoid fatiguing the subjects.

B. Measurement by Electroencephalogram

At present several techniques, such as Positron Emission Tomography (PET), Functional Magnetic Resonance Imaging (fMRI) and Single Photon Emission Computed Tomography (SPECT), are available for conducting brain neuroactivation studies. However, such methods are difficult to apply while the patients are undergoing gait training. We tried to measure the volition level by electroencephalogram (EEG). Body movements made troublesome artifacts in the EEG signals, however, we thought that an EEG was the only practical method for monitoring a patient's brain while walking. As a feasible study, five young students were examined in a silent, shielded room. We carried out several experiments as follows; (1) subjects relaxed on a chair with eyes closed for three

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Abstract

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minutes, (2) then they relaxed with eyes opened for five minutes, (3) they performed a task without any background aroma for ten minutes, (4) relaxed with open eyes for three minutes again, (5) and finally performed the task under an aroma of lavender for ten minutes. The task was folding papers into a figure on a desk. The aroma of lavender has an effect on relaxation. After each situation, the subjects replied to a questionnaire about their mental condition, which was developed by the Research Institute of Human Engineering for Quality Life, Japan. In the questionnaire, several words, which indicated psychological conditions, such as anger, comfort or anxiety, were shown and subjects scaled their own psychological condition from -2 (feel never) to 2 (feel strongly).

The EEG signals from 5 scalp derivations, located according to the International 10-20 System (Fp1, Fp2, T3, T4, Pz) were recorded in each situation. The EEG signals were sampled at a frequency of 250 Hz. Then on each segment, for each selected channel and each subject, the mean power spectrum of the theta (4-8 Hz), alpha (9-13 Hz) and beta (14 Hz-) bands were calculated by using a Hamming window.

III. RESULTS

A. Results concerning Walking Speed

Because of fatigue, one of the subjects stopped walking soon after the conditions changed, and as a result he is excluded from the following discussion. In the first experiment, the presence or absence of the lyrics had no measurable statistical influence upon the subjects' walking speed or tempo. Also, none of the subjects sang along with the music. In the second experiment, 70% of the subjects thought that they walked faster in the FT condition trial than in the NT condition trial, however, neither their actual walking speeds nor their actual walking tempo changed statistically (Figure 1). In both of the experiments, most of the subjects said that they preferred walking with the music to walking without it.

B. Results concerning Electroencephalogram

As a clue to elucidate the level of enthusiasm, we took notice of the frontal midline theta (Fmθ) activity of the EEG signals. The Fmθ is a sinusoidal theta band activity, whose value increases according to psychological condition, such as a concentration or an interest in a task [4]. One of the subjects was excluded from the following discussion, because his EEG was completely different from the others and because his replies were -2 to 81% of the questionnaire. The typical results of the Fmθ analysis are shown in Figure 2. Each plotted point indicates the mean power spectrum of Fmθ activity detected from Fp1 and Fp2 during one minute. For one of the subjects (subject N) Fmθ activity could be detected clearly (Figure 2 (A)), however, for others it could not (Figure 2 (B)). The psychological conditions of the subject N while

(A) Walking speed   (B) Walking tempo
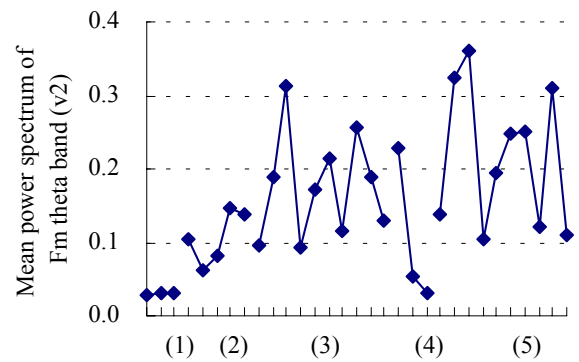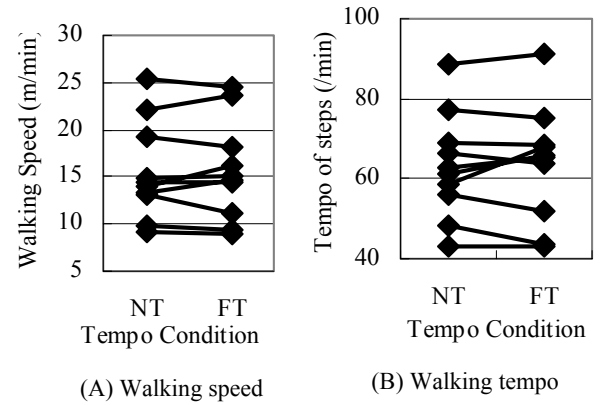
(A) a subject with high Fm theta activities
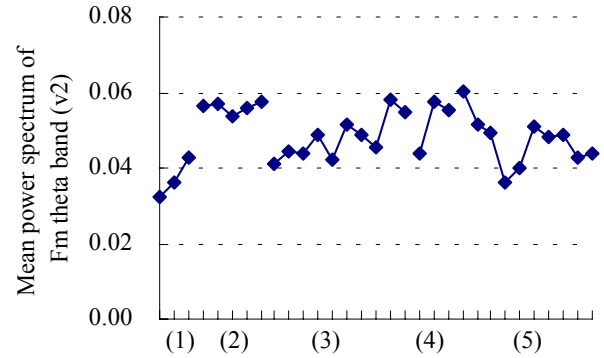
(B) a subject without Fm theta activities
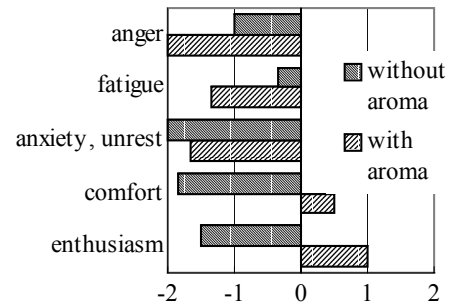Figure 2. Typical results of the EEG analysis

Figure 3. Results of psycological conditions

performing tasks are shown in Figure 3.

IV. DISCUSSION

The music seemed to have a positive influence upon the subjects' psychology. It indicates the possibilities of musical encouragement for the elderly. However, unexpectedly, neither walking speed nor tempo was directly related to the subjects' will or level of enthusiasm to undergo the gait training. Most of the subjects seemed to slow down not because of their lowering enthusiasm but because of fatigue. And because of the physical difficulties for fast walking, even when the subjects thought they were walking faster, they were actually not. In our previous experiment, some subjects walked faster than before after verbal encouragement from their physical therapists, however, this improvement continued for the next two or three steps only. Walking speed was not an appropriate index of the volition level of the elderly patients.

A different kind of music, such as a march, might be adequate for this purpose. We did not use a march as our stimulating music because the tempo of a march is much faster than that of our elderly patients walking tempo. However, the experimental results showed that music with a fast tempo would have a good influence upon the elderly in gait training. Further experiments will be made in the future.

The EEG signals of the subject N were typical; the mean power spectrums of the theta band from the frontal regions were greater than those from temporal or parietal regions, especially when a psychological task was performed. Those findings agreed well with the characteristics of Fmθ activity. However, Fmθ activity in two of the subjects was indistinct, and could be not detected in one of the subjects at all. The individual difference of appearance of Fmθ activity also agreed with its characteristics. Therefore, detection of volition level by Fmθ activity is not applicable to all of the patients.

As is evident from Figure 3, the subject N carried out the task more enthusiastically while exposed to the aroma of lavender than when not. As the average of the mean power spectrum of Fmθ activity while exposed to the aroma was larger than that without it, the mean power spectrum of Fmθ activity may be dependent upon the enthusiastic condition. However, the scattered experimental values of the Fmθ activity might prove be difficult to use as a feedback signal for encouragement. In addition to these facts, the artifacts due to head movements and electrostatic induction disturbed the measurement of EEG signals in a practical stage. In the present situation where a proper countermeasure cannot be found, the Fmθ activity is not appropriate for use as an index of the volition level of the elderly patients.

After all this, neither the patients' walking speed nor their Fmθ activity as shown in their EEG could be successfully used for our purpose. We must find another method for measuring the effectiveness of audio encouragement during gait training therapy. Instead of our elderly subjects volution level, other signals, such as pauses in the walking rhythm or the elapsed time in training might be appropriate to be used as clues to the effectiveness of the audio encouragement. To this end, further experiments will be carried out in the future.

V. CONCLUSION

For developing a gait training system with an audio encouragement function, the volition level of several elderly patients during training was experimentally measured by two methods. A conclusion cannot be drawn due to the insufficient number of experimental subjects, however, both the patient's walking speed and their EEG Fmθ activity were difficult to use as an index of each elderly patient's volition level.

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