# Orientation and Mobility Skills Consideration for Visually Impaired Persons Based on Brain Activity

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***Abstract*- Visually impaired persons recognize their surrounding by using a white cane or a guide dog while they walk. This skill called "Orientation and Mobility" is difficult to learn. The training of the "Orientation and Mobility Skills" is performed at the school for visually impaired persons. However, the evaluation of this skill is limited to subjective evaluation by teacher. We have proposed that a quantitative evaluation of the "Orientation and Mobility Skills" should be required. In this paper, we tried to execute the quantitative evaluation of the "Orientation and Mobility Skills" using brain activity measurements. In this experiment, brain activity was measured when subjects are walking in the corridor alone or with a helper guide. Experimental subjects were sighted persons whose visual information was blocked during walking. The blood flow of prefrontal cortex was increased as the movement distance of the subject increased when subjects walked alone. From this result, it can be considered that the feeling of fear and the attention relayed to "Orientation and Mobility Skills" could be measured quantitatively by measuring human brain activities.**

***Keywords-NIRS; Visually impaired person; Brain activity.***

## I. Introduction

A visually impaired person recognizes the surroundings using a white cane and/or a guide dog while walking. It is very important to hear the environmental sounds for recognition of their own position and surrounding situations in details. This means, visually impaired people need "Orientation and Mobility Skills" [1][2] to recognize the surrounding situation by using sound information [3][4]. "Orientation and Mobility Skills" are necessary to move in an unfamiliar place. The training to gain "Orientation and Mobility Skills" is carried out at the school for visually impaired. However, the evaluation of the education received is a subjective method by teachers belonging to the school for visually impaired person. It is difficult for the teacher to understand everything the student recognizes even if a student is able to successfully walk a very difficult path. There is also a method of estimating the stress state during exercise from HF / LF. However, HF / LF is affected by heart rate variability due to exercise [5]. Therefore, we have proposed that quantitative evaluation of the "Orientation and Mobility Skills" should be required.

Near-infrared spectroscopy (NIRS) is easier to be used to measure brain activity compared to other measurement methods of brain activity such as Positron Emission Tomography (PET) and functional Magnetic Resonance Imaging (fMRI). In these other brain activities measuring methods, the subject's posture needs to be fixed in a supine position. Obviously, brain activity measurement during walking is impossible with these devices. NIRS can measure brain activity while subjects exercise. However, NIRS measurement data is influenced by noise of various factors. For example, there are noises due to heartbeat and body movement. It is also difficult to separate multiple information stimuli into individual elements. In this paper, we measured the brain activity data for the quantitative evaluation of the "Orientation and Mobility Skills".

In Section II, we describe the experimental method conducted in this paper. In Section III, we describe brain activity data obtained by these experiments. In Section IV, we describe the relationship between brain activity data and the stimulation by experimental tasks. In Section V, we present the summary of this paper and future works.

## II. Experimental Method

The three experiments performed in this paper are described below.

 ISBN: 978-1-61208-616-3 

*A) Measurement of brain activity when walking alone in the corridor without visual information.*

In this experiment, the brain activity when subjects walked alone was measured. The walking distance was approximately 20m. The subjects had their visual information blocked by the eye mask. The resting time for stabilizing the brain activity of the subjects was set before and after walking. This resting time was more than 10 seconds. The experimental place was the corridor where subjects walk on a daily basis. These experiments were performed with no other pedestrians. Subjects were 6 males who were sighted persons. The average age of them is 23.6 years old (SD = 0.47).

The experimental task setting was set as shown in the upper part of Figure 3. All subjects of the experiment walked on the same corridor. The subjects were instructed to walk at a constant speed as much as possible. Subjects were orally instructed the timing to start walking and stop walking. The measurement equipment of brain activity used for the experiment is "Pocket NIRS", which was produced by DynaSense Inc. in Japan (Figure 2). This NIRS device is lightweight and could measure brain activity in two channels in the prefrontal cortex. Measurement can be performed at a sampling rate of 100 Hz.

*B) Measurement of brain activity when subjects walk with helper guide in the corridor.*

In the above experiment, subjects walked alone in the corridor. In this experiment, the subjects walked with the pedestrians who simulated the guide helper. The experiment method was the same as the previous experiment. The experimental method is shown in the lower part of Figure 3. Subjects were the same persons as the A) experiment.

C) *Measurement of brain activity when walking in a wide space with visual blocking.*

The environment of this experiment is different from the A) and B) experiments. This experiment was performed in a gymnasium. A large space like gymnasium has different acoustic characteristics from the corridor. Auditory information is important for visually impaired persons to perceive the surrounding environment. Visually impaired persons also use their echoes and environmental sounds to recognize their position and situation. Such ability is referred to as obstacle perception. In the corridor, subject's footsteps sound from corridor floor reach the ear of the subject in a short time. Thus, there is a possibility that the existence of the wall could be recognized from the echo sound. In the gymnasium, it takes longer time for subject's footsteps from gymnasium floor to reach the subjects. On account of not making the subject conscious with the floor, we conducted this experiment in the gymnasium. The method of this experiment was the same as the previous two experiments. Subjects were the same persons as the A) and B) experiments.

## III. EXPERIMENTAL RESULTS

*A) Measurement of brain activity when walking alone in the corridor without visual information.*

Figure 4 shows an example of brain activity data when one subject walked alone. The red line shows the change in oxygenated hemoglobin. The blue line shows the change in deoxygenated hemoglobin. As a result of this experiment, the cerebral blood flow did not increase when the subject started walking according to the instructions. When the movement distance of the subject increased to some extent, a

Figure 1. NIRS and eye mask which were wear when these experiments.

Figure 2. NIRS used in these experiments.

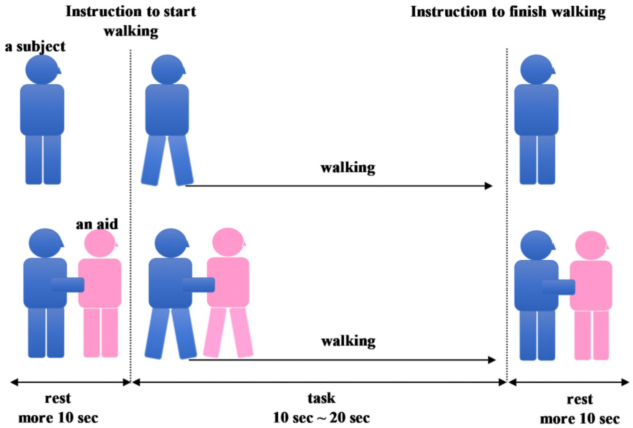


Figure 3. Flow of experiments

large increase in oxygenated hemoglobin could be confirmed on right and left prefrontal cortex. After subjects were instructed to stop walking, the blood flow on right and left prefrontal cortex gradually decreased. This tendency was seen from most subjects.

### *B) Measurement of brain activity when subjects walk with a helper guide in the corridor.*

Figure 5 shows the brain activity result of the subjects when walking with a pedestrian who simulated a guide helper. In this experiment, the subject's cerebral blood flow decreased slightly after the onset of the gait task. Even when the migration distance increased, the concentration of oxygenated hemoglobin in the blood did not increase greatly. In an oral survey after the experiment, subjects said that they were able to concentrate on walking without feeling uneasy in this experiment.

### C) *Measurement of brain activity when walking in a wide space with visual blocking.*

Figure 6 shows the measurement results when walking alone. Figure 7 shows the result of brain activity when accompanied by a pedestrian simulating a helper guide. An increase of blood flow on the prefrontal cortex was seen when the subject received instructions to walk. However, an increase in oxygenated hemoglobin that continued was not confirmed during walking. When subjects walk with a helper guide, there was no change in oxygenated hemoglobin similar to the previous experiment in the corridors.

## IV. DISCUSSION

In these experiments, measuring brain activity was performed when subjects walked with a helper guide and when subjects walked alone. When subjects walked alone, it could be considered that subjects were in the state of mental strain. When subjects walked with a pedestrian who simulated a helper guide, subjects could rely on a pedestrian for safety confirmation and were able to walk by concentrating on walking. When subjects walked alone, most subject's oxygenated hemoglobin on prefrontal cortex did not show an increase after instruction to start walking. As subject's walking distance increased, most subject's oxygenated hemoglobin on prefrontal cortex was increased. Such a change in oxygenated hemoglobin is considered that subjects are strongly conscious of the possibility of collision with the wall or other obstacles. When subjects stopped walking, the oxygenated hemoglobin in prefrontal cortex decreased gradually.

In the case of accompanying the pedestrian who

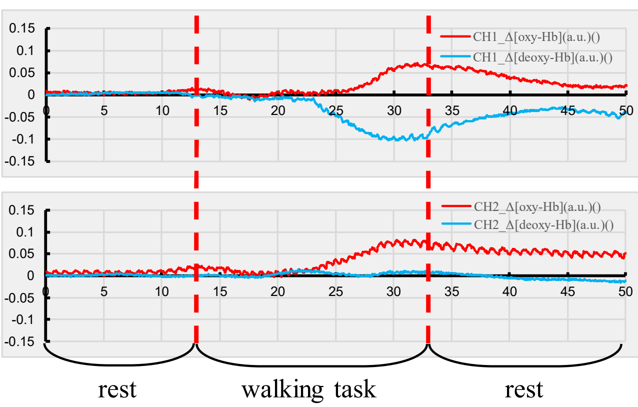


Figure 4. Measurement result of brain activity when the subject walked alone.

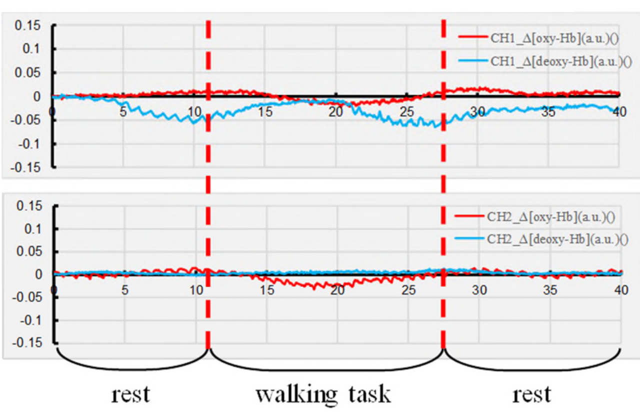


Figure 5. Measurement results of brain activity when subjects walked with guide helper.

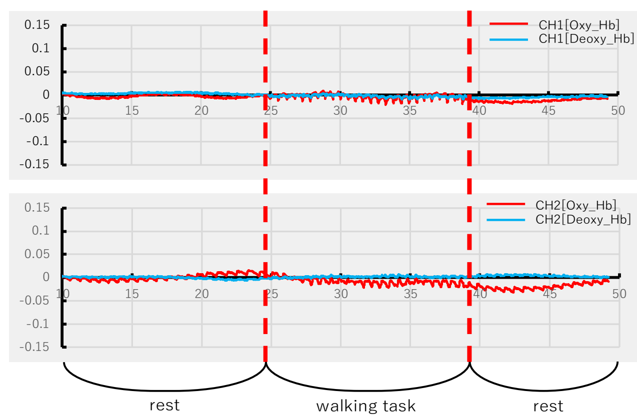


Figure 6. Measurement result of brain activity when the subject walked alone.


Figure 7. Measurement result of brain activity when the subject walked alone.

simulated with helper guide, an increase of oxygenated hemoglobin in prefrontal cortex as compared with the case of walking alone could not be confirmed. Oxygenated hemoglobin in the prefrontal cortex of the subjects decreased slightly during walking.

In addition, when subjects walked alone in the large space such as a gymnasium, no increase in oxygenated hemoglobin was observed with increased walking distance. Therefore, it is considered that the subject was able to walk without being conscious of a collision with a wall or an obstacle.

## V. CONCLUSION

NIRS devices can measure brain activity easily without restraining the subject compared to other brain activity measuring devices. However, the obtained brain activity data may contain many noises originating from body movements and heartbeats. In the experiment conducted in this paper, the subjects were instructed to keep the walking speed as constant as possible. As the result, only heartbeat noise could be confirmed. This noise was sufficiently smaller than the brain activity data. Previous studies have not observed a large change in oxygenated hemoglobin during slow walking as well [6].

It is thought that brain activities data which were measured in these experiments include subjects' consciousness of collision with walls and obstacles. We think that there is a possibility to quantitatively measure if visually impaired persons correctly process the information and walk without feeling uneasy.

In the future work, we think that it is necessary to increase the number of subjects and types of experimental tasks. The place we used for experiments in this paper was a facility frequently used by subjects. As a psychological element, it is an experimental task that does not include brand new environment or interest.

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 ISBN: 978-1-61208-616-3 