学位論文の要旨

Abstract of Thesis

研究科 School	自然科学研究科
専　攻 Division	生命医用工学専攻
学生番号 Student No.	51427605
氏　名 Name	劉　楊

学位論文題目 Title of Thesis（学位論文題目が英語の場合は和訳を付記）

Study on Tactile Spatial and Temporal Processing in Human Somatosensory System using Behavioral Experiments and Event-related Potentials

（人間体性感覚システムにおける触覚時空間処理に関する行動学と ERP 研究）

学位論文の要旨 Abstract of Thesis

Individuals are often surrounded by stimuli from various sensory modalities (e.g., auditory, visual, olfactory, somatosensory). The brain can screen available information from multiple senses and integrate them to better perceive the external environment, shaping and guiding our behaviors. The somatosensory system is a part of the sensory nervous system. The somatosensory system is a complex system of sensory neurons and pathways that responds to changes at the surface or inside the body. Tactile signals are sensed by mechanoreceptors distributed over the elastic surface of the body, i.e., the skin. When the skin contacts an object, it is spatially deformed. As the skin or the body moves relative to the object, this deformation pattern is spatially shifted. This shift is the source of the brain's ability to know the location changes or movements of an object on the skin. Spatial and temporal factors are received separately and integrated in the human brain and, thus, provide a comprehensive understanding of the real world. Therefore, it is important to study integration across sensory modalities. However, the neural mechanism of spatial and temporal processing in human somatosensory system is not completely clear.

The main aim of this present thesis was to investigate the spatial and temporal processing in human somatosensory system by vibration stimulation through behavioral and electroencephalography (EEG) experiments.

The dissertation contains descriptions of the four experiments and a general discussion briefly introduced below.

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Chapter 1 describes the concept of somatosensory system and the sense of touch. The previous studies of spatial and temporal processing in monkeys and humans have also been summarized hear. Additionally, the technique of electroencephalogram (EEG) and event-related potential (ERP) have been introduced. At last, the purpose and contents of the thesis are briefly described.

Chapter 2 describes a device which we developed a novel automatic vibrotactile patterns delivery capable of perform the tactile cognitive experiment. It can serve to determining the sensitivity of each finger that contributes to tactile spatial discrimination. To evaluate the performance of the device, we conducted a basic function test. The results indicated that the device can record reliable data and control the tactile pattern position precisely.

Chapter 3 introduces the first experiment, which measures vibration stimulation in human fingers by using behavioral measurements. This part aim to determine the spatial characteristics when the stimuli simultaneous presented on the different regions of the hand. We investigated tactile numerosity judgments and position report tasks by simultaneously presenting between 1 and 8 vibrotactile stimuli on the hand. The accuracy data from numerosity judgments task indicated that performance was poor when more than 3 stimuli were activated. And as the more stimulus presentation, the answer is smaller than the correct answer. Position report task indicated that the accuracies were changed when the tactile stimuli presented on different place and the increased of stimuli number also effected the accuracy. The results of the two experiments reported in this part demonstrate that people are to some extent able to discriminate between different numbers of tactile stimuli when multiple stimuli are activated simultaneously across the hand.

Chapter 4 describes the second experiment, in which we used a similar parameter to investigated the aging effect of vibrotactile stimulus counting abilities by behavioral measurements in youngers and older adults. In the present study, we asked 15 younger (mean age 22.7±0.8 years) and 10 older (mean age 67.9±5.1 years) subjects to perform a tactile stimulus numerosity task, and we recorded their response accuracy to investigate the effects of aging on vibrotactile stimulus counting abilities. The results showed that as the calculation trials increased, the accuracy rate decreased in both young and old groups ($p < 0.05$). In addition, in the older group, the decrease in the accuracy as the number of calculation trials increased was greater than that in the younger group. In other words, this decrease in the older group may be explained by a reduction in working memory capacity, which is directly

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caused by a decline in basic tactile cognitive ability.

Chapter 5 describes the third experiment. In the present ERP study, we modified the traditional spatial attention paradigm by adding the double stimuli with short interval (i.e., 10, 30, and 100 ms) conditions to approach how the somatosensory system processes the balance between excitation and inhibition. A total of five kinds of stimulation were used in the experiment which are single stimulus (one raised pin for 40 ms), standard stimulus (eight pins for 40 ms), interval 10 ms, 30 ms, 100 ms double stimuli. Subjects were asked to pay attention to the instructed finger and detect whether the standard stimulus was presented to the finger. The results showed clear attention component of the single stimulus condition, but the suppression component of three interval conditions seem dominant in the somatosensory areas. In detail, we found that the strongest suppression effect in interval 30 ms condition, and the suppression and enhancement effects seem counterbalance for both of interval 10 ms and 100 ms conditions. This processing may allow the human easily to discriminate multi-stimulations on the same body part.

Chapter 6 conclusions of the dissertation and future challenges are put forward.

According to the current situation, future studies will focus on tactile spatiotemporal integration with ERP technique. I hope to find the neural mechanism of spatiotemporal integration and to provide important basis for the cognitive neuroscience in human.