学位論文の要旨

Abstract of Thesis

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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）

Neuropsychological studies on human neural mechanism of tactile perceptual learning

（触覚知覚学習の脳内処理メカニズムに関する神経心理学的研究）

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Perceptual learning, which constitutes important foundations of complicated cognitive processes, is learning better perception skills. It is not limited to sensory modalities such as vision and touch, emerges within a training session and between training sessions, and even is accompanied by the remodeling of neural connections in the cortex. However, tactile perceptual learning has been investigated in far less detail than visual and auditory perceptual learning, thus limited knowledge exists regarding the cognitive and neural mechanism of tactile perceptual learning. Although tactile studies have paid attention to between-session learning effects, there have been few studies asking fundamental questions regarding whether the time interval between training sessions affects tactile perceptual learning and generalization across tactile tasks. Additionally, there is little known about the neural basis of tactile perceptual learning, despite some work. Therefore, the present study aims to find out how different training time intervals affect the tactile perceptual learning, what skills acquired lead to tactile generalization across tasks, and what neural changes contribute to tactile perceptual improvement.

Firstly, to investigate how different training time intervals affect the tactile angle discriminability. We applied the tactile angle discrimination (AD) task used in our previous studies, which measures spatial perception of touch involving advanced cognition, such as WM and attention. And then two subject groups were assigned to different time interval training regimes (i.e., 1-day vs. 1-week groups) to consecutively perform five sessions of the AD task. By comparing the AD threshold changes in these two training regimes across sessions, we further assessed the disintegration of the between-session learning effect in the long-interval training regime. Results found that in the short-interval training group, AD task performance significantly improved in the early stage of learning and nearly plateaued in the later stage, whereas in the long-interval training group, significant improvement was delayed and then also nearly plateaued in the later stage. These findings suggest that training time interval affects the early stage of learning but not the later stage.

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Secondly, to explore how a different type of training task generalizes to performance in the untrained tactile task. We added a new subject group, who was instead trained using the tactile orientation discrimination (OD) task, to compare the learning effects that stem from different types of training tasks, but the pre- and posttest assessments still used the AD task. Furthermore, a subject group that only underwent the pre- and posttest using the AD task was recruited as a control group to verify the learning effects of both the first and second experiments. Results found that improved OD task performance resulted in improved AD task performance. This finding suggests that generalization occurs between different types of tactile tasks.

Thirdly, to find out what skills acquired lead to tactile generalization across tasks. We used the n-back task as the WM training task since it requires both maintenance and updating of dynamic rehearsal items during the task. To systematically verify the tactile generalization effect of different levels of WM capacities on perceptual learning, we manipulated the workload level of trained n-back tasks and set 4 different workloads, experimental groups, with 0-back, 1-back, 2-back, and 3-back levels, respectively. The AD task was still used as the pre- and posttest to assess tactile perceptual improvement. Between tests, 4 subject groups were randomly assigned to 4 different workloads (0, 1, 2, 3) n-back tasks to consecutively perform 3 sessions of n-back training. Results found that the AD improvement rate in the 3-back training group was more than ones in the control group, 0-back, and 3-back training groups; no differences between AD improvement rates in other training groups. These findings suggest that the abilities of maintenance and updating contribute to the generalization across tactile tasks.

Lastly, to address how the tactile repeated stimuli affect neural activity in the primary somatosensory cortex (SI). Here, the subject’ index fingerpad was consecutively presented tactile repeated or unrepeated orientation (8-11 times), and she/he was asked to count the number of the orientation, ensuring that attention was similar among orientations. Results found that all the repeated orientation after the 1st orientation attenuated the early neural response in ipsilateral S1, but no difference among the neural responses produced by the repeated orientations; moreover, the 2nd and 3rd repeated orientation gradually attenuated the subsequent, intermediate stage of tactile processing in ipsilateral and contralateral SI, and the neural responses produced by the later repeated orientation had nearly no change; the unrepeated orientations did not attenuate neural responses in SI. These findings suggest that adaptation learning of tactile perceptual processing occurs at the early stage in ipsilateral S1 and the intermediate stage in bilateral S1. Furthermore, tactile adaptation learning in ipsilateral S1 suggests that the high-order areas might involve neural suppression in the early stage; tactile adaptation in bilateral S1 might further verify that top-down perceptual expectations lead to neural suppression in the intermediate stage.

According to the current studies, the training time interval can affect tactile perceptual learning effects. Moreover, different types of training tasks also can improve tactile performance in other tasks, the tactile generalization effect results from the improvement of high-order processes, such as the abilities of maintenance and updating. Furthermore, tactile learning first appears at the early stage in ipsilateral SI and then the intermediate stage in bilateral SI, implying that the ipsilateral SI might modulate neural activity in the intermediate stage.