学位論文の要旨

Abstract of Thesis

研究科 School	自然科学研究科
専　攻 Division	産業創成工学
学生番号 Student No.	51426316
氏　名 Name	Mohd Usairy Syafiq bin Samain

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）

Behavioral and fMRI Studies on Visuotactile Roughness Perception
視触覚による粗さ知覚に関する行動学および fMRI 研究

学位論文の要旨 Abstract of Thesis

To differentiate a surface texture, human apply both visual and haptic information for the perception. We are focusing in roughness, one of significant domain in the perception of textures. In addition, we generally recognize object's texture by using multisensory inputs, combining both modalities to produce final judgement into understanding the texture. During the processes, how do those different modalities affects each other? Are they integrated or disconnect inside our brain? Cognition of surface roughness at the same time in the two senses (tactile and visual) is still undeclared, and how both effects on each other could be intriguing. Moreover, human sensations during roughness perception always involve in interaction, but a lot of brain's response during the interaction is still unknown. Additionally, the perception of roughness has been studied primarily in the haptic domain. Plenty of psychological studies investigating tactile texture perception have been conducted using artificial stimuli such as dot surfaces, grating patterns or abrasive papers. In addition, a lot of research has been devoted to tactile roughness, in particular with respect to the role of vibration cues and to the neural mechanisms. Visual roughness is likely a factor that contributes to the perception of visual gloss, mainly focusing on spatial factors This raises the question on how the temporal factors affect the roughness perception. Does the spatial factors are more significance than temporal? How do we code the temporal code in visual roughness? Present thesis was divided into three studies to test these hypotheses.

Name	Mohd Usairy Syafiq bin Samain

1. The main objective of the first study was to explore how the two modalities influence each other during roughness perception of fine surface. Perception of textures can be divided into two; fine (spatial features smaller than 200 µm) and coarse textures. We designed two unimodal tasks and four bimodal tasks within both modalities using six different fine surfaces and six different grayscale photos. In unimodal visual task (V-V), subjects were asked to judge rougher visual stimuli between two stimuli that were presented in sequential order. In bimodal visual task, (V-Vt), subjects needed to do the same visual roughness judgement while perceiving an interference tactile stimulus at the second order of the presented stimuli. We expected to measure the influence of each modality by considering how subjects were interrupted by the emergence of the tactile interference stimulus. Furthermore, bimodal visual task are divided into two tasks, which applied rough tactile interference stimulus (V-Vt-rough) and smooth one (V-Vt-smooth). Unimodal and bimodal tactile task (T-T, T-Tv-rough, and T-Tv-smooth) were the opposite, which subjects need to do tactile rough-ness judgement. We propose that the roughness of the interference stimulus from different modality may affects subjects judgment and different between the two types. We found that tactile sensory was dominant in the perception of roughness by fine surface. During cross modalities, visual information has almost no effects toward tactile sensory, but in the other hand tactile information had significance effects onto visual sensory. Furthermore, we found that stimuli with smaller particles bring more interference into subject’s perception compared to bigger particles in fine surface. We suggest that particles sizes are as significant as the modalities in visual, tactile, or multisensory integration of both, in roughness perception of fine surface.

2. In the second study, we measured brain activity during pattern perception using functional magnetic resonance imaging (fMRI). Human sensations always involve in interaction, but a lot of brain’s response during the interaction is still unknown.. This study was designed to discover the unresolved part of the brain during performing visual and tactile interaction roughness recognition experiments. We designed four types of tasks: visual task (VV), tactile task (TT), visual - tactile task (VT), tactile - visual task (TV). The common area of each of the brain activation during each task was analyzed; and the results showed that

Name	Mohd Usairy Syafiq bin Samain

activations located in the frontal and parietal, suggesting these regions were actively involved in the cross-modal processing. Specific activation for the information from the tactile and visual modality was seen in the frontal and parietal lobe, respectively, suggesting the particular activation in each at this region.

3. In the third study, we designed a visual base stimulation to investigate the temporal factors of roughness perception. Visual stimulation with regularity and irregularity of spatial spacing were used in this study. In the present study, we used computer-assembled gratings and scrambles images to define time characteristics of visual roughness. The parameters of the grating including pixels per cycle, spatial frequency, and visible size were calculated and one single static grating image was generated. The actual sine grating and drift speed (in cycles per second) were then computed and the amount of pixels to be shifted is specified to perform a perception of movement. We then investigated the effects of changes in those gratings and scrambles parameters to subjects' roughness perception. In the first experiment, we investigated the effects of temporal frequency towards roughness perception by visual drifted grating stimuli. We could understand that gratings do have several limitations for roughness perception to human visual. In the second experiment, we changed our stimulation to scramble stimulation which originated from the grating stimuli. In order to examine the results of the second experiment, we carried out a magnitude estimation experiment on each of the difference temporal frequency of scramble stimuli. The results showed a more converged results during the perception of irregular spacing in scramble stimuli, suggesting the significance of spatial coding. However, we also found the evidence of how visual temporal factors influence the perception of roughness.

The results of three studies showed that the spatial and temporal factors modulate the visuotactile roughness processing differently, but partially overlapping between the modalities and factors. The present thesis investigated the mechanism of roughness perception in visual and tactile. Future tasks for present thesis include approaching spatial and temporal factors in each of both modalities and also in cross-modalities perception to understand more of multisensory integration by behavioral and fMRI methods.