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学位論文題目	Study on psychophysiological methods of evaluating tactile comfort of textiles (繊維製品の接触快適感の心理生理的な評価方法に関する研究)
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論文内容の要旨

It is reported that the status of tactile comfort of textile materials is mainly dependent on two broad types of tactile sensations, i.e., the perception of smoothness and the perception of softness, and in the meanwhile, the perception of coolness and/or moistness is closely related to the perception of smoothness and/or softness. Based on this understanding about tactile comfort, we conducted three studies to confirm whether it is possible to find some physiological indicators for tactile comfort. For fear that the involvement of too many textile materials in psychophysiological tests may cause perceptual fatigue or perceptual adaptation, only two or three types of textile materials were selected as representatives in each study.

Firstly, the similarities and differences between two sensory test methods, i.e., “active hand touch” (“Tezawari” in Japanese) and “passive forearm touch” (“Hadazawari” in Japanese), were investigated by focusing on the perception of coolness and moistness. Three types of single jersey fabrics similar in fabric structure but different in heat and moisture transfer properties were selected as the samples. With the Scheffe’s comparison method which was modified by Ura, coolness and moistness differences between the three types of samples were told by twenty healthy subjects via “active hand touch” and “passive forearm touch”, respectively. The comparative analysis results showed that: when “passive forearm touch” was used, the coolness difference between samples were even more detectable and persistent; whether “active hand touch” or “passive forearm touch” was used, the presentation order had a significant effect on the perception of coolness; within a given contact duration, the ranking of perceived intensity of moistness correlated very well with the ranking of perceived intensity of coolness. These findings indicate that different sensory test methods may lead to different levels of tactile sensations, and therefore should be selectively chosen to differentiate between tactile comfort of textile materials.

Secondly, with the respiratory rate controlled at fifteen breaths per minute, the cardiac reactions caused by touching (“passive forearm touch”) textile materials different in tactile smoothness were examined. Two shower towels different in perceived smoothness but similar in perceived coolness and moistness were selected as the samples. Ten healthy subjects’ electrocardiography (ECG) under three successive conditions (“Rest”: not touched by a towel for two minutes; “Task”: passively touched on the forearm by a towel for two minutes; “Re-rest”: not touched by a towel for another two minutes) were continuously recorded while the subjects were seated quietly in a chair. The average of R-R intervals (RRI (mean): an indicator inversely proportional to the average heart rate), the average of R-T intervals (RTI

(mean): an indicator of the average duration of ventricular depolarization and repolarization) and the normalized high-frequency variation of R-R intervals (HFnorm (RRI): an indicator of the balance between sympathetic and parasympathetic innervation of heart rate) were calculated from each subject's ECG under different conditions. The statistical analysis results showed that: when the results under "Re-rest" condition were compared with corresponding results under "Rest" condition, there was a significant increase in RTI (mean); the change trend of RRI (mean) was similar to that of RTI (mean), but the increase in RRI (mean) was not significant. These results indicate that the removal of dynamic contact with a towel, either a relatively smooth and comfortable one or a relatively rough and uncomfortable one, tends to cause the average duration of ventricular depolarization and repolarization to increase. Since the duration of ventricular depolarization and repolarization depends largely on the duration of heart beat, the average of R-T intervals may be taken as an alternative parameter to study the change in average heart rate caused by the removal of dynamic contact ("passive forearm touch") with textile materials. Moreover, these findings make us realize that it is difficult to tell the difference in tactile smoothness through examining heart rate variability merely, some other physiological measurement techniques should be jointly applied to have a try.

Thirdly, with the respiratory rate not controlled, the cardiovascular and respiratory reactions caused by touching ("active hand touch") textile materials different in tactile softness were examined. Two pillows and a cushion (P1, P2 and P3) whose perceived compressional softness decreased in the order of P1, P3 and P2 were selected as the samples. Ten healthy subjects' ECG, ear photoplethysmography (PPG) and respiration signals (RSP) under three successive conditions ("Rest": not compress a sample for two minutes; "Task": actively compress a sample by hand for two minutes; "Re-rest": not compress a sample for another two minutes) were continuously recorded while the subjects were seated quietly in a chair. In time domain, the average and the coefficient of variation (CV) of R-R intervals (RRI (mean), RRI (cv)), R-T intervals (RTI (mean), RTI (cv)), the pulse wave height (H_P (mean), H_P (cv)), the pulse wave transmitting time (PWTT (mean), PWTT (cv)) and the respiratory rate (RR (mean), RR (cv)), as well as the root-mean-square of the respiration signal's amplitude (RSP (rms)), were calculated under different conditions. In frequency domain, the normalized high-frequency variation of R-R intervals (HFnorm (RRI)) and the pulse wave transmitting time (HFnorm (PWTT)), as well as the ratio of the low-frequency variation to the high-frequency variation of the pulse wave transmitting time (LF/HF (PWTT)), were calculated under different conditions. The statistical analysis results showed that: under "Task" condition, HFnorm (PWTT) tended to increase whereas LF/HF (PWTT) tended to decrease in the order of P1, P3 and P2; as P1 was involved, HFnorm (PWTT) under "Task" condition was significantly lower than that under "Rest" condition and that under "Re-rest" condition, and in the meanwhile, LF/HF (PWTT) under "Task" condition was significantly larger than that under "Rest" condition and that under "Re-rest" condition. These results indicate that both low-frequency and high-frequency variations of the pulse wave transmitting time, which indicate the autonomic regulation of blood pressure, tend to change with the status of perceived compressional softness. Based on these findings, it is concluded that it is a promising way to try to tell the difference in tactile softness through examining the variation of the pulse wave transmitting time in frequency domain.

In summary, the findings of the above-mentioned studies convince us step by step that it is possible to correlate the status of tactile sensations relevant to tactile comfort with certain physiological parameters relevant to cardiovascular autonomic regulation. We believe that the establishment of a psychophysiological evaluation system for tactile comfort will help to develop more and more comfortable and healthy textile products.