EVALUATION OF CLOTHING'S TACTILE COMFORT

by

Yanhua SONG [a], ***Lan XU*** [a,b*], ***and Zhonghao CHENG*** [a]

[a] National Engineering Laboratory for Modern Silk, College of Textile and Clothing Engineering, Soochow University, Suzhou, China
[b] Nantong Textile Institute of Soochow University, Nantong, China

Original scientific paper
DOI: 10.2298/TSCI1603831S

Electroencephalography method was used to evaluate clothing tactile comfort. Physical properties, such as compression, surface and heavy performance, were studied by objective and subjective evaluation. Electroencephalography data were analyzed by Curry 7 and EEGLAB. The results showed that P3 wave could be utilized to evaluate the surface roughness of clothing. When the subjects came into contact with smoother fabric, the latency of P3 wave was shorter and its amplitude was smaller.

Key words: *tactile, clothing tactile comfort, electroencephalography, objective measurement, subjective measurement, P3 wave*

Introduction

In the modern contemporary, consumers purchase clothes not only for liking their attractive styles but also comfortable perception, so the clothing tactile comfort is considered significantly. However, clothing comfort, including tactile comfort, thermal and moisture comfort and pressure comfort, *etc*., is a complicated conception to describe, involving in physiology, psychology, physics and human and social sciences, *etc*. [1, 2].

Three methods are used widely to evaluate the clothing haptic perception, namely subjective measurement, objective measurement, and electro-neurophysiology study. Objective evaluation is also called physical indexes evaluation; it can provide physical properties of fabric handle such as quantitative specifications. Subjective evaluation, is based on the personal point of view and is affected by the subject's own experience and background. Electroencephalography (EEG) is a medical technique that reads scalp electrical activity generated by brain structure [3-5]. Previous studies show that objective and subjective methods can be utilized to effectively evaluate the clothing tactile comfort. Although both of them have shortcomings, EEG method can make up them and we can analyze the subject's feelings from the EEG signals [4].

In this paper, a systematic approach to evaluate clothing tactile comfort was presented. Three kinds of fabrics were selected and were first tested for physical properties by objective evaluation. And sensory evaluation by the semantic differential (SD) method was also used to evaluate the subjective tactile perception. Then EEG method was used to evaluate clothing tactile comfort, and the raw data was analyzed using Curry 7 and EEGLAB.

* Corresponding author; e-mail: lanxu@suda.edu.cn

Materials and method

Materials

In this study, three kinds of fabrics of the same white color were selected as test samples, namely (1) – cotton (100% cotton, plain, 67.23 g/m^2), (2) – polyester (100% polyester, plain, 109.65 g/m^2), and (3) – waffle (100% cotton, implicit grid organization, 187.64 g/m^2).

Objective evaluation

The surface and compression performance of fabric samples were tested by KES-F instrument and their weights were measured by balance. The tests were conducted in a constant temperature and humidity chamber after the fabrics had been balanced for 24 hours.

Subjective evaluation

Five female healthy university students (Age: 23 2 years, weight: 50 3kg, height: 165 3 cm) were recruited as subjects. The SD method was used to evaluate the adhesion, weight, and rough sensation. The subjective evaluation scale was divided into seven parts and marked with number (0 = very weak, 1 = weak, 2 = weaker, 3 = moderate, 4 = stronger, 5 = = strong, 6 = very strong), respectively. Finally, normalization method was used to analyze the datum of subjective evaluation. The following was the calculation process of normalization processing.

Grading range:

$$\frac{\sum_{i=1}^{S}\min(f_{1j},f_{2j},f_{3j})}{S},\ \frac{\sum_{i=1}^{S}\max(f_{1j},f_{2j},f_{3j})}{S} \quad [1.2, 4.8] \tag{1}$$

Interval of the average:

$$k \quad \frac{\dfrac{\sum_{i=1}^{S}\min(f_{1j},f_{2j},f_{3j})}{S} \quad \dfrac{\sum_{i=1}^{S}\max(f_{1j},f_{2j},f_{3j})}{S}}{2} \quad \frac{1.2 \quad 4.8}{2} \quad 3 \tag{2}$$

Converting subjective evaluation rating scale f_{ji} into normalized coefficient F_{ji}, F_{ji} = $= kf_{ji}/\overline{q}_i$, where i is i^{th} subject, j is j^{th} fabric, and $\overline{q}_i$ is the average rating scales. Then the score of j^{th} fabric is:

$$\overline{f} \quad \frac{\sum_{i=1}^{f} F_{ji}}{f} \tag{3}$$

The EEG experiment

The subjects were the same with subjective evaluation. They were asked to shampoo and maintain a calm state of mind, but not allowed to drink and do any vigorous exercise before being tested. We conducted a pre-test before the official test to make sure everything was normal. In this study, Cz, F3, F4, FC5, FC6, P3, P4, Fp1, and Fp2 were chosen as the record electrode and the sampling rate was 1000 Hz. After wearing the electrode cap according to the international 10-20 system the subjects were asked to touch the sample fabrics for 15 seconds with their eyes closed.

Results and discussion

Table 1 showed the results of compression performance test, including compression work (WC), linear degree of compression curve (LC), compression recovery rate (RC), fabric thickness

(T_0 = 50 Pa, T_m = 200 Pa). Generally, the higher the WC, the more fluffy the fabric is. As a result, the waffle fabric was more fluffy and plump than the cotton and polyester fabric samples. On the contrary, it had the worst surface smooth waxy degree. When WC and LC were higher, the fabric was more fluffy. Table 2 illustrated the datum of the surface performance test, including friction coefficient (MIU), the average deviation of friction coefficient (MMD), and surface roughness (SMD). The slippery waxy and smooth degree of fabrics were mainly determined by the fabric surface friction properties. According to MMD and SMD, we could know the waffle fabric was more hard-going and rough than any other fabric tested. In addition, the MIU of the waffle fabric was the biggest. Table 3. showed all the results of subjective evaluation.

Table 1. Compression performance data

Fabric no.	LC	WC	RC	T_0	T_m
(1)	0.238	0.181	28.733	0.838	0.530
(2)	0.154	0.095	95.410	1.204	0.955
(3)	0.256	0.475	44.110	1.523	0.973

Table 2. Surface performance data

Index	Direction	(1)	(2)	(3)
MIU	Warp Weft	0.1200 0.1280	0.1137 0.1560	0.2833 0.2087
MMD	Warp Weft	0.0120 0.0131	0.0069 0.0061	0.0654 0.0386
SMD	Warp Weft	2.2083 1.5433	1.1833 2.2617	11.7700 4.8967

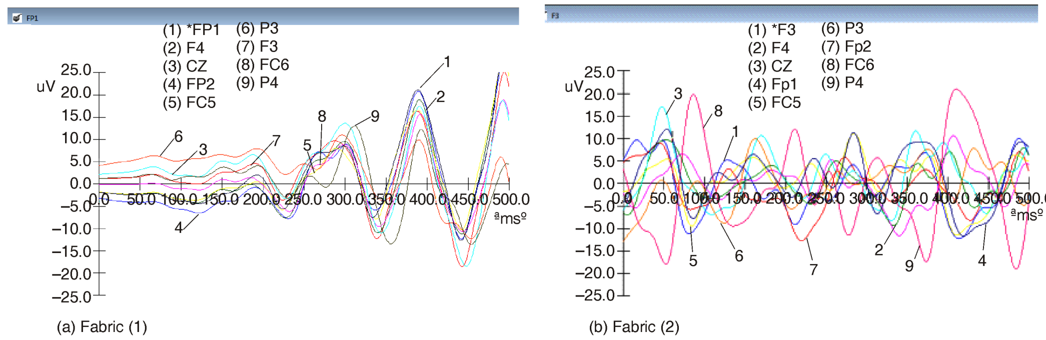
Table 3. Subjective evaluation results

Fabric no.	Weight sensation	Harshness	Sticky sensory
(1)	Medium	Medium	Weaker
(2)	Weaker	Weak	Medium
(3)	Stronger	Strong	Weak

Table 4. The P3 wave parameters

Test no.	Wave change (0-50 ms)	Latency [ms]	Amplitude
1-1	Basically stable	455	20.0-38.0
3-1	Basically stable	440	19.0-25.0
1-2	Basically stable	290	5.0-11.0
3-2	Change largely	290/360	10.0-12.5
1-3	Basically stable	440	16.0-30
3-3	Basically stable	490	10.0-25

Figures 1(a)-(c) illustrated the waveform of all the tested electrodes while subject 3 was touching the three fabric samples. Table 4 showed all the EEG results of subjects 1 and 3. It could be seen that the wave amplitudes were basically stable in 0-50 ms and changed significantly at around 200 ms when subject 3 touched (1) (fig. 1a) and (3) (fig. 1c) fabric samples. In fig. 1, P3 wave appeared at around 440 ms. The P3 wave was the largest late positive wave recorded while subject was identifying a target stimulus. In general, P3 wave appeared in between 250-500 ms. Its amplitude reflected brain excitability, and its latency reflected the speed of neural activity and processing as well as evaluation time. The average amplitude of waffle fabric was higher than that of cotton fabric, which revealed that subject 3 felt more excited about waffle fabric. When touched polyester fabric, subject 3 had a rapid response and P3 wave appeared earlier. This might be due to the smoother surface of polyester, which was beneficial to judge clothing comfort. In addition, frequency-domain analysis showed that the frequency of α wave was mainly concentrated in 9.5 Hz when subject touched fabric, which was probably due to the subject felt quiet and comfortable at that time.



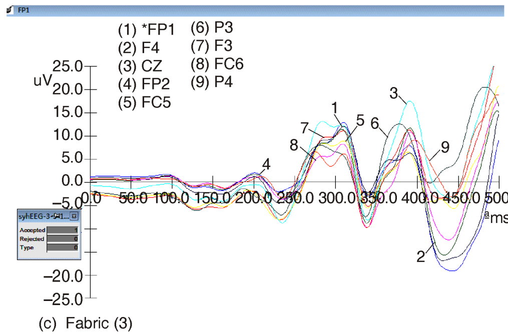


Figure 1. Waveforms of all electrodes when subject touches fabrics

Conclusions

In this paper, subjective evaluation by the SD method was used to evaluate the subjective tactile perception. Statistical analysis was carried out to correlate objective data with subjective data. The results explored the various factors affecting the clothing hand of textiles and validate the EEG method. When the subjects came into contact with smoother fabric, the latency of P3 wave was shorter and its amplitude was smaller. The smaller the amplitude of P3 wave the smoother the fabrics were perceived. It was also evident from the results that P3 wave could be utilized to evaluate the surface roughness perception of the fabrics.

Acknowledgment

The work is supported financially by PAPD (A Project Funded by the Priority Academic Program Development of Jiangsu Higher Education Institutions).

References

[1] Gao, S. W., *et al.*, Near-Infrared Scattering Method for Fabric Thermal Comfort, *Thermal Science, 18* (2014), 5, pp. 1469-1472
[2] Zhu, F. L., *et al.*, Moisture Transport Through Non-Porous Hydrophilic Membranes Used in Protective Clothing, *Thermal Science, 17* (2013), 5, pp. 1293-1298
[3] Teplan, M., Fundamentals of EEG Measurement, *Measurement Science Review, 2* (2002), 2, pp. 1-11
[4] Khasnobish, A., *et al.*, Object Shape Recognition from EEG Signals during Tactile and Visual Exporatin, in: Lecture Notes in Computer Science (Ed. P. Maji), Springer-Verlag, Berlin, Vol. 8251, 2014, pp. 459-464
[5] Wang, Y. P., *et al.*, Experimental Study of Clothing Tactile Comfort Based on Electro-Neurophysiology, *Fibers & Textiles in Eastern Europe, 22* (2014), 4, pp. 102-106

Paper submitted: December 15, 2015
Paper revised: February 2, 2016
Paper accepted: February 2, 2016