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Research on measurement method of dressing contiguous sense

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ABSTRACT

The sense arising from the contact between fabrics and skin is the key factor influencing comfort of dressing. In this paper, based on the analysis of fabric contiguous sense evaluation methods and devices, the experimental paradigm of cognitive behaviors to study the cognitive activities in the contiguous sense cognition of the tested linen fabric is introduced. The experimental program is written with E-Prime 2.0, while the expression of the experimental stimulus material is realized with the self-made dressing contiguous sense measurement device, which output the senses of itch, roughness and smoothness among the fabric contiguous sense. The results show that the evaluation values of the senses of urtication, roughness and smoothness differs little, and can distinguish the intensity of the contiguous senses of 8 fabrics fully. There is no obvious difference among the evaluation values of contiguous senses of those fabrics, indicating a fact that it is scientific and reasonable to study the evaluation of contiguous senses of fabrics with the self-made dressing contiguous sense measurement device combined with the introduction of behavioral experimental paradigm.

KEYWORDS

Contiguous sense; Fabric; Evaluation method; Evaluation device; Perception.

INTRODUCTION

Varieties of senses arise when skin contacts fabric. The sense of urtication, which is described as the itch similar to being punched by many needles, is the main factor influencing comfort of contact. The sense of urtication arising from fabrics has been proven as one of the most discomforting contiguous senses[1]. The sense of roughness, also known as granular sense[2], refers to the sense of smoothness or roughness experienced when skin contacts fabric surface, which is a kind of physiological and psychic combined reaction arising from the stimulation formed by the surface topography and texture features of the fabric.

Evaluation method of urtication sense

Subjective evaluation is a common way to estimate urtication of fabrics[3]. However, this method is quite time-consuming, in particular when the samples are quite many. Moreover, the individual differences of subjects are easy to bring about dispersion and instability to the eventual evaluation of urtication sense.

The several objective evaluation ways currently adopted are[4]: pallial marking method, voice frequency device measurement method, laser counting to highlight the quantity of hairiness, and low stress compression measurement method, etc. The first three methods define the quantity and forms of the surface hairiness through transition of physical indexes, while the latter one directly simulates the compression form when the fabric contacts skin to obtain the relevant force value.

Evaluation method of roughness sense

Except for the sensory evaluation methods, objective evaluation methods are mainly adopted to study the roughness sense of fabric. That is to say, the magnitude of fabric roughness sense is measured with specific indexes, which adopts the basic machineries and physical property parameters by using mathematical statistics method. Adopting texture method to measure the fabric surface roughness; processing the fabric surface image and converting it to the corresponding gray value, followed by a quantization and analysis; and adopting laser to measure the fabric surface roughness initiated by Ramgulam are also commonly used methods[5].

Electrophysiological experiment method

In terms of neurophysiology, contiguous sense has nothing to do with electromyography directly. Meanwhile, many somatic senses need no involvement of proprioceptors[6-8], so it's quite difficult to directly define the contiguous sense of fabric from electromyography.

Event Related Potential (ERP) reflects the cognitive activities such as identification or judgment of the brain to simulation at objective information processing. It is found in the research on the central nervous system evoked potential when contacting fabrics that, there is close association between P300 stimulation (the positive potential with greater amplitude arising after 300 ms) and contiguous sense of fabrics, i.e., the difference on softness of fabrics corresponds to that of P300 amplitude. However, the existing technology is still not capable of distinguishing contiguous sense from the recorded potential diagram.

Fabric contiguous sense evaluation device

Ao Limin[3] has improved the low-stress compression measurement method, and made a fabric single-side compression tester. The friction and surface roughness tester of KES-FB (FB4) can measure the surface properties of fabrics, which conducts the measurement on the surface properties of fabrics with two measuring heads combined.

According to the fiber needle bending model with one end fixed and the other end free, Qi Yuan[9] studied the axial compression bending property of fabric hairiness. On this basis, Liu Yuqing[10] has adopted the multiple measurement ideology based on Euler compression bar model to design the

mechanical device and control software, which organically combined the force measurement and form evaluation to characterize the puncture property of filament.

Based on the analysis on the fabric contiguous sense evaluation methods and devices, the experimental paradigm of cognitive behaviors is introduced to study cognitive activities in the contiguous sense cognition of the tested linen fabrics. The experimental program is written with E-Prime 2.0, while the expression of the experimental stimulus material is realized with the self-made dressing contiguous sense measurement device, which output the senses of itch, roughness and smoothness among the fabric contiguous sense, so as to test the feasibility of the proposed method.

EXPERIMENTAL METHODS

Subjects

64 young female college students with relevant specialized knowledge are selected randomly as subjects, aged from 20 to 23 years. The reason to choose female undergraduate is that the study of Gamsworthy[11] shows that females are more sensitive than males. All the subjects are normal in vision or normal after correction, and are right hander. All the subjects are separately measured, and have not done any similar experiment.

Arms are widely innervated and rich in specific sensory receptors to identify external stimulations. Gamsworthy[11] adopted forearm measurement method to conduct subjective evaluation on the fabric contiguous sense, and found that the skin on the forearms have excellent sensibility for external stimulation. Then, Naylor[12] adopted the method to conduct experiments on urtication sense, and further proved the feasibility and scientificity of arm evaluation method. Therefore, this experiment adopts forearms as measurement location.

Design of dressing contiguous sense measurement device: The self-made device comprises the base (1), main control system (2), and three-freedom-degree driving installation (3) fixed on the base, the measurement installation (4) set on the driving installation, whose location can be adjusted in X, Y and Z coordinate space. Through the driving of the installation, the displacement with different speeds or forces can be realized, as shown in Figure 1.

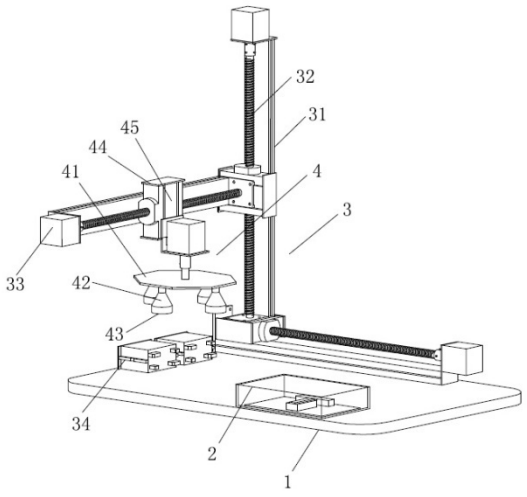

Figure 1 : Self-made measurement device

The main control system adopts a 51 single chip microcomputer (open edition) integrated with A/D converter.

The stepper motor (33) is a two-phase four-wire stepper motor, which controls the mechanical movement of the screw rod (32) at three directions of X, Y and Z. The measurement installation is connected to the screw rod of the driving installation on Y direction, and drives the rotation of the screw

rod with the operation of the stepper motor, thus transforming the rotation of the screw rod to the rectilinear motion of the measurement installation, so as to adjust the moving distance, moving speed and acting force of the measurement installation relative to the body contact position.

The measurement installation comprises a measuring wheel (41), and the measuring heads (42) equally set below the measuring wheel, which are equally distributed on a circle surrounding the center of the wheel, and a pressure sensor (43) set on the surface below the measuring heads. The fabric is packed over the measuring heads, and the measuring wheel can realize an intermittent rotation with an angle of 90° for each time. Every time the measuring wheel rotates, the fabric over one current measuring head is measured.

Experimental program: When using the device, open the power switch of the main control system, and press the start button on the main control system, so as to transmit the order to the stepper motor through the stepper motor driver (34), and regulate the mechanical movement of the screw rod at the three directions of X, Y, Z, and conduct the zero correction of the measuring wheel.

In the behavioral experiment mode, the expression program of the experimental paradigm, the expression of experimental stimulation materials, the random display of evaluation indexes, and the storage program of the evaluation results is designed firstly. The experiment program is shown in Figure 2. The experiment is conducted on computer, and its program is written with E-Prime2.0.

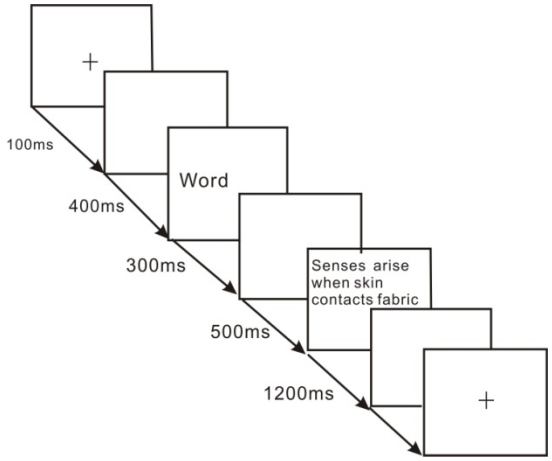

Figure 2 : A schematic illustration of the trial

After the evaluation indexes show, the measuring wheel loading fabric starts to contact the skin. When the contact is detected by the pressure sensor, the sensor will send the information to the main control system, which will send the order to control the stepper motor to run, and the fabric will start to have movement relative to the skin; when the proximity sensor (44) detects the specified route mark, it will give an information feedback to the main control system, which will send an order to stop the measuring wheel. During this process, the subjects feel the contiguous sense with the fabric, and makes quantization judgment. The continuous evaluation results are saved in the storage system.

After completion of one measurement, press the button on the main control system, then the measuring wheel will automatically rotate for 1/4 circle, and the measuring wheel will move to the initial position, i.e., zero position, where the next fabric will contact the skin.

The reaction data will be generated by the subjects through pressing buttons. If the subject feels that the fabric contiguous sense and the meaning of sensory word is same and the sense is quite strong,

press button "/"; if the subject feels the sense is common, press button "X"; if the subject feels that the fabric contiguous sense and the meaning of sensory word is different, press button "Z".

During the experiment, subjects could be given time to rest and everyone participated once in the same experiment to prevent memory mechanism disturbing subjects' cognitive processes.

RESULTS AND DISCUSSION

Device measurement of fabric contiguous sense: Pure linen, cotton linen, and linen -viscose blending, etc. are deeply favored by consumers due to their features such as good wear-ability and environmental protection, etc. 8 kinds of fabric are randomly selected in an apparel enterprise, whose specification parameters are shown in TABLE1.

TABLE 1 : Specification parameters of tested materials

No.	Composition	Yarn count	Warp and weft density	Grams per square meter
1#	L55/V45	20*14	59*52	156g/m^2
2#	100%L	14*14	54*52	160g/m^2
3#	55/45 L/C	21C*14L	54*50	150 g/m^2
4#	L55/V45	10*10	44*38	192g/m^2
5#	L55/C45	11*11	51*47	195g/m^2
6#	L100%	14*14	54*54	165g/m^2
7#	L55/C45	15*15	54*52	165g/m^2
8#	L55/V45	32/2*14	52*51	175g/m^2

In order to conduct a quantitative evaluation on contiguous senses, three-point system is adopted to assign each evaluation index. If the subject feels that the fabric contiguous sense and the meaning of sensory word is same and the sense is quite strong, the evaluation value will be 2 points; if the sense is quite common, the evaluation value will be 1 point; if the subject feels that the fabric contiguous sense is different from the meaning of sensory word, the evaluation value will be 0 point.

Variance analysis on evaluation values of the senses of urtication, roughness and smoothness of 8 kinds of fabric is carried out by using SPSS 20, and the analyzed results are shown in TABLE 2.

TABLE 2 : Variance analysis result

Sensory word	F	P-value
Urtication	4.284	0.000
Roughness	2.843	0.007
Smoothness	3.464	0.001

TABLE 3 : Variance analysis result by manual measurement

Sensory word	F	P-value
Urtication	2.704	0.012
Roughness	3.650	0.001
Smoothness	4.147	0.000

TABLE 2 shows that, when expression of the stimulation material adopts installation, the significance level of the senses of urtication, roughness and smoothness will be: $P<0.05$. Therefore, the contiguous senses among 8 kinds of fabrics have significant differences with each other.

As seen from the fabric specification parameters in TABLE 1, fabrics 2# and 6# are both pure linen fabrics, which have the same yarn count, but fabric 2# is yarn-dyed linen. The difference in terms of weaving process has determined the difference of contiguous senses of the two fabrics. Fabrics 3#, 5# and 7# are all linen-cotton blending (L55/C45), but are different in yarn count, grams per square meter, and weaving processes (3# is yarn-dyed), which has determined the difference of contiguous senses. Fabrics 4#, 1# and 8# are all linen-viscose blending (L55/V45), but are different in yarn count, warp and weft density, and grams per square meter, which has determined the difference of contiguous senses.

Feasibility test: It is a common method for the expression of stimulus materials in the contiguous evaluation to let operators hold the fabrics in hands and contact the fabrics with the skin. The experiment has adopted the method to accomplish the evaluation of the senses of urtication, roughness and smoothness of 8 kinds of fabrics. Meanwhile, variance analysis is done by using SPSS 20, whose results are shown in TABLE 3.

TABLE 3 shown that when the expression of experimental stimulus materials is measured by hand, the significance level of the senses of urtication, roughness and smoothness will be: $P<0.05$. Therefore, the contiguous senses among 8 fabrics also have obvious differences with each other.

Comparative analysis: The mean values of contiguous senses of urtication, roughness and smoothness after contacting the fabrics with skin are shown in Figure 3, 4 and 5.

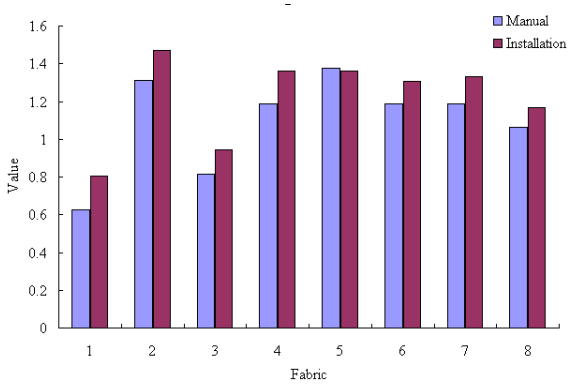

Figure 3 : Evaluation value on urtication

The results of Figure 3 show that, when the expression of experimental stimulus materials is measured by hand or by device, the difference on evaluation values in terms of urtication sense will be quite small, and can well distinguish the intensity of urtication sense of those fabrics.

The results also indicate that, except for fabric 5#, the evaluation values of urtication sense obtained from measurement by device is slightly higher than that measured by hand. The device has set with pressure sensor (thin film pressure sensor) on the lower surface of the measuring head, which has quite high sensitivity, and can well control contiguous pressure. And the device has constant moving speed. Therefore, comparing with manual method, it can realize constant pressure and more stable moving speed, good for the sufficient contact between the fabrics and skin. Garnsworthy [11] has found that mechanics excitation condition for a single fiber is that the bending deformation force of the fiber must be over 0.75mN, or the human body will not feel the sense of urtication, but the value varies with each individual. So, when the expression of experimental stimulus material adopts device measurement, evaluation results of the urtication sense will be more reasonable.

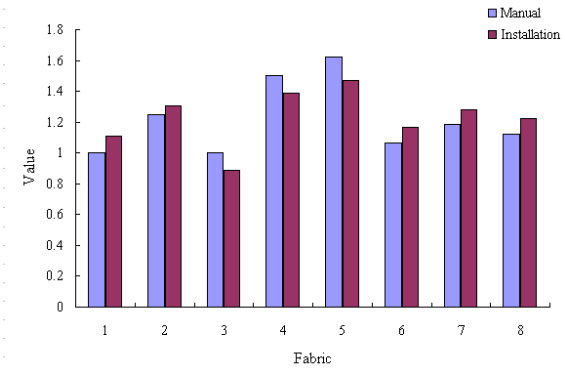

Figure 4: Evaluation value on roughness

As shown in Figure 4, when the expression of experimental stimulus material adopts manual measurement or device, the difference on evaluation values in terms of roughness sense will be quite small, and can well distinguish the intensity of roughness senses of the 8 kinds of fabrics, containing some fibrilia. Because the length and linear density of fibrilia have great discreteness, the fineness uniformity of the linen yarn is not so good. Therefore, the evaluation value of roughness sense obtained with device method is slightly higher.

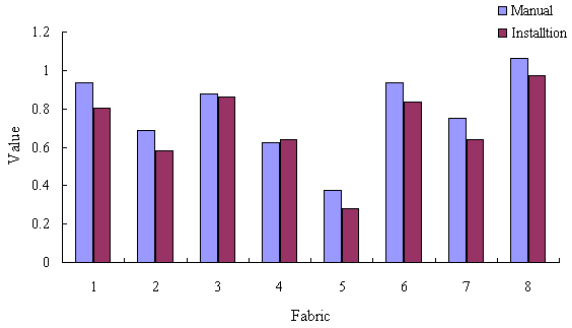

Figure 5 : Evaluation value on smoothness

Figure 5 showed that when the expression of experimental stimulus material adopts manual measurement or device, the difference on the evaluation values in terms of smoothness sense will be quite small, and can well distinguish the intensity of smoothness sense of those fabrics. When device measurement is adopted, evaluation values of both urtication sense and roughness sense will be slightly higher than that measured by hand, so the evaluation value of smoothness sense measured with installation will be slightly lower. The results of Figure 5 have indicated the consistency between theoretically predicted results and actually evaluated results.

In order to further test the feasibility of adopting device evaluation for expression of experimental stimulus materials, the results of T test of the two evaluation values are shown in TABLE 4.

TABLE 4 : T test on installation and manual measurement

Sensory word	Fabric	T-value (2-tialed)	Sensory word	Fabric	T-value (2-tialed)	Sensory word	Fabric	T-value (2-tialed)
	1#	0.363		1#	0.592		1#	0.534
Urtication	2#	0.409	Roughness	2#	0.785	Smoothness	2#	0.646
	3#	0.532		3#	0.621		3#	0.953

4#	0.450	4#	0.584	4#	0.945
5#	0.939	5#	0.433	5#	0.493
6#	0.602	6#	0.542	6#	0.603
7#	0.451	7#	0.650	7#	0.574
8#	0.632	8#	0.570	8#	0.708

As shown in TABLE 4, it is clear that the values of sig. (2-tialed) are higher than 0.05, i.e., P>0.05; it means that the contiguous evaluation values obtained from both experimental methods have no significant differences. Therefore, it is scientific and reasonable to adopt the device method for the expression of experimental stimulation materials. That is to say, the dressing contiguous sense measurement method proposed in the paper is feasible.

CONCLUSIONS

In summary, the experimental paradigm of cognitive behavior is introduced to study the cognitive activities of the subjects in the contiguous sense cognition of the linen fabrics. The expression of the experimental stimulation materials is mainly realized with the self-made dressing contiguous sense measurement device. When the expression of experimental stimulus material adopts manual measurement or device, the difference on evaluation values in terms of urtication, roughness and smoothness sense will be quite small, and can well distinguish the intensity of the senses of urtication, roughness and smoothness.

The evaluation values in terms of contiguous sense of fabrics obtained with manual measurement and device for the expression of experimental stimulation materials have no significant difference. The results indicate that it is scientific and practical to study evaluation on contiguous senses of fabrics with the self-made dressing contiguous sense measurement device combined with introduction of behavioral experimental paradigm.

Furthermore, reaction time that subjects respond to make a decision in evaluating contiguous sense will be measured in further research and the results will provide theoretical and cognitive basis for evaluation or computer simulation system in clothing or fabric design.

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