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Training and Control of Performance of a Tactile Sensory Panel

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Abstract: The sensory measurement provided by a panel of experts to be objective, it must have the same level of reliability and reproducibility as the measurement obtained with a measuring instrument. These two essential criteria are in particular obtained by a sufficient training of the panel. The aim of this research is to establish a sensory evaluation method more reliable and reproducible by using a trained panel which helps the company to foresee the sensory profile of its products. And afterward predict the degree of consumers' satisfaction of their products. This study, present the methodology followed to set up an objective sensory evaluation method using a trained panel for the evaluation of the textile fabrics handle. Indeed a group of judges is selected and trained to identify and to quantify the perceptions obtained, following the handling of the fabrics samples of various aspects. A list of 16 handle attributes is drawn up after principal components analysis. The performance of the panelists on the level of repeatability is controlled in order to diminish the variableness of the provided measurements. A control of the panelists' performance is carried out during the test-retest study using the analysis of variance. These analyses permitted to set up a group of 10 experts selected among 15 trained judges according to the importance of their repeatability. This panel is validated to help the company to foresee the sensory profile of its products with a subjective evaluation method more reliable and reproducible.

Key words: Panel, sensory evaluation, training, textile handle, performance, denim fabric

INTRODUCTION

The perpetual preoccupation of the companies is the satisfaction of their consumers who aim at their comfort. In order to improve the comfort of the products use, a new approach has been set tries to integrate the human perceptions into the design process. It is the analysis of the sensory characteristics of the products. The textile industrials are interested in the characterization of the touch quality or the fabric hand, thus to the clothing comfort. The term fabric "hand" or "handle" has been defined as the quality of a fabric or yarn assessed by the reaction obtained from the sense of touch or the total sum of the sensations expressed when a textile fabric is handled by touching and flexing with the fingers (Bishop, 1996). It implies the ability of the fingers to make a sensitive and discriminating assessment and the ability of the mind to assimilate and express the results in a single judgment (Ellis and Garnsworthy, 1980). This term is treated in several manners in the literature.

The investigators like Binns (1926), Pierce (1930), Houghton and Yaglou (1923), Winslow *et al.* (1937a, b) and others began systematic analyses of subjective responses to textile and clothing. From these early efforts evolved the conceptual bases for the study of fabric "handle" and overall clothing comfort.

Howorth and Oliver (1958) and Howorth (1964) studied the subjective assessment of fabric hand. They used a panel of 25 people with no special experience in handling fabrics to rank 27 samples of suit fabrics which were ranked according to hand by the method of comparison in pairs.

Brand (1994) is one of several researchers who made differences between experts and untrained judges of textile hand. Hui *et al.* (2004) have trained the panelists to understand the definitions of the fourteen significant bipolar pairs of sensory attributes of fabric hand. In order to assess the reliability of these panelists, they conducted a test-retest reliability study.

Yick *et al.* (1995) studied the influence of the judge's experiences on the results of subjective handle assessment. They used a panel of 199 judges with different academic and industrial experiences in the textile and clothing industries. They concluded that the more experienced judges exhibited a higher percentage of significance and gave a higher level of overall agreement.

In the work of Cardello *et al.* (2003) a standardized hand evaluation methodology (HSDA; Handfeel Spectrum Descriptive Analysis method) was checked for its sensitivity and reliability and was used to characterize military fabrics. They concluded that in conjunction with

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the panel training program, result in a sensory hand evaluation method is highly sensitive and reliable over extended period of time.

In this study, we have developed a sensory assessment method which involves experts as a measuring instrument. These experts have taken part in a training program. During this program, we have controlled their performance on the level of repeatability to diminish the variableness of the provided measurements and a list of handle attributes is drawn up thanks to the judge's contest. This panel is validated following the sensitivity and reliability test carried out after a test-retest reliability study at the completion of training.

MATERIALS AND METHODS

Condition of the sensory evaluation: The judges of the panel were selected from volunteer employees at SITEX Company (weaving and finishing factory), chosen on the basis of interest, availability and tactile acuity/sensitivity. It is composed of administrators, laboratory technicians and engineers.

According to the norm NF-ISO-11035 (AFNOR, 1995), the panel must be composed, at least, of 6 judges and it is advised to recruit and train 1.5 to 3 times more people wanted ultimately. In our case, fifteen judges (8 men and 7 women) are recruited at the beginning to end up with ten after the selection. They have experience on the procedures of fabric manufacture, but do not have any idea about the sensory analysis methods. Their age varies between 25 and 45 years. Panelists participated in a one year training program that consisted of training in the basic methodology and operational evaluation techniques employed in the handfeel.

The tests were carried out in a room where the temperature and hygrometry are constant and are felt comfortable by the subjects. The hands of the subjects are washed and dried before each evaluation sitting, in order to avoid the skews gotten by the cosmetic products and the contact with other products. The time of each evaluation session was limited to 30 min., because hands become less sensitive if the test is too long. The number of samples to be evaluated by sitting was fixed to six.

Table 1: List of samples used in training

Fabrics	Thickness (mm)	Weight 10^2(g m^{-2})
Twill	0.85	4.18
Double knits	0.80	2.10
furnishing fabrics (jacquard)	2.21	7.20
Velour	2.57	4.24
Twill (denim)	0.83	3.65
Plain unbleached	0.67	2.24
Wight Satin	0.23	1.01
Veil	0.10	0.25
Blue satin	0.33	1.12

Characteristics of the evaluated fabric: These panelists were trained with textile fabrics (Table 1) of different aspects and structures; furnishing fabrics, knitting, clothing fabrics. The fabrics were cut into 30×25 cm swatches with the longest edge are in parallel to the warp direction. Later samples were given for the panelists' one after the other in a mixed order and they were asked to rank the fabrics. Before testing, specimens were kept in standard atmosphere conditions (temperature 20±2°C, humidity 65±2%) not less than 24 h (AFNOR, 1992).

RESULTS AND DISCUSSION

Establishment of the attributes list: With the aim of obtaining the maximum number of descriptive terms and to avoid skews due to the influence of an individual on the group, a certain number of people of various ages, sexes, regions and experiences were queried using a form to fill,. Each person of this questioned population was invited to argue his/her decision of acceptance or rejection of a textile fabric in general by descriptive terms, thus to explain the significance of each attribute. The questionnaire was made in absence of the samples so that the terms given by the questioned persons are not limited by the characteristics of the provided samples. The result of this questionnaire was a preliminary list of 57 diversified terms. They are classified alphabetically in the Table 2.

We noted that there are other original terms suitable for the Tunisian Arab language which signify "well or beautiful".

We also obtained several terms which describe the material handfeel: cotton, wool, silk, linen, cashmere, polyester. In the list also appear the terms which describe the fabric structure: fabric, knitting, satin, Jean, Denim.

A preliminary qualitative sorting (AFNOR, 1994, 1993) is carried out to eliminate from this generated list the hedonic terms, terms characterizing a material, the irrelevant terms and the attributes referring to the visual feel. We considered as irrelevant, the terms which do not describe the textile hand, such as; hard, absorbent, full, porous etc.

Table 2: Preliminary list of the 57 attributes

Absorbent	Dry	Heat	Porous	Stiff
Ample	Elastic	Heavy	Quick	Stylish
Arab words mean well/beautiful	Extensible	Jean	Resisting	Fits the shape of body
Bright	Falling	Knit/fabric	Satin	Tender
Cashmere	Flexible	Light	Silk	Thick
Comfortable	Folded	Linen	Silky	Thin
Cold	Full	Linked	Sleek	Uniform (smooth)/ unified
Cool	Grainy	Loose	Slippery	Velvet
Cotton	Grooved	Marrowy	Soft	Well
Dark	Hairy	Moist	Supple	Wrinkly
Din	Hard	Polyester	Sticking	Wool

We also removed the terms which are rarely employed by the consumers and the terms which do not have the same meaning, for example; unified, it can relate to the color or to the fabric structure, fits the shape of body, it can be elastic or flexible, etc. But for the terms which represent the same meaning, we kept the more significant ones, for example; cool is eliminated and cold is kept, marrowy is eliminated and hairy is kept, extensible is eliminated and elastic is preserved and soft, tender are gathered.

Table 3 presents the list of 25 attributes preserved after the preliminary sorting. In this list appear some antagonistic terms (bipolar), such as; thin-thick, light-heavy, supple-stiff, cold-heat, moist-dry and smooth-grooved.

The terms preserved in the preliminary list are classified by 200 Tunisians of various regions and various experiences using a second questionnaire. Where, we took account of the antagonistic terms, in order to decrease the dispersion of information. The results of this last questionnaire are studied using SPSS software

Table 3: List of the descriptors preserved

Cold	Grainy	Light	Slippery	Stiff
Dry	Grooved	Loose	Smooth	Tender
Elastic	Hairy	Moist	Soft	Thick
Falling	Heat	Silky	Supple	Thin
Flexible	Heavy	Sleek	Sticking	Wrinkly

which yielded the following histogram (Fig. 1). This histogram shows that there are 11 attributes (soft/tender, supple-stiff, sleek, falling, elastic, light-heavy, thin-thick, smooth-grooved, cold-heat, silky, flexible) which are classified by more than 50% of the questioned peoples, in the first 10 ranks.

The attributes grainy, dry, loose, hairy, wrinkly and sticking, are classified in rows superior to 10. Among these last terms, we find the terms which were not understood by some questioned people, for example grainy.

A first analysis of the results obtained of this evaluation consists in classifying the attributes according to the importance of the geometric mean M of the sum of the attributes quotation frequencies and the sum of the cumulated intensities allotted to the attribute. It is calculated by the following equation (AFNOR, 1994):

$$M = \sqrt{F * I} \quad (1)$$

Where:

F: The frequency of the quotation. It is the ratio of the number of the attribute quotations to the total number of possible quotations for the attribute. In our case, the total number of quotations is 117 (13 subjects and 9 fabrics)

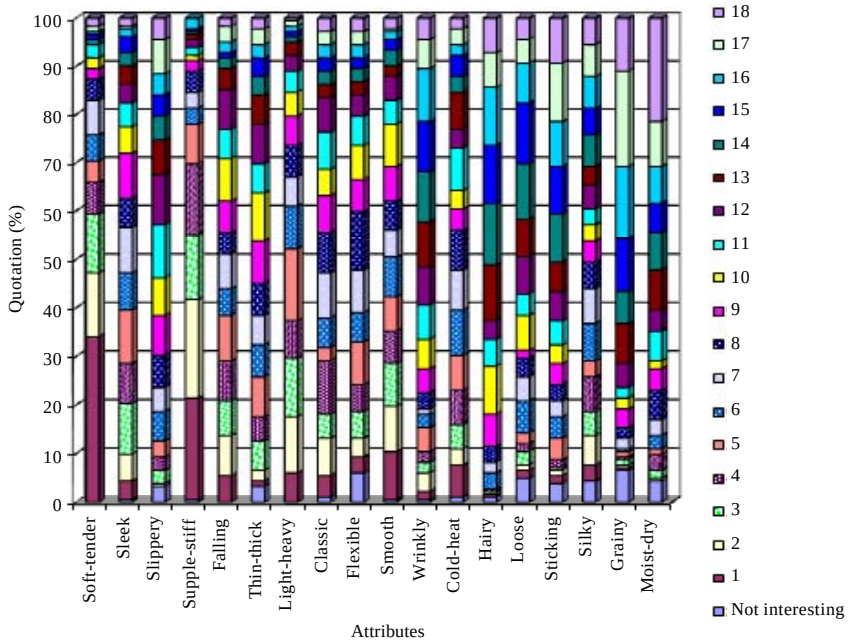

Fig. 1: Diagram of attribute classification at first sitting

I: The relative intensity which is the ratio of the sum of the intensities given by all the members of the jury for an attribute to the sum of the possible maximum intensities for this attribute. In our case, the sum of the maximum possible intensities is 585 (maximum intensity on the scale is 5 per 9 fabrics and 13 subjects)

In the Table 4, the attributes are classified in the decreasing order according to the importance of their geometric mean M. thirteen attributes have a geometric mean more than 50%. The attributes smooth, flexible, elastic and tender have the most significant averages. The sticking attribute has the weakest average (25.135%). This last attribute will be eliminated from the list of attributes with grainy classified in the last rows according to the second questionnaire. The grainy term is classified according to the geometric mean among the last before the terms moist and grooved. We did not eliminate these last two terms because we considered them as the antagonistic terms respectively of dry and smooth. There are certain panelists who preferred to use moist instead of dry and grooved instead of smooth.

A second analysis of the results, by the method of Principal Components Analysis (PCA), allowed us a second reduction. This reduction consists of a regrouping of the synonymous attributes (correlated positively) or antonyms (correlated negatively) and an elimination of the attributes which contribute very little to highlight differences between the tested fabrics in a sensory profile.

Table 4: Classification of attributes

Attributes	Geometric mean: M (%)	Class
Smooth	62.346	1
Flexible	60.214	2
Elastic	60.213	3
Tender	59.756	4
Supple	59.469	5
Thick	59.314	6
Sleek	55.919	7
dry	55.272	8
Soft	54.508	9
Heavy	53.286	10
Falling	52.860	11
Slippery	52.298	12
Heat	51.179	13
Silky	47.626	14
Light	45.238	15
Wrinkly	43.920	16
Loose	42.906	17
Stiff	41.934	18
Thin	41.150	19
Cold	38.014	20
Hairy	37.644	21
Grainy	36.503	22
Moist	34.988	23
Grooved	33.475	24
Sticking	25.135	25

To determine these correlations, the circles of correlations were presented in the Fig. 2a and b. On the first circle, 42.34% of information is gathered on the first two axes. To visualize the maximum of information (63.162%), it was necessary to present the circles of correlations on the first five axes. These circles of correlation have allowed to highlight the antagonistic terms. Indeed, they show a significant negative correlation between; thin-thick, heavy-light and cold-heat which is obvious especially on the circle of the axes F4 and F5 (Fig. 2b). Nevertheless, there is no significant correlation between; moist-dry, supple-stiff and smooth-grooved. These attributes are antagonistic by definition. This shows that these latter's are badly interpreted by the panelists.

These correlation circles also show a significant correlation between; attributes tender, soft and silky and

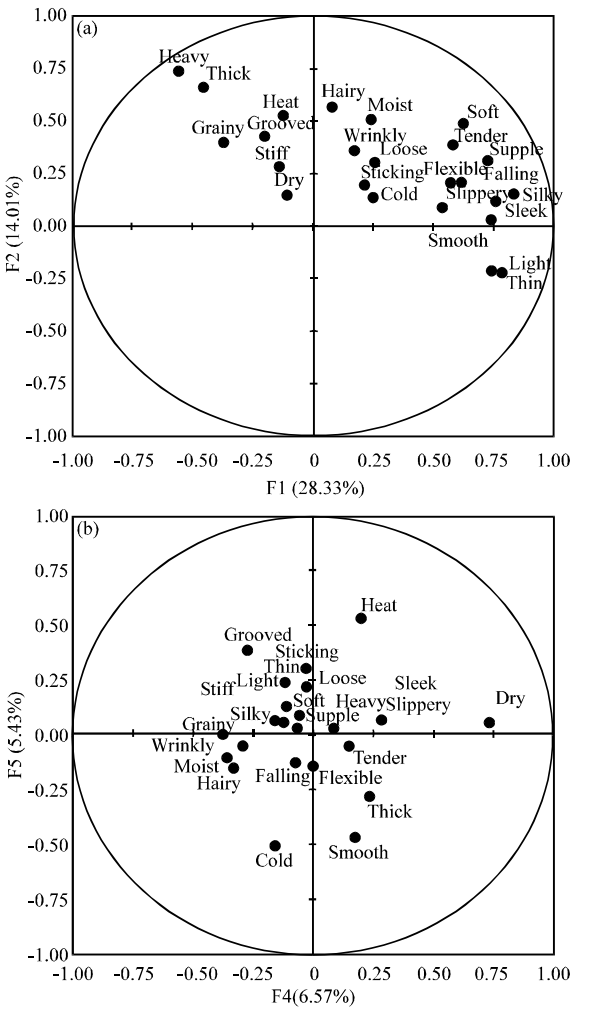

Fig. 2(a-b): (a) Circle of correlation on axis F1/F2 and (b) Circle of correlation on axis F4/F5

Table 5: Final list of attributes

	Categories				Reference		
	Surface	Physic	Dynamic	Attributes	Negative	Positive	Assessment technique
Bipolar	◙			Cold-heat	Glass or leather	Wool	To take the sample suspended with full hand
	◙			Moist-dry		Wool	To take the sample suspended with full hand
		◙		Thin-thick	Veil	Velvet of furnishing	To estimate the thickness with the thumb and index finger
		◙		Light-heavy	Veil	Fabric furnishing	To weigh with the hand the mass of the sample
	◙			Smooth-grooved	Paper	Fabric furnishing	To estimate the relief and the grooves with the end of the thumb
			◙	Supple-stiff	Viscose and lycra Jersey	Raw Twill	To handle and to compress the fabric with the two hands
Simple		◙		Falling	Raw Twill	Viscose and lycra Jersey	To take the closed hand, if it open while passing on the suspended fabric, therefore not falling
			◙	Flexible	Raw Twill	Viscose and lycra Jersey	The sample is held between two fingers in one hand and swept from top to bottom with the palm of the other hand
	◙			Tender	Raw Twill	Cashmere	To graze with the fingers and the palm of hand
	◙			Silky	Raw Twill	Silk satin	To rub gently with the fingers and thumb
	◙			Sleek		Satin	To make flat pass the fingers on the fabric, it is smooth when there is not roughness
	◙			Slippery		Paper	To move the palm of the hand across the surface of the sample
	◙			Hairy	Paper	Angora	To estimate the density and the length of fibers at the surface of the fabric with the ends of the fingers
			◙	Elastic	Paper	Viscose and lycra Jersey	The edges of the sample are held with both hands then stretched for three times in the same direction
	◙			Compact		Paper	To check the density of the fabric with the ends of fingers
			◙	Wrinkly		Paper	To get the sample into one hand and to compress, open the fabric and check if the folds persist

attributes slipping and sleek. In this step, we didn't take into account this positive correlation because the definitions of these attributes are different, we only took into account the antagonistic attributes and the attributes reduced by the first (grainy) and the second classification (sticking), thus the reduced list of 17 attributes are represented in Table 5.

These 17 attributes are classified in three categories (Table 5):

- **Surface handle:** Group of terms which characterize the properties of the textile fabric surface
- **Physical handle:** Group of terms which characterize the physical properties of the textile fabric
- **Dynamic handle:** Group of terms which characterize the dynamic properties of the textile fabric and which require the application of a light force on the fabric to determine them

During these first sittings a precise definition and an evaluation method gave for each attribute of the established list. To each one of these attributes was also associated a stable and adapted reference fabric which will be preserved like memory assistance for the training of panel to define the perception intensity associated to each attribute.

Training to the use of scale and the identification of tactile perceptions: The general goal of the training program is to provide to the panelists' knowledge techniques of sensory analysis and to develop their ability to detect and describe the sensory stimuli. To train the subjects to evaluate and note the intensity of perceptions corresponding to each attribute according to a structured scale, tests of comparison were carried out in the presence of negative reference (corresponding to the lowest intensity) and positive reference (corresponding to the strongest intensity). The test of comparison consists to represent these two references to the subject and when this last acquire certain knowledge the references will be replaced by the sample to evaluate.

Before the beginning of the training program, the subjects were informed about the concept covered by the scale of quotation. The scale used for notation is graduated from 0 to 10. This type of scale is preferred to make it easier on the one hand to the subject the notation of the detected perception intensity and on the other hand to make easier the later recording of the results.

During the first sitting, the subjects are asked to evaluate each attribute for only two samples, with the assessment method indicated in the provided form. They are started with two samples so that the subjects focus all their attention on the evaluation methods. In each following sitting, the number of samples was increased until six. On the total, six different samples are evaluated during these first sittings by thirteen subjects, because two of them were already eliminated from the group considering their unavailability.

To study the way of notation of the attributes by the subjects, we represented the diagram (rank according to panelists) of the results obtained for the sample 1341 during the first sitting.

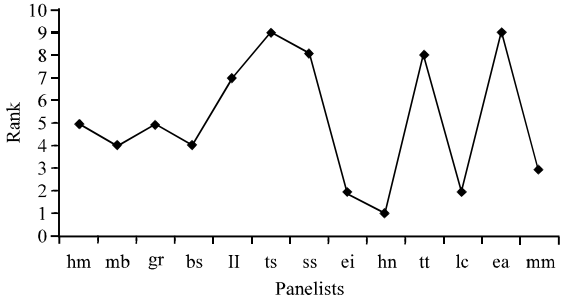

Fig. 3: Cold-heat attribute

It was logical to obtain, for the first sitting, dispersed notes and to have dissensions between the subjects, since they do not have experience in tactile sensory evaluation.

The study of the diagrams (Fig. 3) showed that the notes are very dispersed for the terms; cold-heat, moist-dry, soft, tender, silky, flexible, hairy, supple-stiff and wrinkly. These attributes present a standard deviation which varies between 2.29 (silky) and 3.17 (tender). This result was discussed again and the evaluation procedure was rectified for these attributes with the group in the presence of the references.

For the remainder of the attributes, the notes are not very dispersed, only there were some panelists, who did not agree with the rest of the group. These panelists are re-examined the samples and readjusted the notes for the attributes which there is a dissension. For example for the thin-thick term, most of the subjects noted between 6 and 8 except two (lc noted 4 and ea noted 0), for the elastic term the majority of the subjects noted between 0 and 1 except three (ts noted 5 and rr&mk noted 8).

This study was re-carried out during the second and third training session, in order to decrease the dissension between the panelists.

Such training allowed to familiarize the subjects with the notation method of the perceptions intensity and also allowed a certain selection of the attributes. Indeed, some attributes were eliminated following a statistical PCA study from the results obtained at the last training sessions.

The circle in Fig. 4 shows a positive correlation between soft and tender with a value of 0.913 and between sleek and slippery 0.867 on a level of significance alpha equal to 0.05. Indeed, soft is eliminated and tender is kept which is the closest in Arab terminology, because they are also defined with the same manner by all the subjects. But, it did not hold in account the correlation between sleek and slippery, because they are different by definition. So that, the subjects identify the difference between these two terms, their assessment methods and

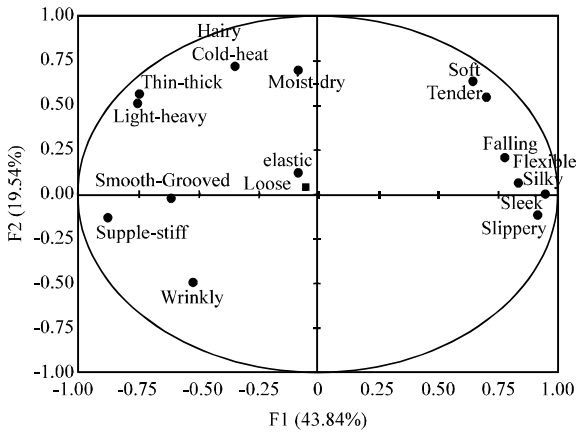

Fig. 4: Circle of correlation after training

the definition were rectified for each two terms. The term loose also changed with the term compact this is considered by the panelists more significant.

Following these analyses, the form used for the evaluation was rectified. Indeed, on this questionnaire is indicated the selected references as well as the new evaluation method for each attribute. The order of evaluation also was changed so that the attributes qualifying the surface and physical handle will be evaluated the first according to the assessment method and that the attributes qualifying the dynamic handle will be evaluated the last.

After establishing the assessment methodology judges were trained individually to use the prescribed techniques. They were also provided with explanatory and visual information how to assess these features. Descriptions how to assess each fabric attribute are given in Table 5.

Training and control of the performance of the panel: After several training sessions, the judges have received a certain competence in standardized tactile sensory evaluation. They, then, became qualified subjects. In order to assess the reliability and sensitivity of these judges, test-retest reliability study was conducted at the completion of training program. During the test-retest sessions, the panelists have examined six different samples. The same sample was evaluated several times, in two evaluations not successively in each time. The results obtained were treated by the variance analysis, in order to study the repetitivity and the reproducibility of each judge. This analysis consists in studying the variation of the residual standard deviation for each attribute, for all the panelists during the sittings of assessments. The standard deviation calculated during the sitting N°0, after the 6th sitting and the 12th for and represented for each judge.

The Fig. 5 shows that the judge hm represents a significant standard deviation which exceeds 2.5 in the beginning, but after six sittings his standard deviation decreased enormously and approximately become stable for the most of the attributes (lower than 1).

According to the curve of repeatability of the subject mk (Fig. 6), we noted that this subject, since the beginning, has a weak standard deviation except for some attributes, but after six sittings his standard deviation is stabilized for all the attributes.

The repeatability of the subject ss (Fig. 7), after six sittings, was improved for most of the attributes, except for some of them (sleek, slippery and smooth-grooved) the standard deviation increased. But after 12 training

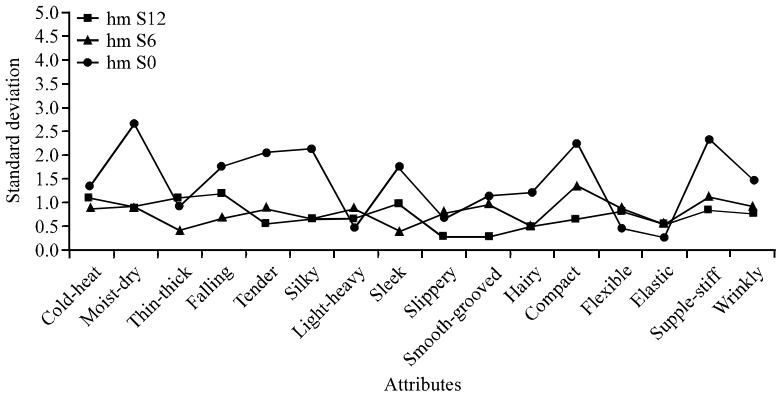

Fig. 5: Repetitivity diagram of panelist "hm"

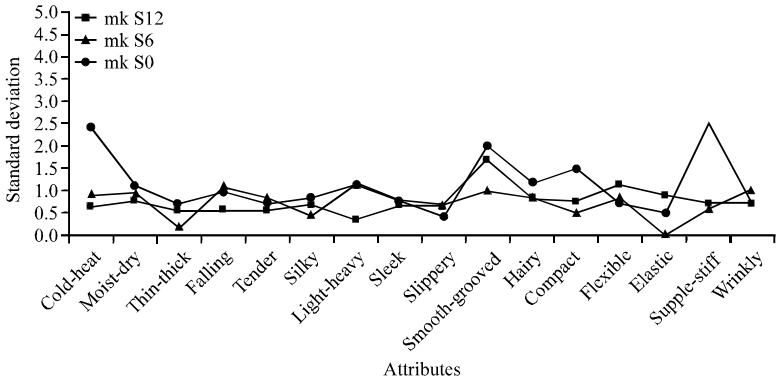

Fig. 6: Repetitivity diagram of panelist "mk"

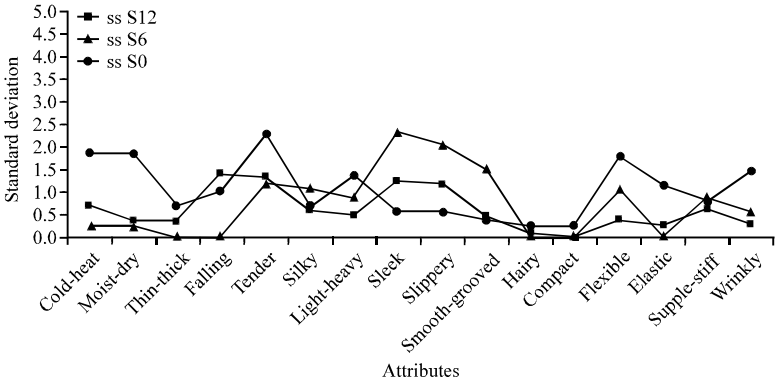

Fig. 7: Repetitivity diagram of panelist "ss"

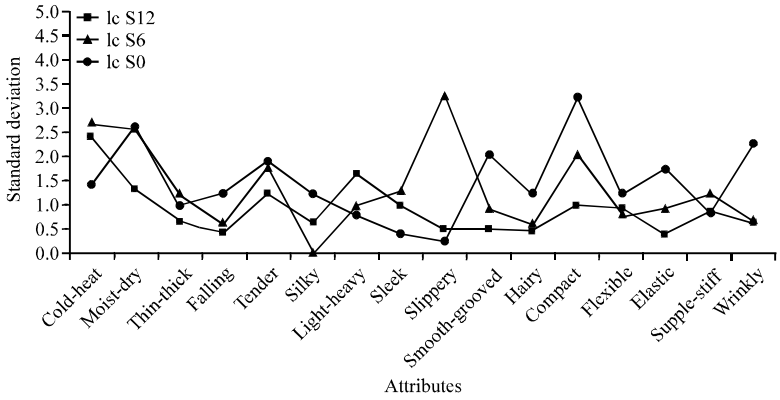

Fig. 8: Repetitivity diagram of panelist "lc"

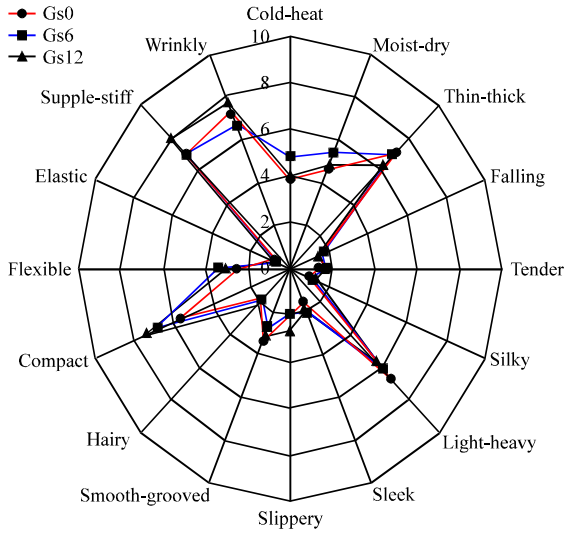

Fig. 9: Long-term repeatability of the group

sessions his standard deviation was decreased for all the attributes. On the other hand, the repeatability of the subject lc (Fig. 8) did not represent a significant improvement, his standard deviation did not change too much after 6 sittings, but it was improved after 12 training sessions.

This case was noted with other panelists during training sessions, but it was accidental and was recovered in the following sittings. For this reason, the training program did not stopped after the sixth sitting and it is extended until most of subjects give the same evaluations for the same stimuli from one sitting to another taking into account a dispersion around an average of 1.

To assess the long-term repeatability of the group the total hand obtained during three distant dates was represented in Fig. 9. This diagram shows that there is not a great difference between the notes given by the group especially during the sixth sitting and afterwards during the 12th sitting for all the descriptors. This implies that the repeatability of the group is improved according to the number of training sessions and that the group acquired certain reliability. This also shows that there is an improvement of agreement degree between the panelists.

In order to check the individual repeatability of the subject during the same training session and to visualize his manner of noting on the intensity scale, the standard deviation of two notes is represented for each panelist according to the average of these two notes for each couple attribute/sample. The graph is thus a cloud of dots the distribution of which reflects the behavior of each subject. The value 1is considered like reference of standard deviation to better visualize the evolution of repeatability of the subjects at the beginning and the end of the training program.

Figure 10 and 11 show that the two panelists rr and hn have a homogeneous and continuous dispersion of points along the notation scale. This shows that these two subjects are able to use quantitatively all the scale from the beginning of the training program. The repeatability of hn is significant from the first sitting and improved towards the last sitting to reach a maximum standard deviation of 1.4 from 2.3 at the beginning with 3 points only located at the top of reference 1. The repeatability of rr is also improved at the last training session, its maximum standard deviation was decreased from 6 to 1.4 with two points which values of standard deviation are higher than 1.

However, the repeatability of the panelist lc (Fig. 12) is not significantly improved, because several points are at the top of reference 1 after 12 training sessions. Thus, the distribution of the points on the graph is not uniform which shows that the panelist lc assimilates the scale of notation to categories and that he does not respect the quantitative aspect.

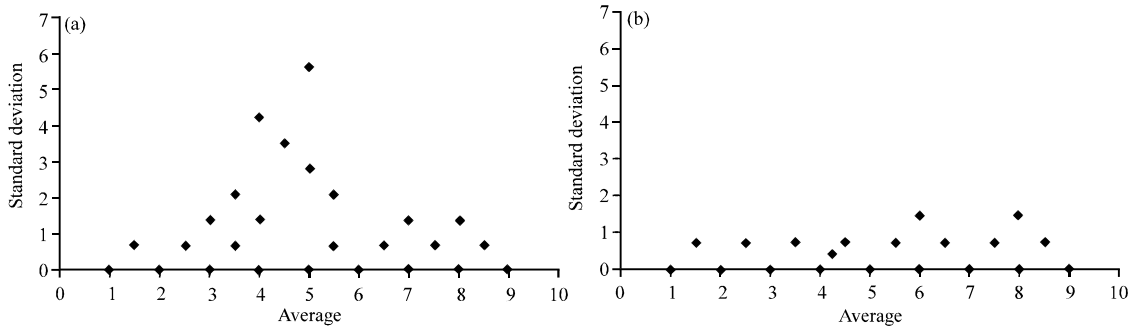

Fig. 10(a-b): Individual repeatability of panelist "rr" during the same training session (a) rr s0 and rr s12

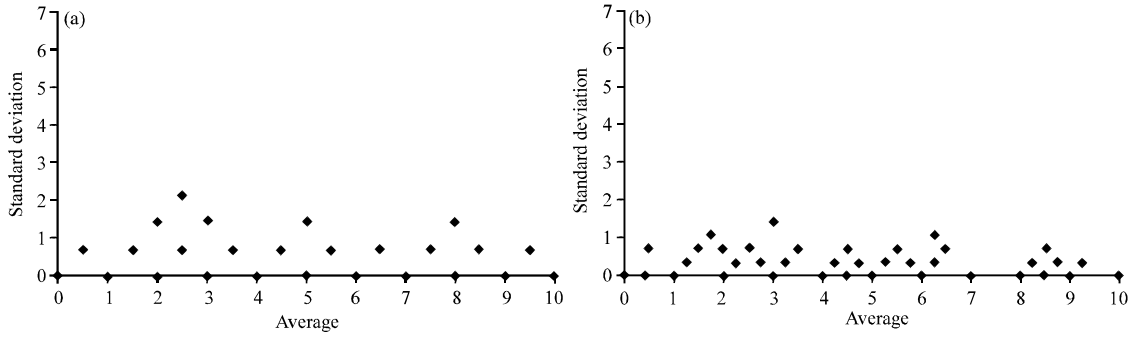

Fig. 11(a-b): Individual repeatability of panelist "hn" during the same training session (a) hn s0 and (b) hn s12

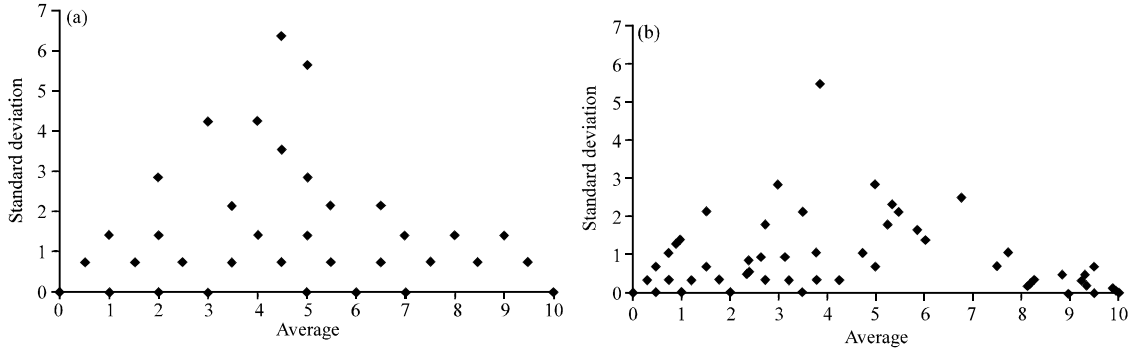

Fig. 12(a-b): Individual repeatability of panelist "lc" during the same training session (a) lc s0 and (b) lc s12

For this reason, this panelist is eliminated from the group with the panelist gr who represents the same problem, thus the panelist bs who represents an unstable standard deviation during the same sitting and a poor repeatability.

After this study, only ten subjects have been selected to form our panel of experts among 15 recruited in the beginning. The remainder of panelists represented, along the training program an improvement of repeatability and of notation scale use.

We applied the PCA analysis also to verify the degree of agreement between the panelists. Indeed the circle of correlation is represented at the beginning and at the end of the training program with repetition.

The Fig. 13a shows that the panelists are dispersed on three independent groups. This implies that the intensity of correlation between the panelists was poor at the beginning of the training program. On the contrary, at the end of the program, the degree of agreement between the panelists was improved, that is legible on the second

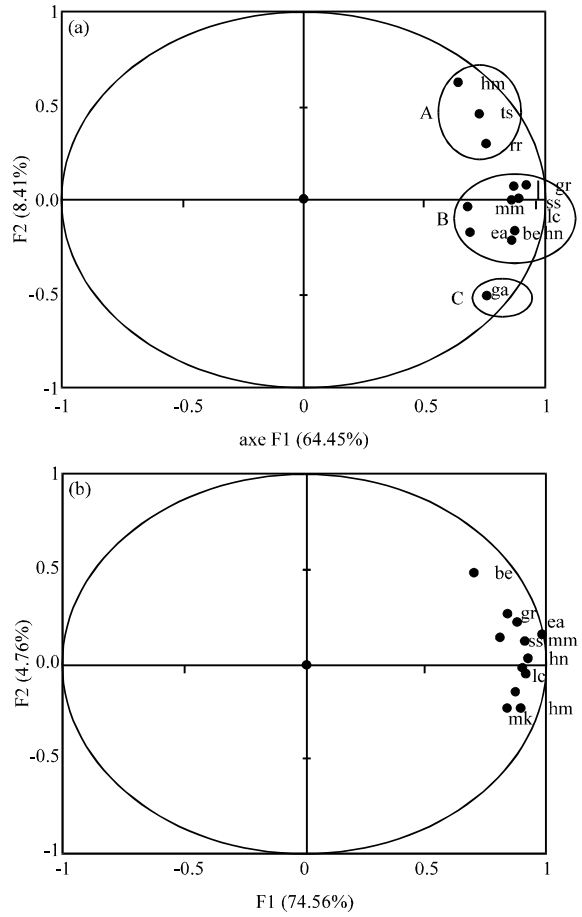

Fig. 13(a-b): Degree of agreement during (a) S0 and (b) S12

circle of correlation (Fig. 13b). On the second circle all the panelists are gathered on the positive edge (1) of first axis F1 excepts the panelist bs who does not agree with the others. For this reason also this panelist is eliminated from the group.

CONCLUSION

In this study, we tried to establish a practical organization adapted for the tactile sensory evaluation of the textile fabrics. To do that, 56 tactile attributes were generated following a preliminary questionnaire, after a qualitative and quantitative reductions, 17 attributes are revealed relevant to describe the textile fabrics. During the first training sessions, an analysis of correlation enabled us to eliminate another one to have a final list of 16 attributes. During the training of the group to use the notation scale (0 to 10), discussions are established with the group to define the evaluation method and the negative and positive references of each attribute.

The PCA and ANOVA analyses carried out in this study, permitted to set up a group of 10 experts of textile handle, they are selected among 15 trained judges according to their repeatability and their discriminative capacity. These selected experts represent a very weak standard deviation, lower than 0.8 and agreement with the remainder of the group. This group is ready to carry out a sensory profile of 16 attributes to describe the tactile quality of the textile fabrics.

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