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Analysis of Fabric Tailorability Subjective Evaluation

Abstract

By developing objective evaluation methods, the subjective evaluation of fabric tailorability is essential to obtain the fabric properties which are relevant to finished-garment quality and necessary for control in the garment manufacture process. In this study an analysis of the subjective evaluation of fabric tailorability was carried out. A preliminary test was performed to assess the most influential fabric properties in the garment manufacture process, and to obtain a set of criteria against which a judgement can be made. The fabrics were then evaluated for tailorability and other criteria of judgement (stretchiness, stiffness, roughness, thickness and density) by a panel of experts, principally researchers and students from the textile and clothing sectors. Both rating and ranking scales were used. The results show that the criterion of fabric tailorability, which can be widely interpreted, is useful in subjective evaluation. However, in order to relate subjective evaluation with objective measurements, tailorability needs to be divided into narrow parts (sewability, formability etc.) according to the experience of experts in manufacturing.

Key words: *fabric, subjective evaluation, tailorability, manufacturing.*

Introduction

Consumers' current demands regarding aesthetic appearance and product comfort have increased interest in the subjective evaluation of textiles based on the stimuli evoked by the specimen on the major sensory centres [1]. Quality, in terms of comfort and aesthetic appearance, is perceptible in a subjective way; it depends on each person's individuality, and is influenced by culture, social status and other factors. This subjective method provides useful information, notwithstanding the fact that it expresses the individual assessor's experience and knowledge. The properties of textiles are usually estimated by objective methods, using indications from instruments. The main weakness of these methods is that they may not exactly represent the performance of the specimen being tested (e.g. a pleasant feeling while wearing clothes). Subjective evaluation is often more applicable to practical conditions, because it gives a measure of the human response to a specific situation, reliably predicting the acceptability of a product by the final consumer. On the other hand, an objective experiment could closely simulate the practical behaviour of a given textile by developing test equipment able to provide results which can be satisfactorily correlated with subjective evaluations. This is the aim of many modern textile testing programmes [2-5].

The automatisation of a garment manufacturing process, together with the modernisation of equipment, allow competitive garments to be produced in the minimum time at minimum cost. This undoubtedly requires the machines and systems to be selected with specific fabric properties in mind. In these circumstances, the ability to predict the behaviour of fabric performance at each stage of manufacture process plays a significant role. It is thus essential to develop and also use objective evaluation methods based on a given fabric's mechanical properties, together with its quality and appearance as relevant to the finished garment, all of which are necessary for control in sewing and other processes involved in converting fabrics into garments. Though the relationship between subjective evaluation and objective measurement results are studied in order to solve new manufacture problems, subjective evaluation of fabric tailorability is still not clearly defined.

This study provides some results of a subjective evaluation of fabric tailorability (the ease with which a fabric can be converted into an acceptable garment), using different criteria of judgement, rating and ranking scales. These results can be guidelines for selecting appropriate, objectively measurable fabric properties related to problems of garment manufacture.

Experimental

A subjective analysis of fabric tailorability comprises several elements:
- the judges (experts),
- the criteria of judgement,
- conditions of assessment,
- methods and technique of ranking and rating.

The experts are asked to evaluate each fabric's tailorability taking into consideration the rules as specified.

Subjective evaluation of each fabric's tailorability was performed as follows: a list of word pairs with opposite meanings relevant to fabric properties and their definitions was prepared, to obtain a set of criteria according to which a judgement can be made. The experts were asked to classify 22 word pairs from 'most important' to 'unimportant' according to fabric tailorability, i.e. they were required to evaluate which fabric properties were the most influential in the garment manufacturing process. On the basis of these results, the criteria of judgement were selected.

The experts received a detailed description of the criteria of judgement, judgement scales and tested fabric specimens. The specimens of 10x20 cm dimensions were marked at random to eliminate any influence of suggestion in judgement. The fabric attributes for evaluation were stretchiness, stiffness, roughness, thickness and density and the complex criterion of tailorability, which characterises problems related to such fabric properties as seam puckering, damage, shrinkage, ply slippage, fraying, or difficulty of shaping. The fabric properties differ in various directions, and the experts were therefore instructed to evaluate stretchiness and roughness in a marked direction on the specimens. The experts were asked to rate their preferences on a 1-5 scale, where 1 - uncharacteristic, 2 - fairly characteristic, 3 - an average characteristic,

Table 1. *Basic fabric characteristics.*

Fabric parameter		Fabric					
		A	B	C	D	E	F
Composition		Wool/PA	Wool/PA/Rayon	Wool/PA	PES	Wool/PA/Rayon	Wool/PES/Rayon
Weight, g/m^2		273	200	284	215	295	304
Density, dm^{-1}	Wa	159	172	133	476	170	113
	Wf	136	152	112	266	124	112
Weave		Plain	Plain	Plain	Twill	Twill	Plain

Table 2. The results of the first test.

Criterion of judgement	Polar word pairs	Definition	Coefficient of weightiness
Stretchiness	Resiliency/Non -elasticity	Rate at which a fabric returns to its original position after deformation is removed	0.10
	Stretchable/Non-stretchable	Degree to which a fabric stretches without tearing from its original shape	0.12
	Strength/Weakness	Possibility of tearing/not tearing	0.09
	Firmness/Fragility	Fabric's yarn resistance/non-resistance to crack	0.06
Stiffness	Stiffness/Limpness	Non-resistance/resistance to bending	0.12
	Hardness/Softness	Resistance/non-resistance to compression, shear	0.10
	Stability/Liveliness	A possibility to keep/lose form	0.07
Roughness	Roughness/Smoothness	Large/small amount of small particles rise on a fabric's surface	0.07
	Slippery/Stickiness	Small/large force required to move a fabric over itself	0.06
Density	Compactness/Looseness	Number of yarns per area	0.06
Thickness	Thickness/Thinness	A distance between the top surface of the fabric and the bottom surface	0.08
	Heaviness/Lightness	Weight of a fabric	0.07

Table 3. Subjective evaluation results.

Criterion	w	χ^2	Rating for fabric:					
			A	B	C	D	E	F
Stretchiness	0.72	82.59	3.28	1.61	2.83	1.11	2.44	2.56
Stiffness	0.33	38.48	2.39	2.00	3.06	2.44	2.06	2.61
Roughness	0.78	90.18	2.50	2.61	2.22	1.22	2.00	4.61
Density	0.54	62.18	2.94	3.00	4.00	4.39	3.22	2.28
Thickness	0.75	86.32	3.94	2.44	4.33	1.67	3.44	3.72
Tailorability	0.67	77.51	3.19	3.50	4.00	3.25	3.88	2.88

4 - characteristic, 5 - very characteristic property of the fabric. The basic characteristics of the evaluated fabrics are listed in Table 1. Both ranking and rating scales were used. The subjective evaluation entailed ranking the fabrics in an ordered hierarchy in each category of judgement criterion.

The evaluation was performed in standard atmospheric conditions for textile testing. The experts individually evaluated and scored each fabric attribute at their own speed; the time of the evaluation was not limited. The assessment involved both touch and sight together; the experts could manipulate the fabric instinctively in any manner they thought the fabric attribute could be fully assessed.

Kendall's coefficient of concordance w was used to describe the level of agreement between the experts [6]:

$$w = \frac{12\left(\sum_{j=1}^{n}\left(R_j - \bar{R}\right)\right)^2}{r^2 n\left(n-1\right)\left(n+1\right) - r\sum\left(t^3 - t\right)} \quad (1)$$

where:

R_j - the sum of the ranks given to each object (fabric),

$\bar{R}$ - the means of these rank sums,

r - number of experts,

n - number of objects (fabrics),

t - number of ranks that were tied.

The significance for w was a test using the χ^2 distribution with φ=n-1 degree of freedom [7]:

$$\chi^2 = wr(n-1) \quad (2)$$

when $\chi^2 > \chi^2_{\alpha}$, w are weighted significance at significance level α (in this case α=0.05)

In order to obtain the most important word pairs, the coefficient of weightiness was calculated [7]:

$$\gamma_i = 100 / R_i / \sum 100/R_i \quad (3)$$

where R_i is the sum of the rank given to object i (word pair).

The rank correlation coefficient q was computed to investigate the relationship between tailorability and other fabric attributes [6]:

$$q = 1 - \frac{6\sum_{j=1}^{n} d_j}{n\left(n^2 - 1\right)} \quad (4)$$

where $d_j = x_j - y_j$ is the difference in ranks assigned to each of the objects n, x, y criteria of judgement.

Results and Discussion

A panel of thirty experts, mainly researchers and students from the textile and clothing sectors, attended the preliminary testing to obtain criteria of judgement. In order to establish whether the individual judges ranked the fabric properties at random, the rank correlation coefficient was computed. The opinions of five experts were rejected according to the smallest rank correlation coefficient. The coefficient of concordance (significant according to the χ^2 criterion) obtained (0.69) shows good agreement between the experts' ranking of fabric properties related to tailorability. The coefficient of weightiness γ_i was computed, and the main word pairs were selected according to $\gamma_i > 1/n$ (Table 2). It was observed that these word pairs are related to the deformation and structural properties of the fabrics. On the basis of the results obtained in the preliminary test, five criteria related to subjective evaluation and objective measurements were selected for the fabric tailorability subjective assessment (Table 2).

A panel of 23 experts participated in the subjective evaluation process, mainly textile and clothing research workers and students. In order to analyse the consistency in subjective evaluation, Kendall's coefficient of concordance was computed and tested on χ^2 criterion for each judgement criterion. To observe the rating tendency in each set of judgement, the means for each fabric attribute were used. The results are summarised in Table 3.

The results indicate that the experts are in good agreement on evaluating fabric stretchiness, density, thickness and tailorability. The coefficient of concordance for stiffness is poor, but significant according to χ^2 ($\chi^2 > \chi^2_{0.05}$, when φ=5, $\chi^2_{0.05}$=11.1). The highest agreement between the experts was observed evaluating the fabric roughness.

The obtained rating results show that the fabric roughness rating varies within the 1-5 score; that is to say, extreme diversity was observed in this evaluation. The assessments of density and thickness vary within two scores. Meanwhile stiffness evaluation varies within a one score. That means the fabrics selected for testing are similar in this property, and the experts had difficulty in assessing the fabrics' stiffness, as it was more difficult to distinguish the small differences in testing specimens. In addition, the definition of stiffness (fabric resistance to bending, compression and shear) may be less clear than other definitions. On the basis of the above, it can be assumed that

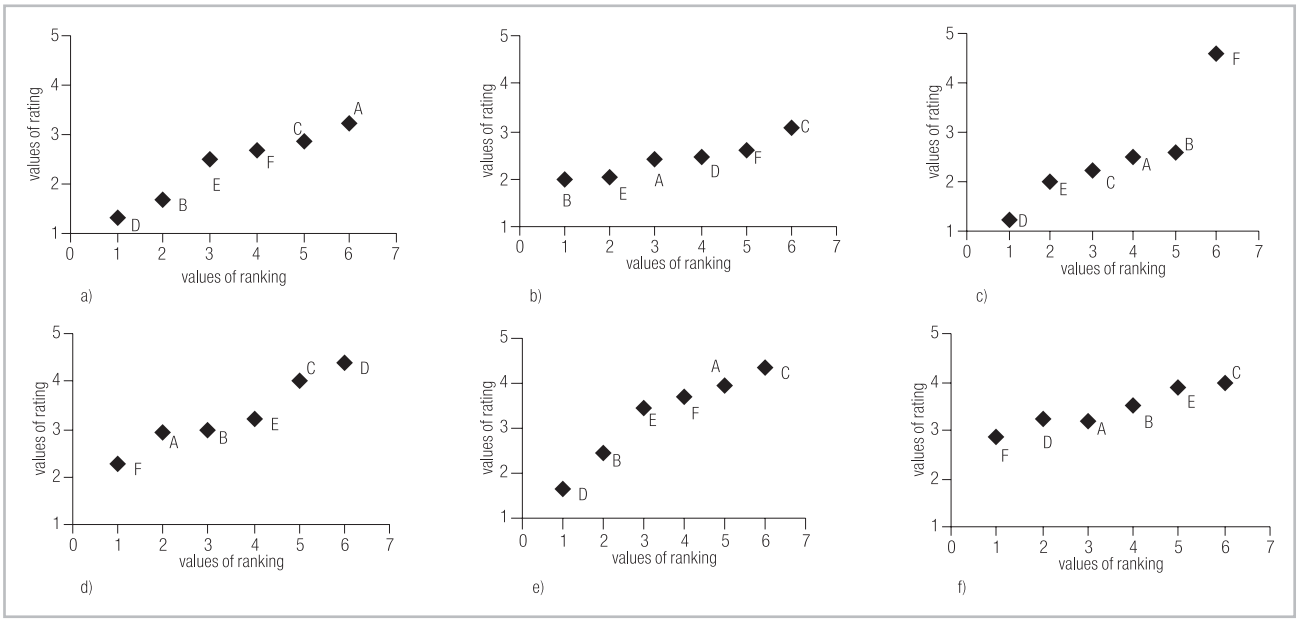

Figure 1. *Relationship between rating and ranking scales regarding a) stretchiness, b) stiffness, c) roughness, d) density, e) thickness, f) tailorability.*

the greater or lesser agreement between the experts may be influenced by more or less perceptible differences between tested fabrics.

The mean values of the rating and rank order are presented in Figure 1. The data in the ranking scale are highly correlated with those in the rating scale, indicating that the two scales agree with each other, but the rating scores provide more information about the differences between fabrics than the ranking scores. On the ranking scale, the data points are forced to fit into an equal distance, which can only reflect the rank order. On the rating scale, the data points vary according to perceived differences between the fabrics, showing not only the rank order of the fabrics but also the actual differences between the fabrics in subjective perceptions. For example, according to the evaluated fabric stretchiness on the ranking scale, the fabrics were ranked in a hierarchy of D, B, E, F, C, A from non-stretched to stretched. On the rating scale, the distance between B and D is smaller than that between B and E, suggesting that fabric B is closer to fabric D than to fabric E in the subjective perception of stretchiness.

An attempt was undertaken to establish a relationship between tailorability and the other criteria of judgement on the basis of rank correlation analysis. The results show (Table 4) that tailorability fails to correlate with other fabric attributes. Our analysis indicated that this problem requires additional experiments, which will be performed in the future. The failure of a correlation may be caused by inaccuracy in choice and formulation of judgement criteria relating to the results of the first set of the experiment. The assumption may be made that the results of subjective evaluation could be improved, by devising more precise and narrow conception of tailorability which takes into account different aspects such as sewability, formability etc., and by enlarging the panel of the experts which have experience in manufacturing.

Conclusions

The subjective evaluation of fabric tailorability was investigated. The results obtained in the preliminary test show that according to the experts' opinion, the deformation and structure properties of the fabrics are important in manufacturing process. The good agreement among the judges shows that the criterion of fabric tailorability can be used in subjective evaluation. However, tailorability fails to correlate with other evaluated fabric attributes. This suggests that the criterion of tailorability must be described more precisely or divided into narrow parts (sewability, formability etc.). The opinion of experts from this point of view is especially important. The method of subjective evaluation which takes so complex a criterion into account needs to be improved.

The consistency of experts' opinion is higher when the fabrics assessed show perceivable differences in their properties. Both ranking and rating scales are highly correlated with each other, but the rating scale provides not only the rank order of the fabrics but also the actual differences between the fabrics in subjective perceptions. The results obtained in this study can be guidelines for preparing assessment techniques of the fabric tailorability subjective evaluation. The trend of the experts' preferences for assessing fabric tailorability enables this data to be related to objective measurement.

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Table 4. *Rank correlation coefficients, agreement between tailorability and other fabric attribute.*

Rank correlation coefficient q between tailorability and:				
Stretchiness	**Stiffness**	**Roughness**	**Density**	**Thickness**
0.2	-0.09	-0.31	0.34	0.37

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