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Sensory Study of Knitted Fabrics that Have Gone Through Washing Cycles with Domestic Softener. Part I: Establishment of a Panel and Assessment Thereof

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Abstract
This study involved the sensory evaluation of knitted textiles which have gone through different domestic laundering treatments with respect to whether their sensory attributes or a combination of different measured sensory attributes can best predict the preference of consumers in the aspect of comfort . The textile consumer always has specific preferences which are related to textile properties at the time of purchasing textiles and also to the perception of how long lasting these properties will be. In the large competitive market of softeners, all softener producers claim the improvement of fabric hand as well as the mechanical properties of textiles. The main aim of this study is to find the important sensory parameters enhanced by the use of softener during washing and the impact of repeated washing on sensory attributes. The study is based on cationic softener (rinse cycle type). We also examined the change in the handle of fabric using the fabric life cycle. The change in the handle of fabric after washing is unavoidable because of strong mechanical action during washing, but it can be improved with the use of domestic softeners during the rinse cycle. In Part I, we established a panel for the sensory evaluation of knitted fabrics that have gone through the ageing of washing cycles with/without the use of fabric softener. The panel assessed the fabrics using criteria defined by the author. In part II, we will discuss the influence of ageing during the washing cycle and the use of fabric softener on sensory properties.

Key words: *sensory properties, knitted fabrics, laundering treatments, domestic softener.*

Introduction

When a garment or fabric is purchased, the consumer always tries to select it on the basis of personalised choice based on his own method of assessment for a particular end use. This kind of assessment is called 'subjective evaluation of fabric'; the result of this kind of assessment is not same for a fresh fabric and the same fabric after a certain use i.e. the fabric becomes inferior as it goes through a certain number of wash cycles. Machine laundering leaves fabrics with an uncomfortable hand as a result of the removal of the fatty finish and lubricating waxes on the fabric when the synthetic detergents remove dirt and oil. Therefore, after the introduction of synthetic detergents to the market, the need for a fabric softener was recognised. Fabric softeners were introduced to the United States market in the early 1950s to modify the hand and to restore the lost physical properties of laundered clothes [1].

Fabric softeners are chemical compositions applied to textiles which claim to give a better comfort feeling. Softeners can be roughly classified into two groups: Non-permanent softeners, which can be removed fairly easily by washing, and permanent softeners, which still exhibit a distinctly soft handle even after several washes [2]. Household fabric softeners are a non permanent type of softener used during the washing process. The three methods of applying softeners to textiles which are presently the most commercially successful are rinse cycle softeners, wash cycle softeners and dryer sheet softeners [3].

In addition to the benefit of improving fabric hand, another reason for the increasing usage of fabric softeners is to decrease unpleasant static cling, which tends to form in synthetic fibres. Friction between fibres causes static electricity, resulting in static cling. Static charge can be dissipated by natural moisture present in textiles. Natural fibres like cotton, linen and wool have a high moisture regain (i.e., percent of moisture in a fibre calculated on the basis of its dry weight). Synthetic fibres, such as polyester, nylon and acrylic have a very low moisture regain, and static charge may accumulate on fabrics, resulting in clinging and crackling. Fabric softeners act as anti-static agents by enabling synthetic fibres to retain sufficient moisture to dissipate static charge [4].

Cationic softeners are the ubiquitous ingredients used worldwide as rinse-added fabric softeners. Cationic softeners contain quaternary ammonium ions as their hydrophilic parts [5]. The physical arrangement of the usual cationic softener molecules on the fibre surface is important, shown in ***Figure 1*** [6].

Cationic softeners bind by electrostatic attraction to the negatively charged groups on the surface of the fibres, neutralising their charge; the long aliphatic chains are then oriented towards the outside of the fibre, imparting lubricity [7].

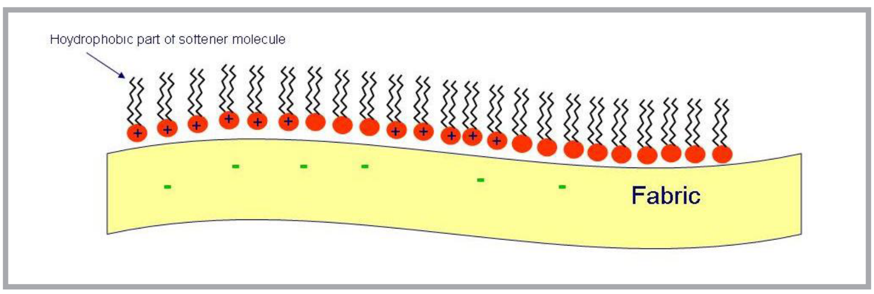

Figure 1. *Schematic orientation of cationic softener on a fabric surface.*

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The effects of household fabric softeners on textiles have been studied in various areas such as fabric weight, fabric strength, dimensional stability, wrinkle recovery, pilling, whiteness, hand, static electricity, odour, absorbency, flammability, and stain release. Both subjective and objective studies have been done in this area. Chiweshe and Crews [8] found that the tensile strength of cotton flannel and polyester woven fabrics decreased significantly after the fabrics were treated with rinse cycle softeners. The authors suggested that the lubrication of the softener on fibres increased fibre mobility, resulting in weak spots and fibre slippage, which caused yarn to break more easily and reduced the tensile strength of the fabric. Karen reported the influence of domestic softeners on wrinkle recovery, the whiteness of the fabric and soil release [3].

Some researchers have studied the effects of fabric softener on fabric hand, static electricity, and odour. Simpson and Silvernale found that rinse cycle softener yielded the best performance in hand, followed by dryer spray. Wash cycle softener gave the poorest performance in hand, which was sticky and gummy [9]. Mackay explained that when fabric is washed without softener, cotton fabric becomes stiffer, the felting of wool occurs, and there is the stretching of acrylic in tumble drying. He also reported that changes occur in the mechanical and sensory properties of fabrics after repeated laundering [10, 11]. Daukantiene and Bernotine worked on the influence of multiplex washing on textile and found that liquid softeners significantly influence the slower deterioration of hand parameters during the use of fabric [12].

Thermal properties are another aspect of the comfort of a garment. The thermal properties of knitted fabrics differ significantly with the structure. Nida and Arzu reported that single Jersey fabrics have remarkably lower thermal conductivity and relatively higher water vapour permeability than a 1 × 1 Rib and Interlock structure [13]. It is expected that as cationic softener makes a boundary layer on fabrics, this would influence the thermal properties of textiles. Baker and Regan tried to find the effects of laundering with and without softener on the thermal properties of softener, but they did not find any significant influence [14].

Ultimately it can be summarised that all mechanical and comfort properties are influenced by domestic cationic softeners because of two mechanisms: boundary lubrication and reduction in inter fibre and inter yarn friction. Sebastian examined the effect of a softening agent on the yarn pull out force and found that it reduces inter yarn adhesion and inter yarn sliding friction by about 40% [15].

Thus significant work has already been done to study the effect of laundering with and without a softener on the mechanical and thermal properties of fabrics, but there has been no study of how to describe human perception regarding touch or the handle of fabric. Of course, to some extent, the combination of a few mechanical parameters can together predict the main attributes of fabric hand. Sensory perception is complex and involves an individual's perceptive representation, implying that, generally, an instrumental approach may not be sufficient to simulate the richness of perception as a whole [16].

Sensory analysis is defined as the examination of sensory attributes by the sense organs and is divided into two parts: discriminative tests and descriptive tests. Descriptive analysis methods involve the description of both the qualitative and quantitative aspects of perceptions and require a highly trained panel. The development of an attribute list, description of the attributes and panel training are crucial steps of the descriptive sensory evaluation test [17]. Hrada tried to describe different fabric attributes and explain them in the ordinary terms used by consumers [18]. The sensory study of textiles started long ago and still continues today, not only by consumers - it is also used in textile production units for quality assessment. There is no standard technique for the sensory evaluation of textiles, but it can still be classified into two groups: (a) Creating a sensory evaluation scale and comparing the samples using it, and (b) ranking the samples by paired comparison [19].

Improvement in the tactile feel of fabric by the application of various chemical products has been recognised for many years. The effect on the hand of the same cotton fabric treated by different chemical finishes was reported by Phillipe [17]. Sensory attraction and good feel are increasingly influencing consumers of fabric softeners in developed countries. However, limited work has been found on the sensory evaluation of knitted textiles, which has its own disadvantages such as curling, pilling after washing etc. Alma reported that sensory assessments can be successfully quantified by instrumental measurements [20]. The sensory evaluation aspect of this work is presented in Part: 2. Part: 1 is concerned with the selection of knitted fabric samples, establishment of a panel, selection of appropriate sensory attributes and the assessment of the panel.

Experimental

Material and methods

As the main objective of the study is to get a general overview of the influence of fabric laundering on sensory properties, it was important to select a group of fabric samples which can represent all fabric types used in garments. In knitted garments, dimensional instability, pilling, the deterioration of fabric handle and shape distortion after laundering is perceived by consumers as an area of great concern, despite the fact that softener producers claim to have reduced these problems. Hence it was decided to select knitted fabric in this study (***Table 1***, see page 102).

On the apparel market, man-made fibres are used more and more (representing 60% of the market) to the detriment of natural fibres (40%). Polyester represents 70% of synthetic fibres on the market. On the natural fibre market, cotton is by far the most used fibre. Synthetic fibres are hydrophobic, whereas cellulosic ones are hydrophilic. They are very different from a chemical point of view, thus they behave very differently with chemicals (softeners, washing powder etc.) and, therefore, are expected to be different in terms of sensory perception and ageing behaviour. We chose polyester as it is the most used man-made fibre, and viscose, which is a cellulosic fibre, hence it is quite close to cotton in terms of behaviour. Viscose is a man-made fibre, thus it is possible to fully control the morphology and all the other yarn parameters. Different relevant knitted fabrics available on the market were selected, varying in knitted construction (Jersey, Rib and Interlock) and fibre type (micro or regular). One open end jersey knitted fabric was also included to observe the effect of yarn construction on softener performance. In ***Table 1***, details are given of the knitted fabrics used in the study. The gsm

Table 1. Yarn and knit parameters of the fabrics studied.

Code	X1	X2		X3	X4	gsm	Gauge
	Fibre type	Fibre fineness & yarn construction		Knitting structure	Porosity		
VμJ	100% Viscose	Micro Fibre (1.30 dtex)	Ring-Modal 50 Nm	Jersey	0.884	145	28
VμR				1×1 Rib	0.895	180	20
VμI				Interlock	0.879	240	20
VRJ		Regular (1.95 dtex)	Ring 50 Nm	Jersey	0.894	160	28
VRR				1×1 Rib	0.905	175	20
VRI				Interlock	0.882	250	20
VROJ		Regular (1.30 dtex)	Open End 50 Nm	Jersey	0.897	150	28
PμJ	100% Polyester	Micro Fibre (1.13 dtex)	Multifilament 60 Nm	Jersey	0.895	130	28
PμR				1×1 Rib	0.882	165	20
PμI				Interlock	0.864	230	20
PRJ		Regular (1.83 dtex)		Jersey	0.867	172	28
PRR				1×1 Rib	0.862	200	20
PRI				Interlock	0.854	250	20

Table 2. Lower and upper boundaries of the sensory attributes.

Boundary	Wrinkle	Fluffy	Stretchable	Slippery	Light-Heavy	Flairy	Flexible
lower (score:1)	free	most	most	most	hevay	most	most
upper (score:52)	with	least	least	least	light	least	least
Boundary	**Cool**	**Drapable**	**Mellow**	**Pills**	**With Relief**	**Greasy**	**Synthetic**
lower (score:1)	coolest	most	most	least	full relief	most	cottony
upper (score:52)	warmest	least	least	maximum	no relief	least	synthetic feeling

of the other fabrics is 130 - 160, 165 - 200 and 230 - 250 for Jersey, Rib and Interlock fabrics. All the Jersey fabrics were knitted on a machine of the same gauge i.e. 20, while a machine of 28 gauge was used for all the Rib and Interlock fabrics.

A front loading washing machine from Miele (model: A W3268) was used for laundering. The whole study required running washing cycles in the same conditions: same cycle, same softeners, same water hardness and same loading weight, which should be close to consumer laundry practices in order to make this study market relevant. All the washing experiments were done under the following conditions: - a) load: 1 Kg, b) no prewashing, c) washing product: 45 ml of non-bio liquid detergent, d) fabric conditioner: 35 ml (rinse cycle cationic conditioner: Comfort Pure (White), provided by Unilever in 2008 e) cotton cycle temperature: 40 °C, f) water hardness: 25 °F and g) line dried.

We chose the minimum load possible for our washing machine to provide sufficient mobility to the fabric in order to achieve maximum uniformity of deposition of the softener. The recommended temperature for washing these fibres is up to 60 °C, hence we decided to opt for a 40 °C cotton cycle for washing.

Each panellist was given a set of 52 fabric samples composed of four subsets of 13 different knitted fabrics (***Table 1***) which had gone through four different process: 1) Fabrics that had gone through 1 washing cycle without the use of fabric softener; 2) fabrics that had gone through 1 washing cycle with the use of fabric softener; 3) fabrics that had gone through 40 washing cycles without the use of fabric softener, and 4) fabrics that had gone through 40 washing cycles with the use of fabric softener.

Choice of sensory attributes

When conducting a sensory study, the generation of vocabulary is a critical point. The terms that are generated have to be appropriate to describe the products. Then it is critical to ensure that all panellists understand the terms and use them accurately in the agreed way of evaluation.

In subjective evaluation, the establishment of a list of attributes is crucial. Attributes should account for consumers' perceptions and be understood by professionals for efficient communication. The attributes generated should be a complete representation of the end product, hence we decided to use a different attribute list for each single fabric washed and for each sample of the ageing cycle.

The panel members were 3 textile engineering students, who were asked to generate different terms concerning fabric handle. About 50 terms were generated by the panellists. Among the most used were as follows: light, flexible, thin, hairy, undulating, flabby, cool, warm, fluffy, with pills, slippery, creased, draped compact, and dense. After a round table discussion among the panellists on the meaning of the terms they used, the list of terms was reduced:

- Only terms that were generated by a single person were removed.
- Terms with a similar meaning were merged.
- Opposite terms were associated with each other, for example thick and thin were reduced to thickness, where a thick sample was given a high score for thickness whereas a thin sample was scored low for.

Table 3 presents the list of terms generated during a brainstorming training session of the panel, including their methods of evaluation and definition.

For sensory evaluation of the 52 knitted samples, the pair comparison method was used i.e. a comparison of two samples with respect to a particular attribute. Then a new sample was ranked relative to one of the samples that had already been compared. In this way, the fabrics were ranked on a scale of 1 to 52. ***Table 2*** shows the upper and lower boundaries of the attribute.

Screening of the panel

To join a sensory panel, it is critical to be both motivated and able to perceive differences between fabrics and to describe what is felt. As there are no standards to screen panellists, a screening procedure was set up to check the abilities of panellists with respect to their sense of touch, based on the type of evaluation they were asked to do. This aimed to check abilities in terms of understanding tasks, such as ranking and discrimination tests - the triangle test, the generation of terms etc. The screening should also enable one to

Table 3. Sensory attributes and methods of evaluation.

Attribute	Definition (+)	Ways of evaluation	
Light-heavyy	Gives an impression of lightness due to the weight of the sample	- Lay the piece of fabric down flat in the hollow of the hand and throw it in the air. Evaluate the weight when falling down.	
Thick	Have an important thickness	- Take the piece of fabric between the thumb and index finger and press it slightly to evaluate the thickness.	
With relief	Gives an impression of relief due to the construction and especially to the Wales	- Take the piece of fabric between the thumb and index finger and press it slightly, and then pull the fabric widthwise (perpendicular to the wales).	
Flexible		- Pinch the centre of the piece of fabric and raise it. The more the fabric falls, the more flexible it is.	
undulating	Making some undulations	- Lay the fabric on a table. Put your fingers on the middle of the fabric and make it move, following a circular trajectory. Observe the undulations during and after the movement.	
Flabby	Can be compressed	- Fold the fabric 3 times (i.e. 8 stratums) and compress it between the thumb and index finger.	
Cool	Provides a cool sensation when coming in contact with the skin	- Take the fabric at one of its corners with one hand and pass it along the back of the hand.	
Fluffy	Gives a sensation of having softness because of fibres.	- Slip the fabric between the thumb and index finger without any pressure.	
With pills	Having some irregular pills	- Observe the irregular pills.	
Stretch (lengthwise)	Stretching by pulling	- Hold the fabric in the middle of the widths and pull.	Evaluate stretch behaviour
Elastic (lengthwise)	Returning to its shape after pulling		Evaluate the capacity of the fabric to return to its shape
Stretch (widthwise)	Stretching by pulling	- Take the fabric in the middle of the lengths and pull.	Evaluate stretch behaviour
Elastic (widthwise)	Returning to its shape after pulling		Evaluate the capacity of the fabric to return to its shape
Slippery	Sensation of roughness/smoothness on the surface of the fabric	- Lay the fabric on a table and slide your index finger along it.	
Crease	Keeps the creases even after removing the load	- Make a bowl with the fabric in your hand, then lay it on a table and evaluate it visually with respect to the amount of remaining creases.	
Draped	Behaviour of the fabric with respect to drape	- Put the fabric on the back of your hand with your fingers slightly separated and evaluate the behaviour of the fabric in terms of drape.	

Table 4. List of tasks for screening sessions.

Attributes	Type of evaluation	Products	Instructions given to the panellist	Requirements to pass
Smoothness	Triangle test	Sandpaper with different grains (3 tests: 0 vs. 0', 0 vs. 2 and 2 vs. 4)	Three pieces of sandpaper are stick on each sheet, two of which are the same and one is different. Please indicate the odd one out.	To get the correct answer for two more different pairs of products (2 vs. 4 and 0 vs. 2)
Softness	Ranking	Four nonwoven fabrics with different softness	Please rank those products from the least soft to the softest.	To organise them in the right order or no more than one shift.
Any	Generation of terms	Different objects: ■ Sand paper ■ Sponge ■ Enamelled paper ■ Elastic ■ Non-woven fabrics	Please give 2 to 3 terms that better describe the products you handle.	To be able to generate spontaneously (within 2 minutes) 3 or more accurate terms to describe the objects
Any	Generation of terms	One woven fabric and one knitted fabric	You are presented with 2 different fabrics. Please describe the differences between them	To be able to provide an accurate description of the differences between the samples (within 2 minutes and at least a list of 3 differences)

check if people can discriminate products in terms of softness and smoothness, being two parameters that are very common for fabric evaluation. The screening procedure consists of the tasks listed in ***Table 4***.

Each panellist goes through the different tasks individually. The tests are run with the panellists blind-folded. The screening process is planned to be conducted in a 10-to-15-minute session.

The samples were cut into A4-sheets. Using a rectangular shape enables to give instructions regarding the direction of the knitted fabric. All the samples were conditioned for a minimum of 24 hours under standard atmospheric conditions (20 ± 2 °C temperature, 65 ± 2% relative humidity) because these conditions can influence the mechanical properties of textiles.

Panel assessment

It is important to assess the panel members because for each individual the evaluation of a sample gives a relative result depending on the comparison with other samples. The sensitivity to each attribute is different for each individual, hence it is important to check the sensitivity and similarity of all panel members. Panel assessment by calculating the standard deviation and covariance of sensory data is the most common approach. We used a more appropriate approach based on internal relative variation of data. The idea behind choosing the internal variation approach is that the standard deviation and covariance simply give us an overall idea of the evaluation, while our approach gives us more information about the contribution and sensitivity of each individual panelist. The criteria designed are better when the number of available samples is small (lack of samples). The method proposed is more adapted to processing a small number of data and allows to establish a suitable compromise between the accuracy and capacity of the interpretation of results obtained.

The sensory data of two panelists P_a and P_b constitute two evaluation spaces U_a and U_b. For the data of these two differ-

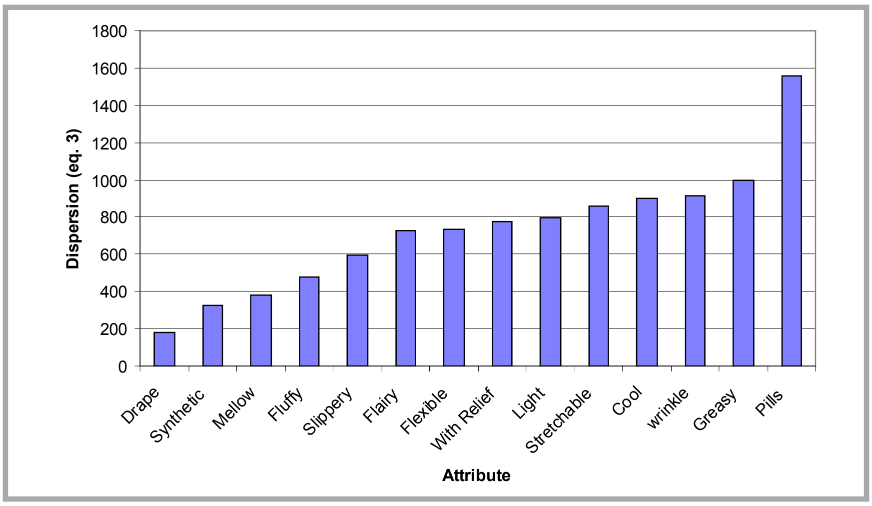

***Figure 2.** Dispersion value of different attributes.*

ent spaces, a new dissimilarity criterion between two panelists P_a and P_b was defined by Zeng and Koehl [21 - 23].

The principal behind calculating the dissimilarity between panelists was to check the internal relative variation of data. If the internal relative variation of data between two panelists is close to each other, then the dissimilarity between the panelists is small; contrariwise, the dissimilarity is great. The dissimilarity between two panelists can be defined by

$$D_{ab} = \frac{2}{n \times (n-1)} \sum_{i<j}^{n} d_{ab}(i, j) \quad (1)$$

Where n denotes the number of samples, depending on the following elements:

- The dissimilarity between P_a and P_b is related to the relative variation between fabric samples t_i and t_j:

$$d_{ab} = |vr_a(i, j) - vr_b(i, j)|$$

- The relative variation between t_i and t_j for panelist P_k:

$$vr_a(i, j) = \frac{1}{\sqrt{m(k)}} |U_{ki} - U_{kj}|$$

$m(k)$ denotes the number of attributes used by P_k, U_{ki} and U_{kj}: normalised scores (whose values lie between 0 and 1). Where $vr_a(i, j)$ characterises the relative variation of sensory data given by panellist P_a from sample t_i to t_j.

Here we can also define the criterion in order to compare two panellists according to the sensivity of the data for the evaluation of samples of T. The sensivity of P_a can be defined by:

$$S_a = \frac{2}{n \cdot (n-1)} \sum_{i<j} vr_a(i, j) \quad (2)$$

The definition of D_{ab} allows the comparison of two panelists on the basis of the relative variation of samples. The dissimilarity between two panelists reaches its minimum only when the internal variations of sensory data of these panelists are identical.

The ability of panelists to score like each other can be defined by the dispersion:

$$Disp = \frac{2}{n \times (n-1)} \sum_{a=1}^{n-1} \sum_{b>a}^{n} D^2_{ab} \quad (3)$$

If the attribute has a lower dispersion value, this shows that panel members have understood that attribute in a similar way and evaluated it in the same manner.

We can also define the contribution of every panellist in the sensory evaluation in terms of contribution dispersion (percentage), which computes the ratio between one panelist and all the others.

$$Contrib_B = \frac{2}{(Disp)_{wb}} \sum_{a=1}^{n} D^2_{ab} \quad (4)$$

Where $(Disp)_{wb}$ is the dispersion without considering the sensory data of Panellist b.

Results

Each panellist was asked to rank the 52 fabrics according to the sensory attributes defined in ***Table 2***. The panel assessment was made using the criteria mentioned above.

It can be observed from the graph (***Figure 2***) that the dispersion of attributes related to the handle of fabric i.e. Drape, Synthetic, Mellow, Fluffy, Slippery, Flairy, and Flexible is lower than those which correspond to appearance (pilling, wrinkle), thermal feeling (cool), structural relaxation (Stretchable, With Relief), surface feel (Greasy) and mass (Light). It implies that panellists are able to understand the handle of fabrics in a similar way with respect to handle attributes; however, for attributes related to appearance, their ranking criteria are quite different. The reason behind this variation could be flaws in the method of evaluation of particular attributes, or the involvement of some external factors in the sensory evaluation of particular attributes. If we take the example of coolness, they found frequent changes in the sensation of coolness of a sample with time. As they used the pair composition method, they had to feel a sensation of coolness for each fabric several times in order to compare it with the others; they found this sensation quite different every time. With respect to pilling, they found a number of samples which did not have pills at all, hence it was difficult to rank all of them.

Figure 3 represents the value of all criteria for the panel assessment of the 'Drape' attribute. The dispersion value of this attribute was found to be the least among all attributes, implying that the panellists could do the evaluation for it in a similar way. The distance between panellists (***Equation 1***) is also the least among all the attributes, having the same level between any two panellists. The percentage contribution for the evaluation of drape is almost equally distributed, meaning that the data provided by panellists has equal importance.

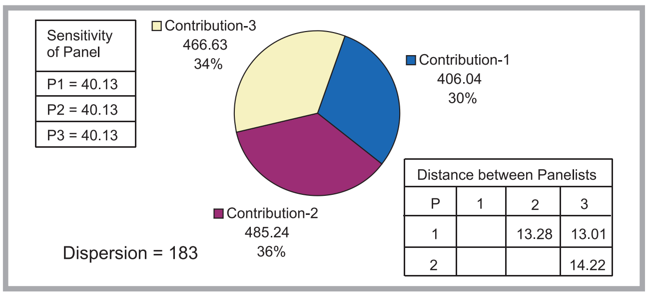

***Figure 3.** Panel assessments for the 'Drape' attribute.*

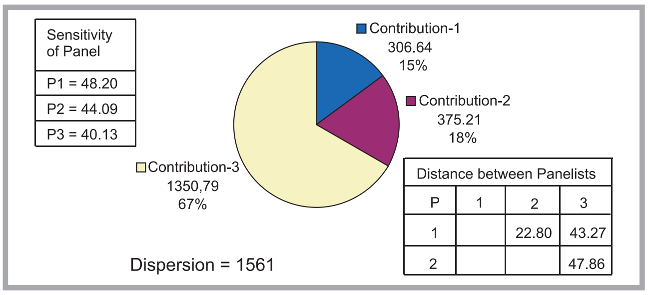

Figure 4. *Panel assessment for the 'Pilling' attribute.*

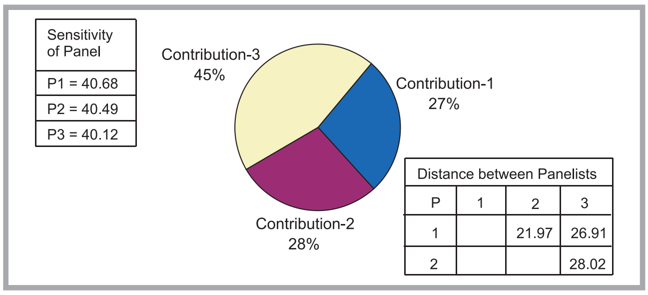

Figure 5. *Average values of panelists' assessment criteria.*

The dispersion value for the 'Pilling' attribute is maximum, i.e. the maximum variation between panellists, which is clear from the value of the distance between panellists (***Figure 4***). The value of the distance of the 3rd panellist from the 1st and 2nd panellists is very large, and because of the high distance, the contribution of the 3rd panellist in the evaluation is also high i.e. 67%.

Figure 5 shows the average of the different panel assessment parameters defined in this paper. Ideally the contribution of each panellist should be 33.33%, whereas for our panel we achieved 27.28 and 45% for first, second and third panellists, respectively, which is assumed to be acceptable. The sensitivities of the panellists obtained were almost the same. On the basis of these criteria, our sensory data for this study were assumed to be acceptable for the second part of this study.

Conclusion

In this study the process of establishing a trained panel was defined. The panel trained was assessed by our defined criteria, on the basis of which our sensory data for this study was assumed to be acceptable for the second part of this study. All sensory studies are made with a new panel and new samples. The reliability of the results depends on the efficiency of the panellists. Generally, it is considered that the higher the number of panellists, the more reliability of sensory evaluation results there is. The criteria used in this paper can be used as tool for the quantification of the efficiency of a panel. An efficient panel with a lower number of panellists can be chosen using these criteria.

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References

1. *Simpson B.G., "The effect of silicone softeners on resin treated cottons", Textile Research Jounal, 28(2), 1958, pp. 170-179.*
2. *Prasad A.K., "Novel Effects in Garment Processing and Value Added Finishes", Journal of Textile Association, 2007 June, pp. 39-43.*
3. *Baumert J. Karen, Penney JC, "Influence of Household fabric softener on properties of selected woven fabrics" Textile chemist and colorist", 28(1), 1996, pp. 36-43.*
4. *Ward H.L., "Textile softeners for home laundering" Journal of home economics, 49(2), 1957, pp. 122-123.*
5. *Mishra Shilpi, Tayagi V.K., "Ester Quats: The Novel Class of Cationic Fabric Softeners", Journal of Oleo Science, 2007, Vol. 56(6), pp. 269-276.*
6. *Daukanitiene Virginija, Bernotiene Birute, Gutauskas, "Textile Hand: the Influence of Multiplex Washing and Chemical Liquid Softener, FIBRES & TEXTILES in Eastern Europe, Vol. 13, No. 3/ 2005, July/September, pp. 63-66.*
7. *Linfield, W.M., et al., Journal of the American Oil Chemists Society, 19558, Vol. 35(11), 590.*
8. *Chiweshe, A., & Crews, P. C. "Influence of household fabric softeners and laundry enzymes on pilling and breaking strength", Textile Chemist and Colorist & American Dyestuff Reporter, 32(9), 2000, pp. 41-47.*
9. *Simpson, H. N., & Silvernale, C. C. (1976). How laundering with fabric softeners affects flame retardant cotton fabrics. American Dyestuff Reporter, 65(1), 36-42, 58.*
10. *Mackay Colina, Anand C Subhash, Bishop P David, "Effects of Laundering on the sensory and Mechanical properties of 1x1 Rib Knitwear fabrics, Part-1", Textile Research Journal, 66(3), 1996, pp. 151-157.*
11. *Mackay Colina, Anand C Subhash, Bishop P David, "Effects of Laundering on the sensory and Mechanical properties of 1x1 Rib Knitwear fabrics, Part-2", Textile Research Journal, 69(4), 1999, pp. 252-260.*
12. *Daukantiene Virginija, Bernotiene, Gautauskas Matas, "Textile Hand : the influence of washing and chemical liquid softener", Fibres and textiles in eastern Europe, 3(51), 2005, pp. 63-66.*
13. *Orglakcioglu Nida, Marmarali Arzu, "Thermal comfort properties of some knitted structures", Fibres and textiles in Eastern Europe, 15(5), 2007, pp. 94-96.*
14. *Baker Wann Marjoire, Regan M. Barbara, "The effects of dry cleaning and of laundering with and without fabric softeners on thermal properties of blankets", Textile Research Journal, 49, 1979, pp. 302-308.*
15. *Sebestian S.A.R.D, Bailey A.I., Briscoe B.J., Tabor D. "Effects of softening agent on yarn pull out force of a plain weave fabric", Textile Research Journal", 56, 1986, pp. 604-611.*
16. *Solfflet Ivanne, Calonnier Maurice, Dacremont Catherine, "A comparison between industrial experts' and novices' hepatic perceptual organisation: a tool to identify descriptors of the handle of the fabrics", Food quality and preference, 15, 2004, pp. 689-699.*
17. *Philippe Flora, Schacher Laurence, Adolphe Dominique, "Tactile feeling: sensory analysis applied to textile goods", Textile research journal 74(12), 2004, pp. 1066-1072.*
18. *Harada Takashi, Saito Minoru, Mastsuo Taatsuki, "Study on the hand- The method of describibg hand", Journal of textile machinery society of Japan, 17(4), 1971, pp. 111-123.*
19. *Sular Vildan, Okur Ayse, "Sensory evaluation methods for tactile properties of fabrics", Journal of sensory studies 22, 2007, pp. 1-16.*
20. *Alimaa D, Matsuo T., Nakajima M., Takahashi M., "Sensory measurements of the main mechanical parameters of knitted fabrics", Textile Research Journal, 70(11), 2000, pp. 985-990.*
21. *Zeng Xianyi, Ding Yongsheng, Koehl Ludovic, "A 2-Tuple Fuzzy linguistic model for sensory fabric hand evaluation", book chapter- Intelligent sensory evaluation- methodologies and applications, pp. 217-234.*
22. *X. Zeng, D. Ruan and L. Koehl, "Intelligent Sensory Evaluation: Concepts, Implementations, and Applications", E-Service Intelligence Book, Eds.: J. Lu, D. Ruan, G. Zhang, Springer, Berlin, 2007 (ISBN: 978-3-540-37015-4)*
23. *L. Koehl, X. Zeng, B. Zhou and Y. Ding, "Intelligent Sensory Evaluation of Industrial Products for Exploiting Consumer's Preference", Mathematics and Computers in Simulation, Vol. 77, No. 5-6, May 2008, pp. 512-521*

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