Sensory analysis: approach for total handle evaluation of wool-type fabrics

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Abstract. This research investigated the tactile sensory analysis of total handle in a range of wool-type fabrics. Considering the interaction of textile materials from garments with the consumer's senses as an essential performance property, seven wool-type fabrics selected as suitable for the final use, which is women office trousers for the cold season, were evaluated by a panel with non-experts for assessing the Total Handle Value. Experiments were conducted in two successive stages: by the individual panelists (as blind handling) and by the panel of assessors for consensus (visualization-with-handling). Previously developed ICT-based learning tools, STAT-Hand and STAT-ConCor, were used for both, the sensory analysis trials accomplishment and the processing of the total handle results. One outcome was that a panel of non-experts can get a good enough degree of agreement among individuals after the blind handling of a range of fabrics and, statistically, this cannot be considered accidental. The result of the consensus reaching on a panel level, through visualization and handling, about the Total Handle Value was not as good as expected and this was argued in the paper. After the blind handling, within the panel of individuals and visualization with handling as a panel consensus, the most proper fabric for women office trousers for the cold season was emphasized from the selected range.

1. Introduction

Considering the well-known definitions for fabric handle, the approach of fabric quality by sensory analysis is a widespread practice, due to the physical interaction with the textile product [1-7]. Regarding the total handle, this is not a property in itself but it was defined as a summary of all the feelings of a person when handling the fabric so, the total handle subjective evaluated could be assessed because the overall sensory analysis allows emphasizing the overall feelings of the fabrics properties linked to the sensorial comfort as handle attributes. Consequently, an overall fabric quality measure associated with fabric sensory properties, used by panelists as subjective judgment criterion, can be defined as Total Handle Value subjective evaluated (THVs) [1, 3, 5-11] .

An earlier work approached the subject of wool-type fabrics selection for ensuring sensorial comfort in women's clothing, using the multi-criteria decision analysis based on a rating scale delivered by customers (participants in a survey) with knowledge in the textile field but non-experts in the fabrics hand evaluation topic [12].

The current study aims to investigate the results of subjective evaluation sessions for THVs and to highlight the links with the virtual perception of potential buyers, expressed in the survey mentioned above. The sensory analysis will be conducted by a panel of master students for the same collection of wool-type fabrics and carried out in two successive stages, considering just the subjective assessment

of Total Handle Value : first by "handling" (as blind individual evaluation of each panel member) and afterwards, by "visualization-and-handling" (as visualization and consensus evaluation from the entire panel).
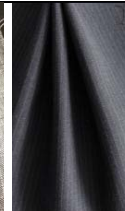
2. Materials and Methods

2.1. Fabrics
Seven wool-type fabrics were chosen for this study for their similarities as a range of materials suitable for the final use that is women office trousers for the cold season [12]. Table 1 summarizes the main description of the selected fabrics with codifications F1 to F7 by including: pattern, weave and fibre content, yarn count size for warp and weft, warp, and weft density.

The seven wool-type fabrics where tested for properties linked to the sensorial comfort (flexibility, thickness, and weight) under controlled environmental conditions.

Table 1. Characteristics of the selected wool-type fabrics.

Fabrics	F1	F2	F3	F4	F5	F6	F7
Pattern							
Weave type	plain	plain	plain	twill 2/2	plain	twill 2/2	twill 2/1
Fibre content	PES 64% /CV 34% /EL 2%	Wool 45% / PES 55%	PES75%/ CV23%/EL 2%	Wool 100%	Wool 44% /PES 54% / EL 2%	Wool 45% /PES 55%	Wool 44% /PES 54% / EL 2%
Yarn count size (warp & weft)	Nm 64/2	Nm 64/2	Nm 52/2	Nm 72/2	Nm 64/2	Nm 64/2	Nm 56/2
Warp density /10cm	336±10	254±10	284±10	350±10	234±10	338±10	313±10
Weft density/10cm	280±10	230±10	244±10	316±10	222±10	288±10	194±10
Fabrics properties linked to the sensorial comfort							
Flexibility, %	64	51	67	53	63	58	61
Thickness, mm	0.43	0.35	0.34	0.36	0.36	0.49	0.48
Weight, g/m^2	216	167	180	182	158	210	220

2.2. Previous work
A former paper advanced the subject of wool-type fabrics selection for ensuring sensorial comfort in women's clothing by using the previously developed software for multi-criteria decision analysis STAT-ADM, based on a rating scale with established criteria for rating given not by experts, but by a large group of consumers as decision makers [12]. The analysis criteria for STAT-ADM were three fabrics properties (flexibility, thickness, and heaviness) tested in the textile laboratory (see table 1), selected due to the estimated links with the sensorial comfort defined by three groups of bipolar attributes (flexible/stiff, thin/thick, and light/heavy). The ranking has been achieved from a survey with nineteen questions about preferences manifested in buying clothes, conducted on a sample of 187 consumers with background in the textile field (women aged between 18 and 60 years). One aim of the survey was to ask women to make a hierarchy for the virtually feeling of sensory comfort, in the idea of purchasing office trousers for the cold season, made of wool-type fabrics. The survey result was the

"niche reaction to the market" and the virtual feeling of sensory comfort was characterized by a hierarchy of bipolar attributes in the following order: thin/thick, flexible/stiff, and light/heavy.

Therefore, the criteria grading of the seven wool-type fabrics for running STAT-ADM was carried out according to the ranked options reached from the survey. Hence, a hierarchy of the seven wool-type fabrics was obtained in descending order of preference (from the best to the worst choice) for office trousers suitable for the cold season, as follows F7, F1, F6, F3, F5, F4 and F2.

2.3. Subjective evaluation of fabrics' total handle
Sensory analysis techniques are widely used for subjective assessing of the fabrics hand, mostly for garments design [2-4, 7-9]. In pursuit of making a subjective evaluation that is characterized by accuracy and reliability, a greatest attention should be paid to the following factors.

Selection of the evaluators for the panel configuration
Because the sensory analysis uses by default the human senses, the panel must be composed of six assessors at least, hence, for this work, the panel of evaluators included a homogeneous group consisting of eight master students as experts, having similar preferences in fashion style.

Subjective assessment procedure for the tactile properties perception
The panel has been trained to evaluate a wide range of woven fabrics by quantifying their individual feelings when blind handling for the evaluation of the mechanical and surface properties by means of bipolar physical attributes of fabric handle. However, the assessment technique applied for this paper was just a free fabric manipulation for total handle evaluation, having in view only the definition of total handle and the proposed fabric end-use. The assessment was carried in two successive stages: by the individual panelists (as a "blind handling") and afterwards, by the panel of assessors (as a "visualization-and-handling" for panel consensus).

Ranking the Total Hand Value during the subjective evaluation trials
After the total handle sensory analysis, the ultimate goal was to correlate the evaluators' feelings with the fabrics' end use. Therefore, it was assumed that grades should be given according to the evaluators' purchase preferences for each fabric item as if they were wearing office trousers for the cold season made of each of the evaluated fabric. For quantifying their sensorial feelings during fabrics handling, panelists were taught to use a rating scale for THVs, with grades from 1 to 5 (the most appropriate to the most inappropriate for the end use).

Analysis' strategy of the evaluation results
The panel performance checking is mandatory and needs specific techniques for data analysis, to establish the reliability and validity of the sensory analysis accomplished by the panel of assessors. For the selected case study, previously developed interactive ICT-based learning tools STAT-Hand and STAT-ConCor [10, 11].

3. Results and Discussion

3.1. On the subjective evaluation of Total Handle Values
After using STAT–Hand software for the blind evaluation trials, the THV profiles of the seven wool-type fabrics, based on the assigned grades awarded by each of the eight evaluators, are quite different, as are the fabrics (figure 1).

For each of the three fabrics (F2, F3 and F6) the evaluations were more heterogeneous and different grades for the same fabric were obtained, which rated it from the most appropriate to the most inappropriate material for the designated destination.

For each of the other four fabrics (F1, F4, F5, and F7), some individuals ranked similar or remarkably close the fabric suitability to a specific end-use. Evaluators E01, E05 and E06 awarded the grade 1 to fabric F1 (considered to be the most appropriate for the intended end use) and evaluators E02, E03, E04, E07 and E08 awarded the grade 2 (they rated the fabric as appropriate for the end use). For the fabric F4, evaluators E01, E02, E05, E06 and E07 awarded the grade 3 (as moderately proper

for the intended end use) and evaluators E03, E04 and E08 awarded the grade 2 (they rated the fabric as right for the end use). For the fabrics F5 and F7 the assessors judged also in an analogous way.
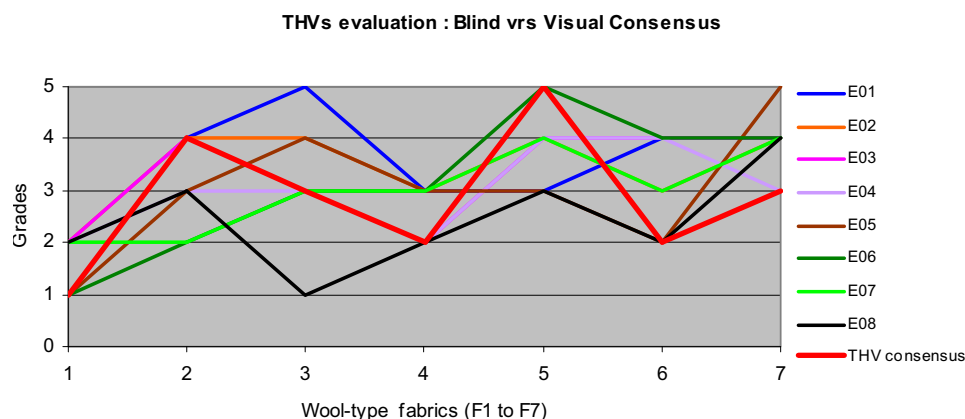

Figure 1. Total Handle Values subjective evaluated: "blind handling" and "visualization with handling".

In the figure 1, the red line stands for the Total Handle Values subjective assessed by the panel of assessors for consensus after "visualization-and-handling". In this case, obviously the "consumer perception" about the overall sensorial comfort potentially assured by each of the seven wool-type fabrics was influenced not only by the fabric properties linked to the overall sensorial comfort perceived when handling, but also by the aesthetic properties perceived visually. The consensus in the panel had the following results: for the fabrics F1 and F4, the grades were very close to the blind evaluation and for the fabrics F6 and F7 an evaluation very different from the blind handling was achieved. For the fabrics F2, F3 and F5, the feelings' meaning after "visualization-and-handling" had only a few tangents with the perceptions of some assessors at the blind handling. Altogether, according to the consensus after "visualization-and-handling", the seven wool-type fabrics have the following potential for the designed end use as women office trousers for the cold season: fabric F1 was chosen as the most appropriate for the end use (grade 1); fabrics F4 and F6- appropriate (grade 2); F3 and F7 -moderately appropriate (grade 3); F2 -inappropriate (grade 4) and, fabric F5 was chosen as the most inappropriate for the end use(grade 5).

In terms of common results, the blind subjective evaluation of Total Handle Values can be considered as moderate compared to the panel evaluation, achieved after the visualization and handling.

However, only by studying the THV profiles after both, individual blind handling, and visualization-with-handling at the level of the entire panel, it is hard to predict whether the panel structure with non-expert evaluators may be endorsed as a disturbing factor for the data accuracy.

3.2. On the rating consistency after blind evaluation vs. visual and handling evaluation
The outcomes from the overall processing with STAT-ConCor facilities of the subjective evaluation results after both, blind and visualization for consensus are presented in table 2. This summary table includes overall results by respecting the usual calculation relationships for each of coefficients (Kendall and Spearman), and the statistical significance tests to prove coefficients' statistical significance, considering the "null hypothesis" as a general statement that there is no relationship / agreement among the rankers.

Regarding the reliability of the panel with non-experts, the Kendall's coefficient of concordance value was 0.393, which means that, during the blind handling the eight evaluators (master students) were in poor to medium agreement on the suitability of the seven wool-type fabrics in women office

trousers for cold season. However, following the results of the statistical significance test, the coefficient of concordance was significant at a level of 0.05. This situation strengthens the hypothesis that there was agreement between non-expert assessors during the blind handling evaluation but with a lower than a middle one degree.

Table 2. Kendall and Spearman coefficients' statistical significance (at 0.05 significance level).

Chi-Squared Test		Student's t Test	
(*Kendall's coefficient of concordance* , W=0.393)		(*Spearman's correlation coefficient,* r_S =0.571)	
Computed value	Critical value χ^2 0.05,6	Computed value	Critical value t 0.05, 5
18.86	12.6	1.56	2.01

Regarding the connection between the two ways of evaluation the Spearman's correlation coefficient value was 0.571 so, it was emphasized a better than medium level of correlation between the blind evaluations from individuals and evaluations with visualization from the panel consensus. Nevertheless, in accordance with the results of the statistical significance test, the coefficient of correlation was insignificant at a level of 0.05. This situation strengthens the hypothesis that there was no agreement between the blind handling evaluation and visualization handling for this panel of non-expert assessors.

Table 3 summarizes an overall hierarchy (after three approaches) of the seven wool-type fabrics in descending order of preference for destination. The greatest ranking for THV could be regarded as the best fabric that would be designed and manufactured for specific end use.

Table 3. Overall hierarchy of seven wool-type fabrics after sensory and virtual analysis.

Ranking for the intended end use Fabric evaluation	Most proper – appropriate	Moderately appropriate	Inappropriate-most inappropriate
Blind handling (panel individuals)	F1, F4	F2, F6, F3	F5, F7
Visualization and handling (panel consensus)	F1, F4,	F6, F3, F7	F2, F5
Virtually (without visualization and / or handling) [12]	F7, F1	F6, F3, F5	F4, F2

Altogether, from the above range of wool-type fabrics, the fabric with the best evaluated overall comfort seems to be F1.

4. Conclusions

In this paper, sensory analysis techniques were applied for a collection of seven wool-type fabrics, considering just the subjective assessment of Total Handle Value (THVs) by both, "blind touch" and "visualization-with-touch". To be consistent with the reality when it comes to the consumer niche demands, a reliable sensory analysis of the THVs was considered to have a key position in fabrics' choice for the specific end-use, which is women office trousers wool-type designed for the cold season.

Altogether, an interesting outcome was that a panel of non-experts with a low degree of unanimity among the individual responses after the blind handling of each fabric is good enough and, statistically, cannot be considered accidental. The reaching of consensus regarding the Total Handle Values at the panel level through fabrics visualization and manipulation had a less good result than expected although it was supposed that the visual and handling perception to provide a better assessment of fabrics than the blind handling. It seems that when different evaluators are looking at a particular fabric and handle it, they are influenced in evaluations do to the aesthetic aspects of the

fabric, depending on the personality of each one, and subconsciously can create links with the final destination of the material, altering the objective manner on which a consensus can be achieved. Thus, for the selected fabrics, the sensory analysis trials provided better results when the evaluation was with blind handling than with visualization and handling.

The current study also aimed to analyse the results of subjective evaluation sessions for Total Handle Value and to highlight the links with the virtual perception of potential buyers, expressed in the survey and the outcome was the following: from the seven wool-type fabrics after blind handling (panel individuals), visualization with handling (panel consensus) and in a partial consent with virtually assessment for multi-criteria decision making (without visualization and handling), the most appropriate wool-type fabric designed for women office trousers for cold season, was the plain fabric F1 made of PES 64%/CV 34% /EL 2% .

The obtained results highlighted the sensitive aspects of the textile value chain, which can turn from strengths to weaknesses due to the influence of the potential buyers' preferences and it should be basic to consider the subjective perception of the consumer niche on the sensorial comfort properties expectations.

References

[1]   Stearn A E, D'Arcy R, Postle R and Mahar T J 1988 A Statistical Analysis of Subjective and Objective Methods of Evaluating Fabric Handle. Part I: Analysis of Subjective Assessments *J. Tex. Mach. Soc. Japan* **38** (8) pp 62-68

[2]   Naima H A, Mehdi S and Morched C H 2013Training and Control of Performance of a Tactile Sensory Panel *Journal of Applied Sciences* **13** (3) pp 366-376

[3]   AATCC EP 5-2011 Fabric Hand: Guidelines for the Subjective Evaluation 2012 *AATCC Technical Manual* (American Association of Textile Chemists and Colourists) pp 388-390

[4]   Schacher L, Bensaid S, El-Ghezal Jeguirim and Adolphe D 2011 Sensory and Physiological Issues *Advances in Modern Woven Fabrics Technology* ed Dr Savvas Vassiliadis (InTech)

[5]   Valatkienė L and Strazdienė E 2006 Accuracy and Reliability of Fabric's Hand Subjective Evaluation *Mater. Sci. (Medžiagotyra)* **12** (3) pp 253 – 257

[6]   Sülar V and Okur A 2007 Sensory Evaluation Methods for Tactile Properties of Fabrics, *J Sens. Stud.* **22** 1-16

[7]   Kanai H, Morishima M, Nasu K, Nishimatsu T et all 2011 Identification of principal factors of fabric aesthetics by the evaluation from experts on textiles and from untrained consumers *Text. Res. J* **81** (12) pp 1216–1225

[8]   Tester D, McGregor B A and Staynes L 2014 Ultrafine wools: comfort and handle properties for next-to-skin knitwear and manufacturing performance *Text. Res. J* **85** (11) pp 1181 – 1189

[9]   Xue Z, Zeng X, Koehl L and Shen L 2015 Consistency and reliability of untrained consumers' perceptions of fabric hand of men's suiting *Text. Res. J* **86** (13) pp 1425–1442

[10]   Harpa R 2016 Fabric Hand: Approach by Means of Software Package for Teaching Students. Part I. Software Development *12th Int. Scientific Conf. on eLearning and Software for Education* (Bucharest: Romania) ed. Roceanu I vol. **3** pp 512-517

[11]   Harpa R, Cristian I and Piroi C 2017 STAT-CONCOR: Software for Validating the Panel of Assessors, Subsequently to the Fabric Hand Evaluation *13th Int. Scientific Conf. on eLearning and Software for Education* (Bucharest: Romania) ed. Roceanu I vol. **3** pp 431-438

[12]   Harpa R 2017 Selecting wool-type fabrics for sensorial comfort in women office clothing for the cold season, using the multi-criteria decision analysis. *IOP Conf. Ser.: Mater. Sci. Eng.* **254** 142009