RESEARCHES REGARDING CORRELATION BETWEEN MATERIALS' TACTILE FEELING AND PERCEIVED PERFORMANCE

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This paper presents the results of an experiment designed to determine the possible correlations between tactile parameters of different classes of materials and different characteristics associated with those materials. In the first part of the experiment, there were used five samples of material (metal, plastic, ceramic, wood and composite), and in the second - five samples of wood material that varied in surface roughness. Characteristics associated with the considered materials were: quality, performance, price, warmth and liking.

Keywords: touch design, perceived performance, wood materials

1. Introduction

The industrial design is a cultural activity reflecting the reality built by industry. Industry, as a system organized on precise principles, formulates its aesthetic message and embodies it in products' design which is conceived based also on precise rules. In the absence of such rules, the message is affected by "noise" caused by design issues adjacent to product aesthetics. Since industrial design is a scientific activity aimed to satisfy the human being, it is necessary that all its aspects (theoretical and practical) to be deepen with scientific rigor.

In the field of product design, there exist some global trends such as: satisfying all the senses that relates to the product, increasing user satisfaction, systematic and scientific approach to conceiving and evaluating product design.

Even the product's visual design matters about 83% of the perceived information, the visual component has a diminishing contribution to ensure a consistent advantage, because companies, from multinational giants to local SMEs, are increasingly concerned with the development of the products' visual aspect. So, many products resemble a lot even they are manufactured by different companies. Given that information and leading technologies become available more rapidly at global level, the opportunities to produce a competitive visual design are increasing and within reach.

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Designers' attention is increasingly focused on the tactile component, because the user enters in a more direct and intimate contact with the product through the tactile sense than through the hearing or smelling sense. It is estimated that information in tactile format is more important for the assessment of product quality than the information in auditory format, excepting the case of products used for the production, processing or reproduction of sound.

From a theoretical perspective, the visual component of product design has been studied extensively since the beginning of the twentieth century and is considered to be known in detail. The visual vocabulary (shapes, colours, etc.) and ordering principles (contrast, symmetry, etc.) are well-known. Not the same can be said about the tactile component of product design. The human tactile perception was studied, but very little was done about product's touch design.

Worldwide and especially in consumer-oriented companies, a special attention is given to the non-visual aspects (tactile, auditory, olfactory and even taste if applicable) of product design. This has a growing importance in the perception of product quality. As a product increases visual comfort, but also the comfort of the other senses, the perceived quality is considered to be higher.

Development of tactile component of product design led to the development of a new concept: touch design, suggesting that the tactile component should be approached as a field by itself. Moreover, the old design trend, known as the high-tech, that gathered the achievements which reflected the impetus of technology and industry, induced an antithetical trend: high-touch. High touch develops designs rich in significances and close to the human psyche [1]. Not coincidentally, the name of this new trend is high-touch, phrase containing the word touch (tactile touch), revealing by this way the importance of touch to human psyche.

2. State of the Art in Touch Design

Scientific literature for the field of senses [2, 3] contains information on tactile perception psychology (tactile analyser, acuity of various parts of the human body, associated stimuli, etc.), but, until recently, did not included research on the tactile perception of different classes of materials and did not provided useful data for designers.

Professor Diego Ruspini from Stanford University searched for methods to be used for semantic enrichment of tactile information so to become counterparts to those offered by a complex graphic system [4].

Dr. Susan Lederman, coordinator of Touch Laboratory at Queen's University (Canada), conducted researches on subjects with normal vision, and on subjects with visual impairment. The objectives of her research were [5]:

- tactile perception and properties of objects' surface;

- identification of common or unusual tactile objects;
- tactile perception of space for people with normal vision and for people with visual impairment;
- sensorial integration and multimodal perception.

The mechanism of touch is based on mechanical and thermal receptors beneath the skin. The response of these receptors is well documented [6, 7]. The first level of processing involves sensorial judgments, but afterwards affective judgments are activated [8].

H. N. J. Schifferstein found evidence regarding the relationship of dominant sense in perception and the type of product. For example, vision is important in assessing a lamp, smell – for detergent, touch – for kitchen whisk [9].

But several researches indicated a strong correlation between the senses. M. A. Heller analysed the perception of texture through visual and tactile senses [10]. The French researcher Picard discovered that texture information received through vision and touch was just partially equivalent [11]. In the field of fabrics, the emotional values revealed through tactile and visual exploration were investigated by A. L. Bang [12]. Other researches confirmed that mental representation of a product as a result of perception through one sense included elements obtained through other senses [13, 14, 15].

Moreover, the information received through one sense (whatever visual or tactile) creates certain expectations for the information received through other sense. The congruence or incongruence between the information received through different senses may lead to a positive or negative product experience [16].

Some researches pointed out that the following tactile parameters should be considered [1, 17]:

- texture (perceived by lateral movement of skin);
- hardness (perceived by pressure applied on the object's surface);
- temperature (perceived by static contact between skin and object's surface);
- weight (perceived by supporting the object in hand);
- overall shape / volume (perceived by covering the object with the palm);
- precise shape (perceived by tracking the contour).

Other researches based on the perceived similarities of the tactile properties of materials like wood, sandpaper and velvet indicated a slightly different list of tactile parameters: roughness, hardness, slipperiness, bumpiness and warmth. The most robust parameters were found to be roughness, hardness and, weaker, slipperiness [18, 19].

A group of Canadian researchers studied the relationship between human touch and different materials. The materials studied were: fox fur, moisturizing gel, putty, sandpaper, acrylic sheet, glass, fine brush, maple wood, glass coated with olive oil, adhesive tape and silk. The relationship between man and material was measured by two parameters: arousal and preference. If at arousal level, the differences were not significant, at the preference level, subjects liked mostly fox fur, maple wood, silk and less glass coated with olive oil and moisturizing gel and adhesive tape. Also, they investigated the affective responses for both tactile and rendered physical user interface components – surface texture and rotary knob movement. They found out that people rated higher the knob movements that helped them in performing simple tasks [20].

The meanings of materials given by their nature and the associated manufacturing processes were investigated by Karana, Hekkert and Kandachar. They asked the experiment participants to evaluate a selection of products against some properties associated with materials and manufacturing processes and, afterwards, with five meanings: aggressive, nostalgic, professional, sexy and toy-like. They discovered that there was a correlation between the properties and the meanings and also that shape and context of use influenced the correlation [21].

3. Experiment Design

The aim of the experiment was settled to be the study of possible correlations between materials' tactile feeling and perceived performance of the same materials. Because of logistical constraints, it was decided that the materials' evaluation will be done only through contact with the finger. Subsequently, only the following tactile parameters were considered: roughness, hardness and temperature.

There were selected five samples made from generic materials (metal, plastic, ceramic, wood and composite material – Figure 1) and five samples made from wood (displayed in Figure 2). The wood samples were wood veneers covering panels made from medium-density fibreboard. The veneers were from different species.

Fig. 1. Samples from generic materials used in experiment

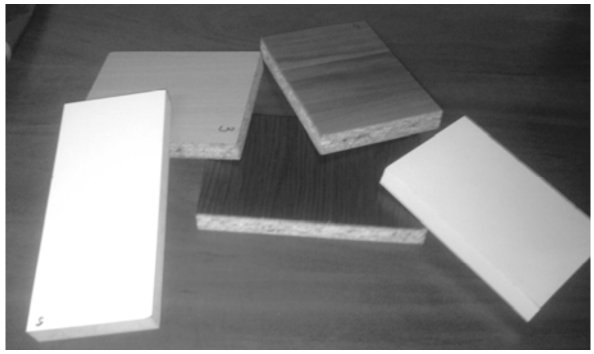

Fig. 2. Samples from wood used in experiment

The roughnesses of wood samples (R_a) were 0.4, 0.8, 1.6, 2.5 and 3.2 μm. The values were determined by visual comparison with a set of roughness standard blocks.

The participants touched the samples blind-folded using only one finger. A message had been composed for them: "You will touch a flat surface made from a certain material. You will not be asked to identify the respective material. We ask you to imagine a product which has the casing made from that material. What is your opinion about that product? What is its quality? What is its level of performance? How cheap / expensive do you think it is? How warm / cold do you think it is? How much do you like it?" In order to record the participants assessment, a 5-point Likert scale will be used, where 1 corresponds to the inferior level ("the worst") and 5 to the superior level ("the best"). The samples were presented randomly to participants.

In the end, the participants will be asked to make a self-assessment regarding their judging. They will be requested to indicate which parameter they used in the materials' evaluation, respectively they will choose among roughness, hardness and temperature.

4. Experiment's Results

The experiment was carried-out with the help of 55 participants. All the participants were volunteers and they did not receive any reward for their involvement in this experiment. The gender distribution of the sample was: 29 female and 26 male. The age range was 18 – 59 years (M = 26.6 years and SD = 9.23 years).

The Cronbach's alpha is a statistic indicator used in the assessment of psychometric tests. If its value is higher than 0.7, the meaning is double: a) the test was well designed; b) the subjects answered correctly and no misunderstandings or ill-will occurred. The values of Cronbach's alpha coefficients for experiment are displayed in Table 1.

Table 1

Cronbach's alpha coefficients

Metal	*Plastic*	*Ceramic*	*Wood (gen.)*	*Composite*	*Wood*
0.74	0.70	0.75	0.66	0.72	0.83

With the exception of generic wood (α = 0.66), all the values of Cronbach's alpha are higher than 0.7, so the experiment's results can be validated. Because Cronbach's alpha for generic wood is lower than the limit, but close to it, its associated results can be taken into consideration, but with a certain care.

The results of quality perception for the generic materials are presented in Table 2. It can be observed that the composite materials scored very well – 4.49 of maximum 5 and 28 scores of "5" marks (50.9%). Also, the ceramic material did quite well. Plastic was assessed as having the poorest quality.

Table 2

Perceived quality for generic materials

	Metal	*Plastic*	*Ceramic*	*Wood*	*Composite*
Mean	3.20	3.02	**4.02**	3.42	**4.49**
Standard deviation	0.65	0.65	0.65	0.81	0.54
No. of "1"	0	0	0	0	0
Nr. of "5"	0	0	11	4	28

Table 3

Perceived quality for wood materials

	Wood 1	*Wood 2*	*Wood 3*	*Wood 4*	*Wood 5*
Roughness [μm]	*0.4*	*0.8*	*1.6*	*2.5*	*3.2*
Mean	4.64	4.40	3.82	3.31	2.62
Standard deviation	0.59	0.74	0.77	1.18	1.16
No. of "1"	0	0	0	0	14
Nr. of "5"	38	30	12	12	2

The results of quality perception for wood materials are presented in Table 3. There is a certain trend of correlation between roughness and quality scores. As the roughness increases the quality mean decreases. This is also reflected by the number of "5" marks. The correlation coefficient has a high number -0.9959.

The output of performance perception for the generic materials is displayed in Table 4. It can be observed that the composite materials scored very well – 4.53 and 31 scores of 5 (56.4%). Also, the ceramic material scored quite well, close to composite material's score. Wood scored the poorest.

Table 4

Perceived performance for generic materials

	Metal	*Plastic*	*Ceramic*	*Wood*	*Composite*
Mean	3.38	3.38	**4.27**	3.13	**4.53**
Standard deviation	0.56	0.87	0.65	1.06	0.60
No. of "1"	0	2	0	3	0
Nr. of "5"	1	4	21	7	31

Table 5

Perceived performance for wood materials

	Wood 1	*Wood 2*	*Wood 3*	*Wood 4*	*Wood 5*
Roughness [μm]	*0.4*	*0.8*	*1.6*	*2.5*	*3.2*
Mean	4.36	4.25	3.45	3.13	2.71
Standard deviation	0.59	0.64	0.72	0.88	0.96
No. of "1"	0	0	0	0	4
Nr. of "5"	23	20	5	4	2

The results of performance perception for wood materials are presented in Table 5. Again, it can be observed a trend of inverse correlation between roughness and performance scores. This is also reflected by the number of "5" marks. The correlation coefficient has a high number -0.9867.

Price was evaluated in terms of how cheap ("1") or how expensive ("5") is the hypothetical product that has the casing touched by participants. The results of price perception for the generic materials are displayed in Table 6. This time, the ceramic material surpassed the composite material as being the most expensive. Metal was perceived as the cheapest from the considered series.

Table 6

Perceived price for generic materials

	Metal	*Plastic*	*Ceramic*	*Wood*	*Composite*
Mean	2.82	3.22	**4.18**	3.65	**4.09**
Standard deviation	0.98	1.07	0.84	0.87	0.87
No. of "1"	10	5	0	1	0
Nr. of "5"	0	8	23	5	23

Table 7

Perceived price for wood materials

	Wood 1	*Wood 2*	*Wood 3*	*Wood 4*	*Wood 5*
Roughness [μm]	*0.4*	*0.8*	*1.6*	*2.5*	*3.2*
Mean	4.09	3.89	3.45	3.27	3.24
Standard deviation	0.59	0.71	0.72	0.87	0.58
No. of "1"	0	0	0	0	0
Nr. of "5"	12	11	5	2	0

The results of performance perception for wood materials are presented in Table 7. Again, it can be observed a trend of inverse correlation between roughness and performance scores. This is indicated by mean values, but also reflected by the number of "5" marks. The correlation coefficient has a high number -0.9519.

Warmth was evaluated in terms of how cold ("1") or how warm ("5") is the hypothetical product that has the casing touched by participants. The output of warmth perception for the generic materials is displayed in Table 8. The scores obtained by all generic materials were close to neutral "3" with composite and wood coming on the two places. The scores at warmth were lower than those obtained for other characteristics. The number of “5” varied independent of mean.

Table 8

Perceived warmth for generic materials

	Metal	*Plastic*	*Ceramic*	*Wood*	*Composite*
Mean	3.13	3.13	3.25	**3.45**	**3.53**
Standard deviation	0.94	0.96	0.95	0.81	1.02
No. of "1"	1	2	0	1	1
Nr. of "5"	3	4	7	3	12

Table 9

Perceived warmth for wood materials

	Wood 1	*Wood 2*	*Wood 3*	*Wood 4*	*Wood 5*
Roughness [μm]	*0.4*	*0.8*	*1.6*	*2.5*	*3.2*
Mean	3.80	3.49	3.58	3.42	3.20
Standard deviation	0.76	0.77	0.74	0.79	0.68
No. of "1"	0	0	0	0	0
Nr. of "5"	11	6	8	2	2

The results of warmth perception for wood materials are presented in Table 9. According to the table, there is not an inverse correlation between warmth and roughness, but the correlation coefficient (-0.8858) indicates a considerable correlation.

The results of liking inquiry for the generic materials are displayed in Table 10. The ceramic material scored well at mean (4.45) and very well at number of “5” marks (33). It was followed by the composite material. Metal scored the poorest.

Table 10

Liking results for generic materials

	Metal	*Plastic*	*Ceramic*	*Wood*	*Composite*
Mean	2.89	3.24	**4.45**	3.89	**4.04**
Standard deviation	0.71	0.94	0.74	1.13	0.79
No. of "1"	0	2	0	3	0
Nr. of "5"	0	5	33	18	17

Table 11

Liking results for wood materials

	Wood 1	*Wood 2*	*Wood 3*	*Wood 4*	*Wood 5*
Roughness [μm]	*0.4*	*0.8*	*1.6*	*2.5*	*3.2*
Mean	4.65	4.16	3.84	3.47	3.15
Standard deviation	0.62	0.88	0.76	0.94	0.68
No. of "1"	0	0	0	0	0
Nr. of "5"	40	23	12	5	0

The results of liking inquiry for wood materials are presented in Table 11. The most liked wood material was the one with the lowest roughness. It has the highest mean (4.65 of maximum 5) in the whole experiment and the highest number of "5" marks (40 of 55) again in the whole experiment. The correlation coefficient is -0.9821 indicating a strong correlation.

The self-assessment of the most important parameter used in material's tactile assessment indicated that the roughness was used by the majority of participants (Table 12). Hardness was considered as insignificant.

Table 12

Contribution of parameters in tactile assessment

	Roughness	*Temperature*	*Hardness*
Contribution [%]	81.82	16.36	1.82

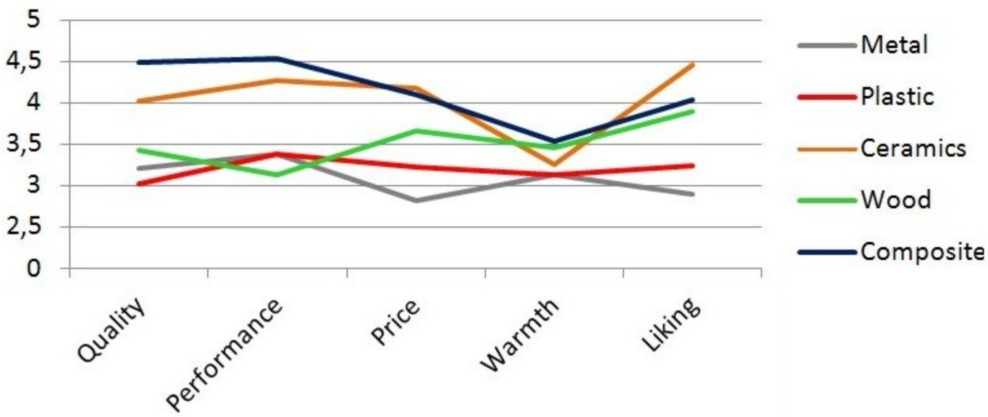

Fig. 3. Overall perception by tactile sense of materials considered in experiment.

The overall perception by tactile sense of materials considered in experiment is displayed in Figure 3.

5. Conclusions

The conclusions of the experiment presented in this paper are:

- Composite and ceramic materials were associated with high quality, performance and rather high price.
- Metal and plastic were associated with low quality and performance, and were considered as cheap materials.
- All the materials did not score very well at warmth.
- Ceramic was the most liked material, followed by the composite material.
- For wood materials, there was a strong inverse correlation between roughness and considered characteristics (quality, performance, price,

warmth and liking). As lower was the roughness the better material was perceived.

- People used mainly roughness in tactile assessment (result based on self-assessment).

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