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USER PROFILE DIFFERENCES IN SEMANTIC DESIGN. APPLICATION TO HAND TOOLS

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ABSTRACT

Nowadays, consumers do not just look for a functional, usable, safe, and cost-efficient product, but for the emotions and feelings it offers them. Emotional design techniques are being successfully applied to consumer products. This paper presents a work aimed at researching the applicability of emotional design to commercial products, in particular to hammers, which may be considered either as a commercial or as a consumer product, depending on the final user.

A semantic differential test with 19 descriptors and images of hammers was designed. A total of 48 subjects from 4 different user groups answered about their perception.

The differences perceived between the groups and their possible causes are discussed and commented. In general, the appreciations of the group of designers differ more from the average, although differences between other groups are also perceived, mainly owing to their previous experience and knowledge.

The suitability of certain aspects of this kind of test applied to commercial products, such as the reliability of the evaluation of some descriptors simply from an image, is challenged.

A principal component analysis shows that the perception of hammers is described through four factors: functional, social image, aesthetic and ergonomic. Positive perceptions in the first two factors are related to a higher willingness to pay.

Keywords: User profile, semantic design, hand tools

1 INTRODUCTION

Nowadays, when selecting a product, consumers do not just consider its functionality, usability, safety, and price, but also the emotions and feelings that it elicits. A good product should satisfy all the expectations required by the user, such as providing a positive emotional response. This goal may be achieved through a set of techniques known as emotional design [1], [2], [3], [4]. Kansei Engineering [5] is one of the forerunner methodologies. These techniques are being successfully applied in consumer product design such as mobile phones, glasses or printers [6], [7], [8], [9], but they have been hardly applied to commercial products such as rocker switches, machining centres or construction machinery [10], [11], [12].

Moreover, there is not a unique consumer profile. Individual differences are unquestionably present in society, and are a consequence of what we experience and what we know. What we experience, understood as the relationship we establish with the environment, is manifested through emotions [13]. We express ourselves through the language what we know, think and feel [14]. Hence, it is important to consider the differences in the language and the emotions [15] of the distinct population groups to whom the product is destined. Only a few works in emotional design have attempted to consider the user profile (age, sex, academic level or professional competence) [12], [16], [17].

Our work is aimed at researching the applicability of emotional design to commercial products, as we noted in a previous work [12] in which differences were observed between different types of users depending on the relationship established with the product. In particular, we studied hammers, as they are a significant instance of hand tools, because they show the interesting property of being both

consumer and commercial products, depending on the population group they are addressed to. Hence, we studied the semantic response to hammer exposure of different population groups, which may consider the hammers either as consumer or commercial products.

2 MATERIAL AND METHODS

2.1 Semantic descriptors

The language through which the subjects express their feelings and perceptions is studied by applying a Semantic Differential (SD) to a set of images of different hammers.

In order to choose the semantic descriptors, a pilot study was conducted [18]. Starting with 213 words obtained from ergonomics papers and web sites of hand tools manufacturers and suppliers, a total amount of 35 attributes were initially selected by discarding those related to hammer attributes not likely to be evaluated from an image and those obviously equivalent. As 35 pairs of semantics were considered excessive, 89 students were asked about the 35 attributes, but each one about one single hammer. The 89 hammers were selected from 248 images obtained from commercial brochures and web sites, taking care to get different features and maintain a good quality of prints. Seven evaluation levels were considered for each semantic. The scale ranged from 3 to 3 without assigning signs to avoid connotative implications of negative signs (Figure 1 shows an example). In addition, the order of the semantics was randomised for each test.

	3	2	1	0	1	2	3	
Comfortable		x						Uncomfortable

Figure 1. Levels of the measurements for the opposite semantics

To reduce the semantics, a hierarchical cluster analysis (HCA) was performed. HCA is a multivariate analysis technique that allows the elements of a set (in this case, the semantics) to be classified into clusters by attending to its similarity according to a certain criterion. In this case Pearson's correlation was used as the criterion for similarity in order to check for patterns in the answers [19]. The results of the HCA allowed the positive semantic of the pair to be identified (in some cases it is not straightforward for the product or user, e.g. young/mature) and the selection of reduced sets of semantics with different levels of detail (see more details of the analysis in [18]). Finally, the reduced set of the 19 semantics shown in Table 1 was considered to be the best choice.

2.2 Population groups

Four different samples, representatives of four different social groups, were considered in the study, i.e. differences in age, education level, professional competences and role. The roles considered include students of technical/professional courses such as woodworkers, carriage-makers, maintenance technicians, etc. (Students), i.e. future specialists (qualified technicians) that will become direct users of such hand tools; current specialists (Professionals), with competences and proven experience in industrial procedures and hand-tools usage; Industrial-Design engineers (Designers), with competences in the design and development of new products; and current occasional users of hand tools in general, with some experience in do-it-yourself and other tasks requiring usage of tools (DIY-users).

Twelve subjects from each group were selected. The main characteristics of the subjects are presented in Table 2.

Table 1. Words used in the study (the original words in Spanish are shown in the second column). The first word of each pair is the positive one identified in the previous HCA.

Well finished / Bad finished	Bien acabado / Mal acabado
Proportionate / Disproportionate	Proporcionado / Desproporcionado
Attractive / Ugly	Atractivo / Repelente
Pleasant / Unpleasant	Agradable / Desagradable
Strong / Weak	Fuerte / Débil
Resistant / Non resistant	Resistente / Nada resistente
Durable /Ephemeral	Duradero / Efímero
Robust / Flimsy	Robusto / Endeble
Good / Bad	Bueno / Malo
Comfortable / Uncomfortable	Cómodo / Incómodo
High quality / Low quality	Alta calidad / Baja calidad
Unbreakable / Breakable	Irrompible / Rompible
Sophisticated / Simple	Sofisticado / Simple
Professional / Do-it-yourself	Profesional / De bricolaje
Safe / Dangerous	Seguro / Peligroso
Fine / Coarse	Fino / Basto
Feminine / Masculine	Femenino / Masculino
Stylish / Conventional	De diseño / Convencional
Modern / Classic	Moderno / Clásico

Table 2. Main characteristics of the subjects participating in the experiment

	Students	Professionals	DIY	Designers
Age: mean (SD)	20 (3)	44 (9)	39 (8)	29 (2)
Men / Female	12 / 0	11 / 1	10 / 2	7 / 5
Those who ever bought a hammer	6	12	10	9
Those who ever used a hammer	12	12	12	12

2.3 Semantic analysis

A detailed classification of hammers (head shape, head material, head to handle joint, handle shape, handle material, grasping texture, etc.) was made in order to select ten different hammers for the study, representative of the formal universe of hammers (Figure 2).

To keep them from getting bored, the 48 subjects participating in the experiment were divided into 24 pairs, both components of each pair from the same group. For each pair of subjects the 10 hammers were randomised and then one subject evaluated the first 5 hammers and the other subject the remaining ones.

The order of the descriptors was randomised for each test. The same 7 levels for evaluation shown in Figure 1 were used, again without negative signs and randomising also the order of the two attributes defining the semantic descriptor.

The pictures of the hammers were presented in the same scale on separate A4 sheets. Once the subject had seen the 5 pictures, he/she answered the test for each hammer in randomised order.

Figure 2. Pictures of the 10 hammers used in the study

At the end of each test a question on willingness to pay was included. The answer was to be chosen out of a five interval scale (less than 6 €, from 6 € to 12 €, from 12 € to 24 €, from 24 € to 48 €, and more than 48 €).

A total number of 240 tests were performed, 24 per hammer.

A global evaluation of results for each hammer was made in order to consider the suitability of the semantic analysis of hammers. The differences between the groups of users considered were also presented. Finally a principal components analysis (PCA) was applied in order to consider the underlying factors of the semantics.

3 RESULTS AND DISCUSSION

3.1 Global evaluation of hammers

Figure 3 shows the semantic profile of hammers, considering the mean value for all participants. As expected, the differences between hammers are high, because they have been selected to be representative of the universe of hammers. However, there are remarkable differences in the range of mean values between semantics: some of them present a wide range, while others not. Table 3 shows these ranges.

The widest ranges of mean values are for ‘Modern’, ‘Stylish’ and ‘Sophisticated’, i.e. the attributes that may be considered to have a closer relation to the image (symbol) of the hammers. These aspects are more easily appreciable from a picture than others are.

The lowest ranges are for: ‘Feminine’, ‘Safe’, ‘Resistant’, ‘Durable’, ‘Strong’ and ‘Unbreakable’. ‘Feminine’ is an attribute that has turned out to be difficult to evaluate for hammers (in fact many of the responses were 0), perhaps because they are mainly considered as commercial products. The other attributes are more related to the functional aspect of the hammers, and therefore, they are more difficult to be evaluated only from a picture, without using or touching them. The subjects are not able to differentiate between hammers so easily as regards these attributes, unless they have previous experience with very similar hammers. This statement is corroborated later on in the evaluation by groups of users.

A special case is the attribute ‘Comfortable’, with a range value close to the ‘Sophisticated’ range value: although it could be considered as a functional aspect, difficult to evaluate without using the hammer, the ranges are more similar to the image attributes and subjects venture to evaluate it without using the hammer.

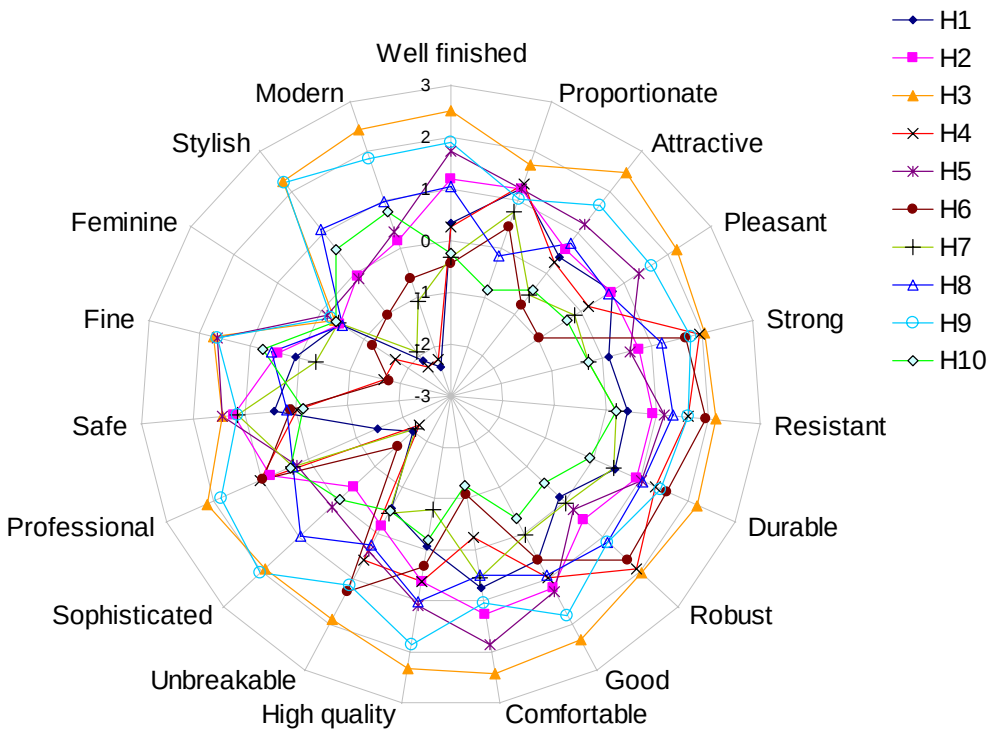

Figure 3. Semantic profile of hammers (average value for all participants)

Table 3. Minimum, maximum and range of mean values for hammers

	Maximum	Minimum	Range
Well finished	2.5	-0.46	2.96
Proportionate	1.71	-0.83	2.54
Attractive	2.46	-0.79	3.25
Pleasant	2.17	-0.96	3.13
Strong	2.04	-0.29	2.33
Resistant	2.13	0.21	1.92
Durable	2.21	-0.08	2.29
Robust	2	-0.54	2.54
Good	2.33	-0.33	2.66
Comfortable	2.42	-1.25	3.67
High quality	2.33	-0.78	3.11
Unbreakable	1.88	-0.54	2.42
Sophisticated	2	-2.17	4.17
Professional	2.13	-1.46	3.59
Safe	1.42	-0.17	1.59
Fine	1.71	-1.79	3.5
Feminine	-0.17	-1.71	1.54
Stylish	2.25	-2.29	4.54
Modern	2.42	-2.42	4.84

The clearly best valued hammer according to the profiles shown in Figure 3 is H3, followed by H9. Identifying the worst one from the profiles is not as straightforward, being H7, H1, H10 and H6 the hammers that in general present the worst values for the descriptors. An alternative global assessment of hammers can be represented by the mean willingness to pay presented in Figure 4. According to the profile results, best valued hammers are confirmed to be H3 and H9. The worst valued hammer in this case is H1, followed by H7, H10 and H6, a result which is consistent with the profile results. In

general terms, hammers with curved axis handles and non-uniform handle sections seem to be the best valuated. In future works with hammers, the features that cause the different affective answers measured with the semantic descriptors should be analysed more rigorously.
Only some Professionals are ready to pay more than 48€ for some of the hammers.

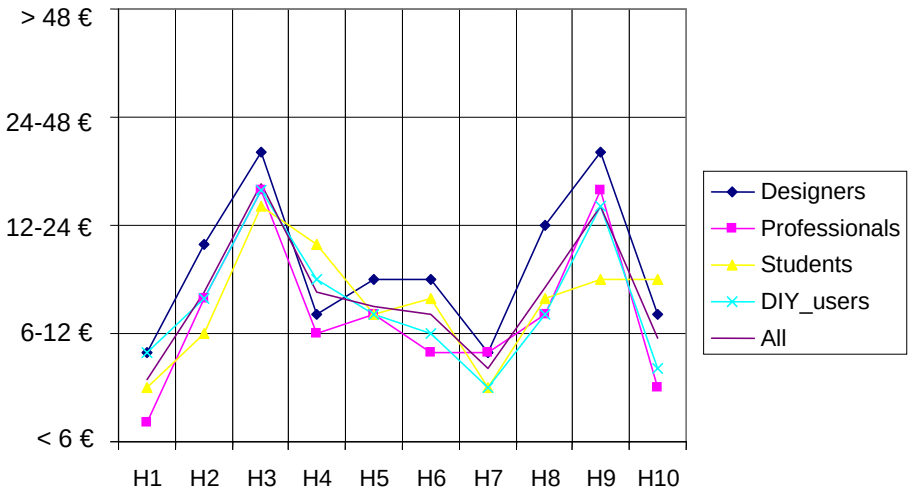

Figure 4. Mean willingness to pay for each hammer

3.2 Evaluation of hammers by groups of users

Figure 5 shows the mean semantic profile of hammers for each group of users. The mean profiles present quite similar patterns for DIY-users, Professionals and Students, but higher values for DIY-users and lower values for Students. Designers profile differs from the average pattern: they seem to be more negative as regards the aesthetic and ergonomic aspects and more positive as far as functional aspects are concerned. However, it has to be noticed that these differences are small, and are statistically significant only for 'Unbreakable' ($p = 0.019$) and for 'Safe' ($p = 0.006$).

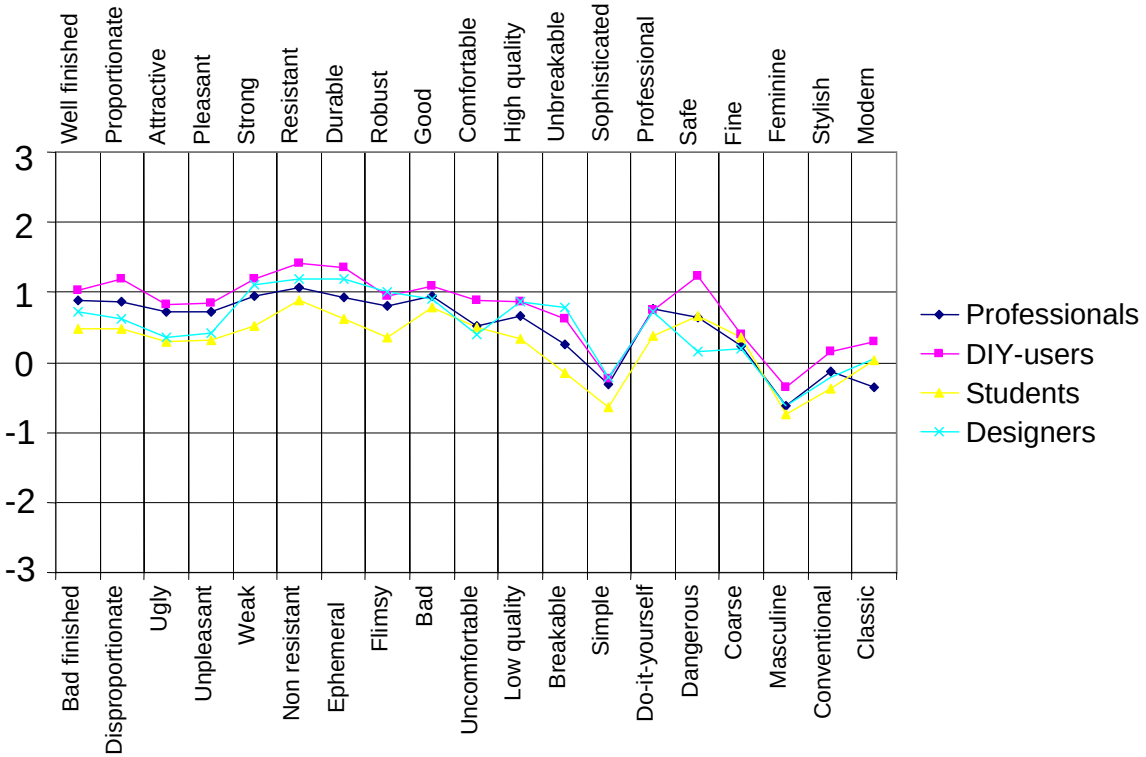

Figure 5. Mean semantic profile of hammers by group of users

After analysing the semantic profiles of each hammer individually by group of users (not shown in this paper), similar differences are perceived: in general, Designers profiles are more different with respect to the mean profiles for almost all the hammers, while DIY-users are more positive and Students more negative. The only remark to do here concerns Hammer 6, which presents a quite different pattern (Figure 5). This may be caused by its specificity, which makes it little known for most users except for professionals.

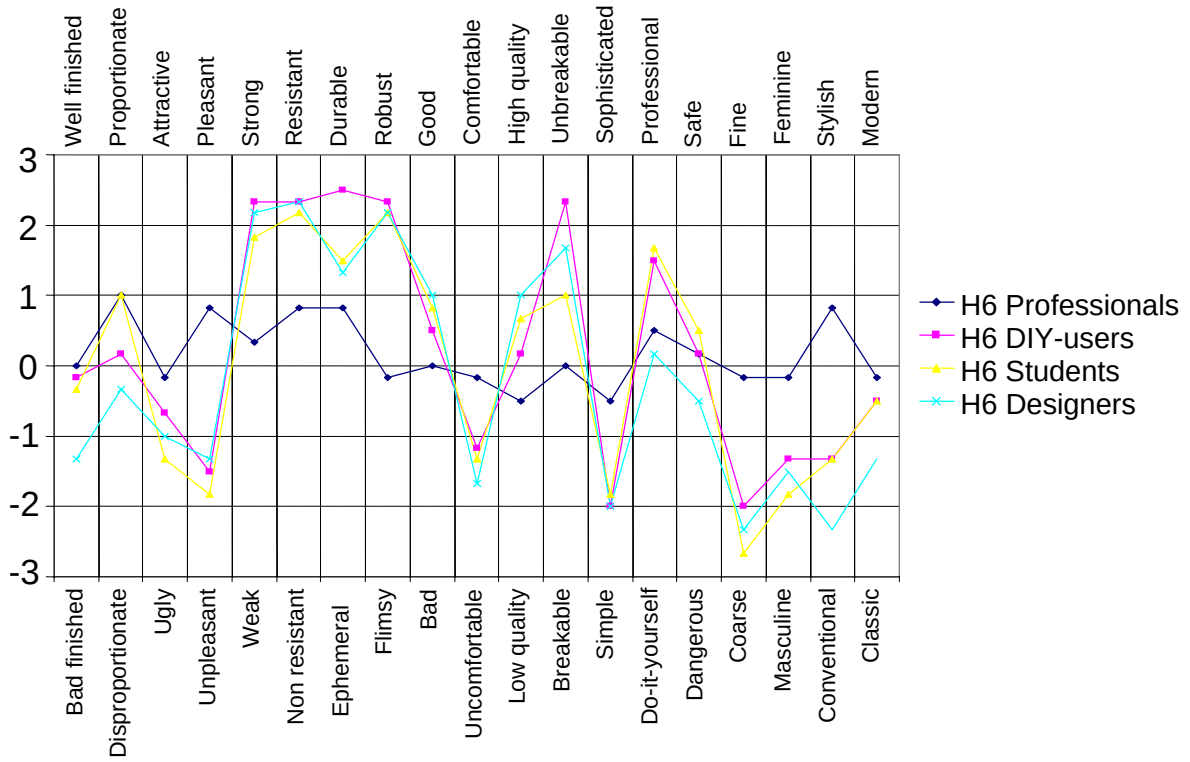

Figure 6. Mean semantic profile of Hammer 6 by group of users

The best evaluated hammers by all groups are H3, followed by H9. The worst evaluated hammers are the same obtained in the global evaluation, although each group has a different order in its grading. Hammer H2 is also badly evaluated by Students. Hammers H5 and H10, which have a very similar design but very different sizes and proportions, are similarly evaluated by Designers, in contrast with the other groups.

Mean willingness to pay for each hammer by group of users can be observed in Figure 4. In general, designers tend to pay more than the other groups for the same hammers and students follow a pattern different to that of the other groups, perhaps because they are younger and have less experience buying products (in fact, half of them had never bought a hammer).

3.3 Principal Components of descriptors for hammers

Principal components factor analysis was used without including the variable Feminine because of the reasons exposed above. Following the recommendation of Hair et al. [19] four factors were extracted, which represent more than 75% of the variance. The result was rotated with the Varimax method for a better interpretation. Table 4 shows the components for each factor (for a better interpretation, only values bigger than 0.5 are shown).

Table 4. Components for each factor of the PCA

	Factor 1	Factor 2	Factor 3	Factor 4
Strong / Weak	0.890			
Robust / Flimsy	0.874			
Resistant / Non resistant	0.853			
Durable /Ephemeral	0.853			
Unbreakable / Breakable	0.804			
High quality / Low quality	0.718			
Professional / Do-it-yourself	0.615			
Good / Bad	0.604		0.534	
Stylish / Conventional		0.909		
Modern / Classic		0.887		
Sophisticated / Simple		0.886		
Fine / Coarse		0.594		
Proportionate / Disproportionate			0.749	
Pleasant / Unpleasant			0.745	
Attractive / Ugly			0.734	
Comfortable / Uncomfortable			0.612	0.555
Well finished / Bad finished			0.553	
Safe / Dangerous				0.834

Factor 1 includes eight descriptors regarding the power and capacity of hammers; it may be interpreted as the **functional** factor. Factor 2 is constituted by six descriptors and describes the expectations that owning it represents; it may be interpreted as the **social** meaning or image factor [20]. Factor 3 includes six descriptors related to the formal aspect of the hammers, so it may be considered as the **aesthetic** factor. Finally, factor 4 is made up of two factors related to personal interaction with the user, and it is thus considered as the **ergonomic** factor.

The scores of the factors were calculated and normalised with a mean of 0 and a standard deviation of 1. As the experiment was balanced as far as groups of users are concerned, if there were no differences between groups, the factors should have a mean of 0 for all groups of users. However, if a group has positive mean value for one factor, this means that they overestimate these attributes (and they are more positive when evaluating the factor) as opposed to the other groups, which are more critical, more concerned with this factor.

Figure 7 shows mean values of the factors by groups. Only the social factor presents a ‘flat’ pattern, which means that no differences exist between groups as regards this aspect, while for the other factors there are more differences, although they are statistically significant only as regards the ergonomic factor.

Students and Designers are more concerned with the aesthetic factor than Professionals and DIY-users are, i.e. the former groups demand the aesthetic function of the hammer more than the latter because they have evaluated the same hammers to be less aesthetic than the others.

Moreover, the ergonomic factor is negatively evaluated by Designers and somewhat by Professionals, while positively by the other two groups. This means that Designers and Professionals demand the ergonomic aspect of the hammers more than the others do. The cause may be, in the case of Designers, their knowledge and curricula concerning ergonomics, and for Professionals, their experience and the importance they accord to comfort and safety.

Finally, the functional factor is negatively evaluated by the Students (probably because of their lack of experience with a large variety of hammers), and is positively evaluated by DIY-users and Designers, because they are less concerned with this aspect than Professionals are.

These differences may be used to focus semantic studies on the groups of users more sensitive to the attributes to be measured.

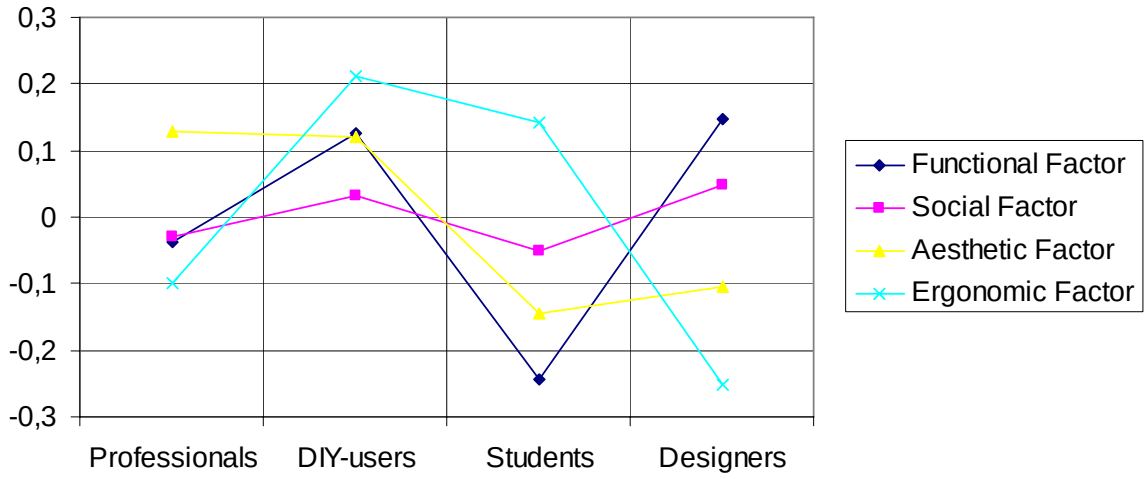

Figure 7 Mean values of the factors by groups of users

Both the functional factor and the social factor are strongly correlated with the willingness to pay (Table 5), while the aesthetic factor is somewhat correlated, and the ergonomic factor is not correlated at all.

Table 5. Pearson's correlation coefficient of each factor with the 'Willingness to pay' and their statistical significance.

Factor	Functionality	Social	Aesthetic	Ergonomic
Coefficient	0,443	0,447	0,131	-0,055
p	0,000	0,000	0,044	0,401

3 CONCLUSIONS

It has been corroborated that hand tools, as commercial products, are bearers of users' feelings, and we conclude that all groups should be considered when testing intended designs of commercial products. However there are differences between semantics and users.

Some of the semantics have been proved to be hardly evaluated for commercial products (e.g. feminine) and others, more related with the functional aspect of the product, have been shown to be difficult to evaluate only with a picture. The semantics more easily appreciable from a picture are the ones related to the image or symbolic aspect of the product (e.g. modern).

The different perception that groups of users have has been confirmed, at least as regards some of the semantic attributes. In general, Designers opinions differ more from the average. The smaller differences between groups are in attributes related to the image or the aesthetics of the product. These attributes are less influenced by previous experience and knowledge of the users.

The observed differences may be used to focus semantic studies on the groups of users more sensitive to the attributes to be measured.

As for the study of hammers, future works should advise on the features responsible for the various emotions expressed, in order to obtain a better design of hand tools.

Finally, the limitations of the semantic studies based on test in which the respondent gives an opinion upon the sight of an image have been checked. Future works should explore the limitations and usefulness of this kind of tests.

REFERENCES

[1] Mc Donagh D., Bruseberg A. and Haslam C. Visual Product evaluation: exploring users emotional relationships with products. *Applied Ergonomics*, 2002, 33, 231-240.

[2] Desmet P. *Designing Emotions*, 2002 (Delf University of Technology).

[3] Norman D.A. *Emotional Design: Why We Love (or Hate) Everyday Things.* 2004 (Basic Books, New York).

[4] Fenech O.C. and Borg J.C. A model of human sensations as a basis for "design for product-emotion" support. *International Design Conference-Design 2006.* Dubrovnik-Croatia, May 2006, pp.705-712.

[5] Nagamachi M. Kansey engineering: a new ergonomic consumer-orientated technology for consumer development. *International Journal of Industrial Ergonomics*, 1995, 15 (1), 3-11.

[6] Lin R.T. Lin C.Y. and Wong J. An application of multidimensional scaling in products semantics. *International Journal of Industrial Ergonomics*, 1996, 18 (2-3), 193-204.

[7] Chuang M.C. Chang C.C. and Hsu S.H. Perceptual factors underlying user preferences toward product form of mobile phones. *International Journal of Industrial Ergonomics*, 2001, 27 (4), 247-258.

[8] Chang W.C. and Van Y.T. Researching design trends for the redesign of product form. *Design Studies*, 2003, 24, 173-180.

[9] Petiot J.F. Yannou B. Measuring consumer perceptions for a better comprehension, specification and assessment of products semantics. *International Journal of Industrial Ergonomics*, 2004, 33 (6), 507-525.

[10] Nakada K. Kansei engineering research on the design of construction machinery. *International Journal of Industrial Ergonomics*, 1997, 19 (2), 129-146.

[11] Schütte S. Eklund J. Design of rocker switches for work-vehicles-an application of Kansei Engineering. *Applied Ergonomics*, 36, 2005, 557-567.

[12] Mondragón S. Company P. and Vergara M. Semantic Differential applied to User-Centred Machine Tool Design. *International Journal of Industrial Ergonomics*, 35 (11), 2005, 1021-1029.

[13] Damasio A.M. *Looking for Spinoza: Joy, Sorrow, and the Feeling Brain*. (Harcourt, 2003).

[14] Maturana H. *La realidad: ¿objetiva o construida?. I. Fundamentos biológicos de la realidad.*. 1995 (Anthopos Editorial, Barcelona). pp.73-75

[15] Maturana H. *La realidad: ¿objetiva o construida?. II Fundamentos biológicos del conocimiento.* 1996 (Anthopos Editorial, Barcelona). pp 41-42

[16] Hsu S.H. Chuang M.C. and Chang C.C. A semantic differential study of designers' and users' product form perception. *International Journal of Industrial Ergonomics*, 2000, 25 (4) 375-391.

[17] Chang C-C. and Shin Y-Y. A differential study on the product form perceptions of different age group users. *6th Asian Design Conference International* Tsukuba, Octuber, 2003.http://www.idemployee.id.tue.nl/g.w.m.rauterberg/conferences/CD_doNotOpen/ADC/final_paper/755.pdf

[18] Vergara M. Mondragón S. Sancho-Bru J. Company-Calleja P. Pérez-González A. Aplicación de la semántica de productos al diseño de herramientas manuales. Estudio piloto para la selección de semánticos en martillos. *X International Congress on Project Engineering*. Valencia, Septiembre 2006, pp.803-812. (Editorial de la Universidad Politécnica de Valencia).

[19] Hair J.F. Anderson R.E. Tatham R.L. Black W.C. "*Multivariate Data Analysis*". 2000. 5ª ed. (Prentice Hall Iberia, Madrid).

[20] Krippendorff K. *The semantic turn, a new foundation for design.*2006, (Taylor & Francis).

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