User-Material-Product Interrelationships in Attributing Meanings

Elvin Karana * and Paul Hekkert

Industrial Design Engineering, Delft University of Technology, Delft, the Netherlands

In selecting a material to create an intended product meaning, several factors, such as the material's sensorial and technical properties, the product in which the material is embodied, and who the user is, may need to be taken into consideration. Each factor consists of a number of aspects (e.g., user covers aspects including gender, expertise, culture, etc.) with each playing a different role in attributing meaning to a particular material. The role that two product aspects (shape and function) and two user aspects (gender and culture) plays in attributing meaning to two materials, plastics and metal, is studied. The study demonstrates the contention that meanings of materials in a particular context are shaped by interactions of materials with aspects of products and users. On the other hand, the effect of a certain aspect (e.g., shape) may change depending on the meaning (e.g., feminine) aimed to be expressed. The results of the study, main effects and interactions are thoroughly discussed in this paper.

Keywords **–** Product Design, Materials Selection, Meaning Attribution, Culture, Shape.

Relevance to Design Practice **–** People encounter versions of a particular product made of different materials or the same material embodied in different products. Designers need insights into the role of materials for creating particular meanings attributable to products. This requires a deep understanding of the key variables affecting the meanings we attribute to materials.

Citation: Karana, E., & Hekkert, P. (2010). User- material-product interrelationships in attributing meanings. *International Journal of Design, 4*(3), 43-52.

Introduction

In the past, a particular material was predominantly used in products similar in form and function (e.g., ceramics in dinnerware or metal in sharp-edged forms or machinery). Improvements in manufacturing technologies and materials science have stimulated new materials and forms in product design. Now, metal can appear in organic forms and high-tech ceramics are used in electronics. Along with advancements in the materials domain, there has been growing interest in the design domain towards the intangible values of materials, i.e., the meanings they evoke or the emotions they elicit (Arabe, 2004; Ashby & Johnson, 2002; Karana & Hekkert, 2008; Lefteri, 2001; Ljungberg & Edwards, 2003; Pedgley, 2009; Van Kesteren, 2008). Consequently, beyond selecting a material that meets a functional need, designers started to raise questions regarding the meanings that materials express: Is it luxurious? Is it convenient for a cozy and friendly room? The problem however is that meanings do not (always) seem to be properties of materials; the same material may represent different meanings under different conditions. In order to convey their intentions properly, designers must understand how a material acquires its meaning and what kind of variables play a role in this process.

Being part of a more comprehensive research project, this paper focuses on user-material-product interrelationships in the attribution of meanings to materials. The main aim is to show that (1) product aspects affect the meanings we attribute to the material(s) of a product, (2) the appraisal of a material is affected by characteristics of the user, and (3) the effect of a certain aspect may vary depending on the type of material (material family). Shape and function were selected as product aspects, whilst gender and culture were selected as user aspects on the basis of the related literature. The paper reports a study conducted with Chinese and Dutch, male and female participants in order to explore the effects of the selected aspects on the meanings of two material families: plastics and metal.

Meanings of Materials

When people are asked to describe a certain material, they frequently refer to its expressive characteristics and these characteristics are grounded in different aspects of materials (and products). A particular material of a product, for instance, might convey professionalism predominantly through its shiny, robust, and smooth properties as well as the product's sharp edged geometry. Herein, shininess, robustness, smoothness, and sharp-edge geometry cooperate and jointly contribute to a material's expressive character. Expressive characteristics (also called figurative or abstract characteristics, see Blank, Massey, Gardner, & Winner, 1984) are not actually a part of a materials' physical

Received September 8, 2009; **Accepted** April 20, 2010; **Published** December 22, 2010.

Copyright: © 2010 Karana and Hekkert. Copyright for this article is retained by the authors, with first publication rights granted to the *International Journal of Design.* All journal content, except where otherwise noted, is licensed under a *Creative Commons Attribution-NonCommercial-NoDerivs 2.5 License.* By virtue of their appearance in this open-access journal, articles are free to use, with proper attribution, in educational and other non-commercial settings.

***Corresponding Author:** e.karana@tudelft.nl

entity or appearance (i.e., a material is not literally feminine or masculine). The expressive character (or meaning) of a material is based on the interactions between an individual and the product and its material, which can change over time.

In the experience of materials, in addition to expressive meanings (e.g., modern, sexy, and sober), certain associative descriptions, which require retrieval from memory and past experiences, can also express particular qualities of materials, such as *toy-like*, *business-like*, and *associated with factories.* These descriptions are commonly used in material appraisals. Accordingly, meanings of materials in this research consist of expressive/semantic and specific associative characteristics, both of which are used for defining the qualities of materials. *Meanings of materials* are what we think about materials, what kind of qualities we attribute after the initial sensorial input in a particular context.

Materials and Shape

People interact with many physical objects on a daily basis, and all of these objects share one property: form, which is the boundary of matter by which we distinguish these objects from each other and their environment (Muller, 2001). A designer decides on the form, which is realised as a product via appropriate manufacturing processes. Thus, form includes material-manufacturing process-shape interactions (Ashby, 2005). Shape refers to the external two-dimensional outline or appearance of something. Shape determines an object's boundary, abstracting it from other aspects, such as colour and material (Chen, 2005). In particular, shape does not depend on the size of the object.

A number of scholars have conducted studies on the effects of shape on people's product appraisals (see Chen, 2005; Chung & Ma, 2001; Hsiao & Chen, 2006; Petiot & Yannou, 2004; Van Rompay, 2005). A study exploring the alterations in attributed meanings to materials due to differences in geometrical shape has recently been carried out (Karana, Van Weelderen, & Van Woerden, 2007). The results demonstrate a relationship between geometrical shapes and the meanings people attribute to materials (e.g., metal in a rounded shape is perceived as cosier than when it is in a sharp-edged shape). People associate particular materials with certain shapes (e.g., plastics with rounded geometrical shapes, metal with sharp-edged geometrical shapes). These associations are mostly due to the prevailing use of a material in a certain shape used in daily experienced products. While plastics allow more organic forms in mass production, metal can be easily produced in sharp-edged or rounded geometrical shapes. Likewise, to see an organic product made of metal may surprise users more than seeing the same shape in plastic, thereby affecting the attributed meanings to these particular materials in these cases. In the study mentioned, different combinations of shapes and materials could have different effects on attributed meanings. However, significant differences were obtained in attributed meanings to materials embodied in sharp-edged and rounded shapes. Taking this prior study into consideration, it is predicted that a material will be appraised differently in rounded and sharp-edged products. We predict that a material of a rounded shape product is perceived as more feminine, cosier, and more toy-like than the same material in a sharp-edged product.

Materials and Function

We expect that users interact differently with different kinds of products, and that this influences the way they describe the materials of which those products are made. For example, people may not perceive a material's expressive meaning if a material is mainly used for its physical appropriateness in a product (such as the plastic handle on a pan) and people might emphasize the materials of products they have an emotional bonding with (such as the fabric cover on an old notebook). Other examples are the difference in perception of materials in products that are mainly touched during use compared to those that are mainly looked at during use or the differences between products that are liked or disliked. It has been shown that the type of product influences the quantity and the variety of the descriptive terms used by participants for describing the product and its materials (Karana & Van Kesteren, 2008). In addition, a clear difference in product descriptions between small products and larger products was noticed. Small products elicit more sensorial descriptions than larger ones. This finding was explained by arguing that daily experiences with big electronic products do not usually provide tactual interaction, holding or grasping. As a result, a lower number of sensorial descriptions of material properties was found for these products.

Similarly, in another study (Karana & Hekkert, 2008), the type of product was often mentioned by participants as an important aspect influencing how people appraise materials. For instance, how a product fulfils the required function and how it is used were found particularly effective in the attribution of *aggressiveness* to products and to the materials of these products. Summarizing, it is predicted that the same material may be appraised in a different way in different products. For instance,

Dr. **Elvin Karana** is an Assistant Professor in the Department of Design Engineering at Delft University of Technology, The Netherlands. She studied Industrial Design at Middle East Technical University (METU), in Ankara, (MSc, 2004). In 2009, she completed her PhD research at Delft University of Technology. In her PhD, she developed a 'Meaning Driven Materials Selection Tool' to support designers in their materials selection activities. She has presented her research at a number of international conferences and has run various workshops on the 'meanings of materials.' She was a member of the organizing committee of the 4th International Design and Emotion Conference (Ankara, 2004), Meeting Materials (Gent, 2006) and the International Conference on Tools and Methods for Competitive Engineering (TMCE) (Izmir, 2007). Dr. Karana's current research areas include *teaching materials in design*, *developing a materials experience library*, and *designing and manufacturing with bio-based materials*.

Prof. Dr. **Paul Hekkert** is a full professor of form theory in the faculty of Industrial Design Engineering at Delft University of Technology, where he chairs the design aesthetics section and supervises a research group that carries out innovative research on our sense perception and (emotional) experience of products. Much of this research is done in cooperation with industrial partners. He has published numerous articles on product experience and aesthetics in major international journals and is co-editor of Design and Emotion: The Experience of Everyday Things (2004) and Product Experience (2008). Together with a colleague/designer, he has also developed an interaction-centered design approach, called Vision in Product Design (ViP), that is widely applied in both education and industry. They are presently finishing a book in which this approach is laid out (to be published in 2010). Dr. Hekkert is founder and chairman of the Design and Emotion Society (www.designandemotion.org) and serves as a member of the editorial boards of The Design Journal, Empirical Studies of the Arts, and International Journal of Design.

we expect that a material is perceived as more ordinary when it is embodied in a household product than in a personal product.

Effects of Gender

According to Johnson (2007), an experience reveals "four recurring qualitative dimensions of all bodily movements: tension, linearity, amplitude, and projection" (p. 22). Johnson gives a number of examples enlightening the effects of gender differences on experience with regards to these four dimensions of bodily movements. Brewer and Bassoli (2006) explored the ways in which gender can constitute an important factor for different types of interfaces. In another study, women showed greater intensity of both positive and negative affective responses to outside stimuli than men (Lukas, 2007). These studies show how males and females experience things differently based mainly on their physical abilities and social and cultural norms. Accordingly, in this study, it is examined if the gender of a user influences the evaluation of materials.

Effects of Culture

The assessment of the qualities of products, their materials, and the attribution of meanings thereto, are related to people's past experiences and personal tastes, which to a large extent manifest in culture (Krippendorff & Butter, 2008; Mono, 1997; Oehlke, 1990). Findings of a study conducted with sixty Turkish people revealed that there are significant shape-material associations and material-product relationships among Turkish people (Karana, 2004). Their associations of certain materials with particular products expressed the effects of their cultural values. For example, a 'wooden box' was associated with a 'chest' that is traditionally used for storing a bride's trousseau.

Because every culture has its own way of living, it is expected that the value of a certain material might show differences from culture to culture. Ljungberg and Edwards (2003) explain that in Scandinavian countries, where wood is very common, a house built of stone is typically perceived as more expensive and prestigious than a wooden one. The authors emphasize that the enterprises of the Scandinavian villa producers to export the wooden villas to Germany did not work since German people also think that wooden houses are inferior and simpler than houses built of stone or concrete. On the contrary, in Mediterranean countries, wood is perceived as a more valuable and luxurious material, perhaps because in these regions it is quite rare (in comparison to Scandinavian countries).

According to Dormer (1990), some cultures do not favour plastics as kitchenware, because it contradicts the common understanding of what plastics are and how they perform. For example, people of a certain culture may fear that a plastic cooking pot might melt when heated (Dormer, 1990). Soentgen (1997) claims that whereas the origin of plastics is not widely known by the public, everybody is familiar with the origin of wood. Therefore, people tend to prefer traditional materials for their everyday use objects. Cleminshaw in his book *Design in Plastics* (1989) quoted Kenji Ekuan, a famous Japanese industrial designer, who explained that Japanese people had so entirely based their sensitivities upon the transience of time that they even included their own deaths in their natural calendar, and they keep transience in mind in everything they do. They project this approach on every aspect of their life, including products. So, they not only feel uncomfortable with, but they even hold a horror of plastics that deny death (Clemenshaw, 1989).

Considering the number of examples given above, it is expected that differences in cultural background lead to differences in attributing certain meanings to materials. We, for instance, expect to find differences between Asian and European cultures on appraisals of plastic products.

Study

The aim of this study is to test if (1) a product's shape, (2) a product's function, (3) the gender of the individual who appraises the material of a product, and (4) the cultural background of the appraiser, each affect the meanings attributed to the material(s) of a product. Furthermore, we expect to find the effect of certain aspects in a particular direction (e.g. materials can be perceived as more ordinary in a household product than in a personal product). Moreover, it is expected that the effect of a certain aspect on the overall expression of a product may vary depending on the material family. These predictions are tested in this study.

Method

Participants

Participants were sixteen Chinese (eight male, eight female; mean age 25.4 years, range 23-30 years) and sixteen Dutch (eight male, eight female; mean age 24 years, range 21- 28) undergraduates of Delft University of Technology. Students of design oriented departments (e.g., industrial design and architecture) are expected to be more familiar with the general (material) features of a variety of products, which may lead to occurrences of 'learned' associations between those features and expressive meanings (Van Rompay, 2005). For this reason, students from these disciplines were excluded from participation. The Chinese participants were exchange students in their first six months in the Netherlands to ensure the differences in cultural background in comparison to the Dutch students.

Stimuli

Two types of materials that are predominantly used in mass produced daily products, were selected to be included in this study: plastics and metal. A market search was carried out to identify two types of products with two different functions, made of plastics and metals, produced in rounded and sharp-edged shapes. A number of products meeting one (or two) of our criteria were found. However, it was difficult to find the two variants of a same product made of metal and plastics. Because different materials require different manufacturing processes, varieties in forms attributable to production details were observed. For this reason, special emphasis was placed on finding simple products with a minimum number of production details. The critical issue

was to select products that would allow participants to easily perceive the differences between material types and geometrical shapes. Following these requirements, a *waste basket* was the first product found in two different shapes and in two materials.

Waste baskets are mostly made of metal or plastics. Even though a waste basket is not considered as a personal product, it may contribute to the image of an environment (or the person who lives in that environment) along with other products. After selecting a 'waste basket' as the first product type, we began to look for products that are not for the household but instead may be considered more personal and require more tactual interaction with users. A lighter met these criteria. We were able to find lighters in two different forms, made from similar kinds of metal and plastics as used in the waste baskets. Figure 1 depicts the stimuli used in this study.

Figure 1. Stimuli used in the study.
(four waste baskets, four lighters)

Procedure

Participants were individually invited in a room at the Faculty of Industrial Design Engineering. They were presented with the eight products one by one. Together with each product, the participants were given a page with 7-point scales presenting nine meanings with their opposite poles (*aggressive-calm*, *cosy-aloof*, *elegant-vulgar*, *frivolous-sober*, *futuristic-nostalgic*, *masculine-feminine*, *ordinary-strange*, *sexy-not sexy*, *toy like-professional*) (Appendix 1). A previous study was conducted in order to select a number of meanings which are relevant for material appraisals and which are also clear and understandable for measuring spontaneous responses of users to stimuli. The meanings used in this current study were selected from five conceptually different sets of meanings that were extensively reported in a previous paper (see Karana, Hekkert, & Kandachar, 2007).

Participants were asked to evaluate "to what extent the material of the presented products expressed the given meanings." Before starting the actual study, an example scale was presented. Although there were no time limits, participants were instructed to base their judgments on their first impression. The eight products and nine meanings were presented in random order. The sessions took approximately 15 minutes for each participant. All meanings and instructions were presented in English, as well as in the participants' mother tongue (Dutch or Chinese).

Results

The effects of the selected aspects on meanings of materials were analyzed by a 2 (function) X 2 (shape) X 2 (culture) X 2 (gender) X 2 (material) multiple analysis of variance (MANOVA) with the nine meanings as dependent variables. MANOVA in statistical analysis is concerned with examining the differences between groups and explores the group differences across multiple dependent variables simultaneously. All 2-way interactions were included in the analysis. Significant main effects and 2-way interactions ($p \leq .05$) are listed in Table 1.

Main Effects

Looking at the product factor, main effects for FUNCTION were obtained for almost all meanings, except for cozy, masculine, and toy-like. The materials of lighters are found more *elegant*, more *futuristic*, more *frivolous*, more *aggressive*, *sexier* and less *ordinary* than the materials of waste baskets (see Fig. 2a).

Table 1. Multiple analysis of variance summary table.

	Dependent Variable	F value	Sig.
Function	Aggressive*	11.738	.001
	Elegant*	31.153	.000
	Frivolous	7.482	.007
	Futuristic*	36.606	.000
	Ordinary*	98.003	.000
	Sexy*	54.976	.000
Shape	Cozy*	11.850	.001
	Elegant	6.932	.009
	Masculine*	15.811	.000
	Sexy*	17.439	.000
Culture	Cozy*	61.712	.000
Gender	Aggressive	5.412	.021
	Ordinary*	20.876	.000
	Sexy	6.980	.009
Material	Elegant*	11.357	.001
	Frivolous	5.125	.024
	Futuristic*	21.760	.000
	Masculine	3.876	.050
	Sexy	6.108	.014
	Toy-like*	32.040	.000
Function X Shape	Elegant*	11.357	.001
	Sexy*	15.369	.000
Function X Material	Toy-like	7.121	.008
Culture X Function	Futuristic	9.012	.003
	Ordinary	4.475	.035
	Toy-like*	13.241	.000
Culture X Shape	Cozy	6.552	.011
	Futuristic*	10.753	.001
	Masculine	4.186	.042
Culture X Material	Elegant	5.368	.021
	Sexy*	16.735	.000
Gender X Material	Futuristic	9.012	.003
	Sexy	4.184	.042
	Toy-like	5.499	.020
Materials X Shape	Futuristic	3.944	.048

Note: $p \leq .05$ (note: (*) effects with $p \leq .01$)

SHAPE showed main effects for the meanings *cozy*, *elegant*, *masculine,* and *sexy*. As expected, the materials of rounded shape products are appraised as cosier, sexier, more elegant and less masculine than the materials of sharp-edged products (see Fig. 2b). Coming to the second main factor, *user effects*, the main effects obtained for GENDER were for the attribution of the meanings *aggressive*, *ordinary* and *sexy* to materials. Males, in general, found the materials of the presented products more aggressive, sexier and less ordinary than females (see Fig. 2c). With regard to CULTURE, the only main effect obtained was on *cosy*. In general, Chinese participants perceived the presented materials as cosier than Dutch participants (see Fig. 2d).

MATERIAL type was found to have main effects for six meanings (out of nine), excluding *aggressive*, *cosy* and *ordinary*. Overall, metal was perceived more *elegant*, more *futuristic*, more *frivolous*, *sexier,* and less *toy-like* than plastics. Interestingly, plastic is perceived more *masculine* than metal (see Fig. 2e).

Interactions

The first two interactions show how a change in shape and material influence the main effect of FUNCTION on the meanings of materials. A FUNCTION X SHAPE interaction was obtained for the meanings *elegant* and *sexy* (Figures 3a and 3b). Participants appraised the materials of waste baskets as more elegant when they are produced in a rounded shape; the materials of lighters were perceived as slightly more elegant in a sharp-edged shape. While a rounded shape has a large influence on attributing sexiness to waste baskets, it has no effect on perceiving lighters as sexy. The only FUNCTION X MATERIAL interaction is presented in Figure 3c, showing that plastics, as compared to metal, is perceived as much more toy-like in waste baskets than in lighters.

The GENDER X MATERIAL interaction was significant for the meanings *futuristic*, *sexy,* and *toy-like*. Figures 4a, 4b, and 4c reveal that these interactions are due to the differential effect of the two MATERIAL types. As can be seen in the figures, whether

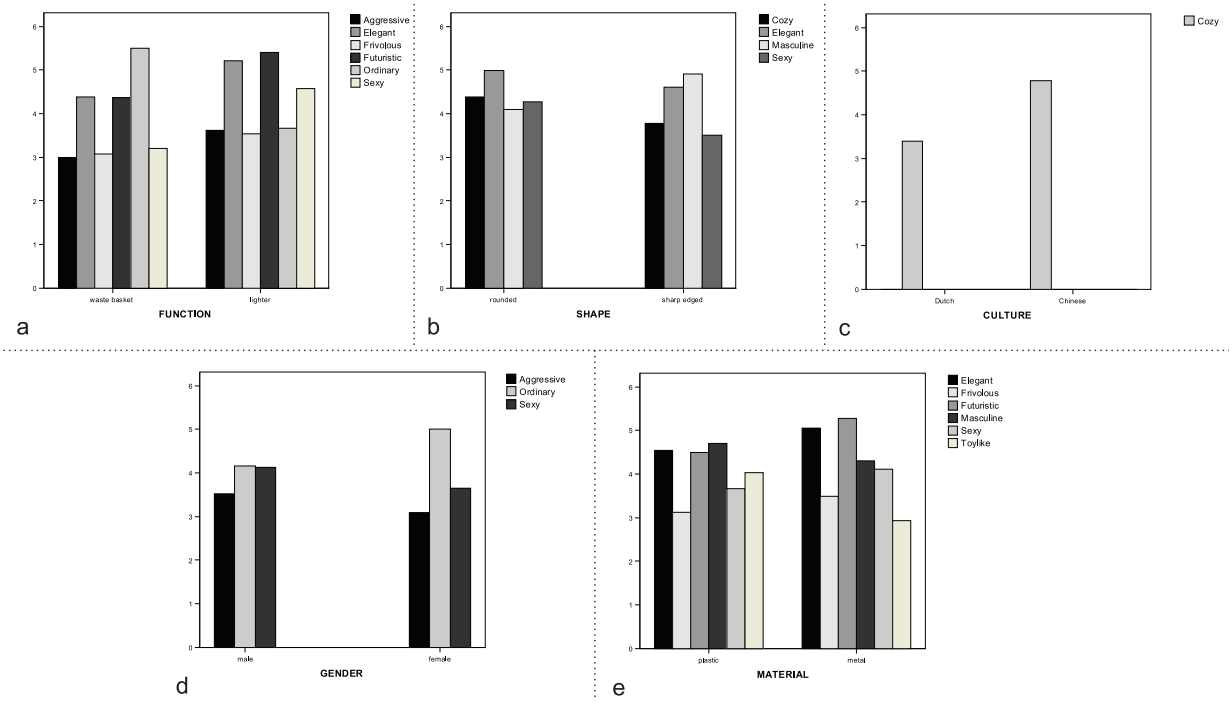

Figure 2. Main effects of function, shape, culture, gender, and material (the scale -3 to +3 is converted into 0 to 6).

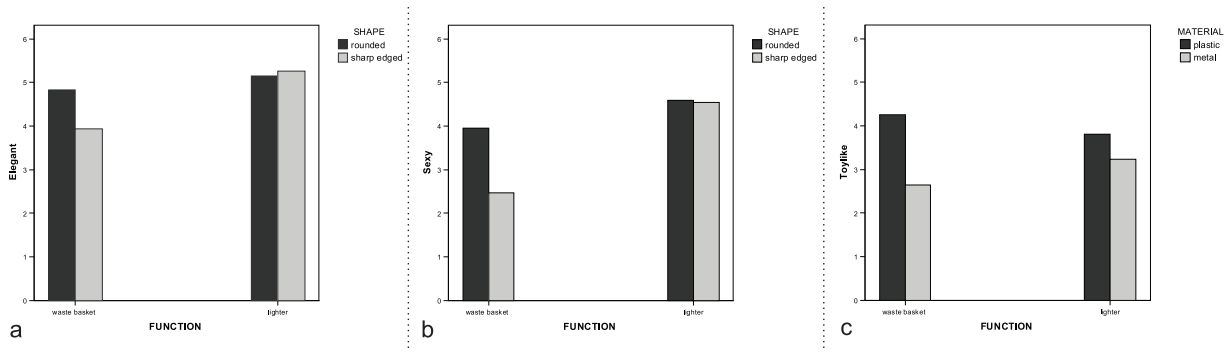

Figure 3. Interaction effects of function.

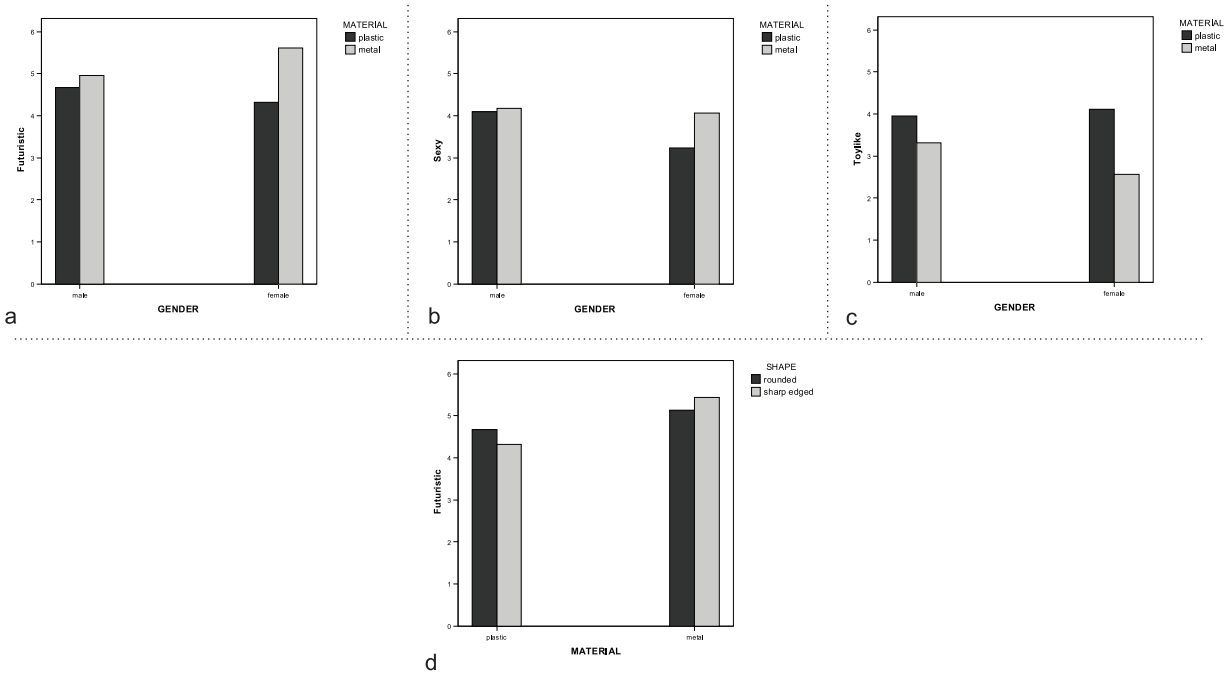

Figure 4. Interaction effects including gender, and material.

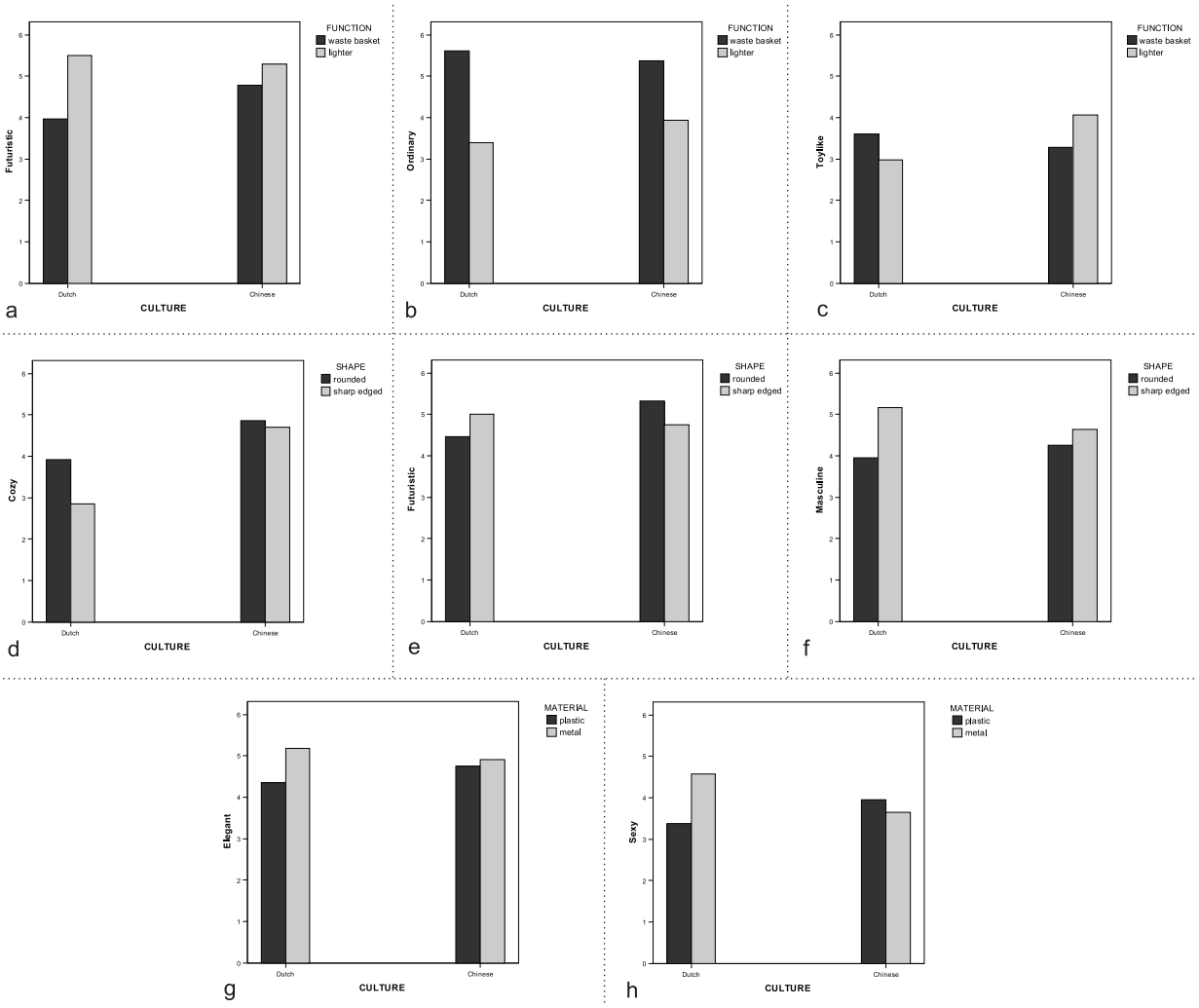

Figure 5. Interaction effects including culture.

a product is made of metal or plastics is more important in attributing the meanings *futuristic, sexy,* and *toy-like* for females than for males. MATERIAL X SHAPE interaction only reached significance for the meaning *futuristic*. Figure 4d reveals that rounded shaped plastic is perceived as more futuristic than sharp-edged plastic, whereas metal is perceived more futuristic when it is in a sharp-edged form.

CULTURE was implicated in three significant two-way interactions with SHAPE, MATERIAL, and FUNCTION (see Figure 5). A CULTURE X FUNCTION interaction was observed for three meanings: *futuristic*, *ordinary,* and *toy-like* (Figures 5a, 5b, and 5c). Regardless of the type of material, materials of waste baskets were appraised as relatively less futuristic and more ordinary by Dutch participants than Chinese participants. Also, Dutch participants found the materials of waste baskets more toy-like than the materials of lighters, whereas Chinese participants found the materials of lighters more toy-like.

For Dutch participants, a difference in geometrical shape of a product had relatively more effect on attributing the meanings cozy and masculine to materials than for Chinese participants (Figures 5d and 5f). Interestingly, while sharp-edged products were found more futuristic by Dutch participants, Chinese participants saw rounded products as more futuristic (Figure 5e). A CULTURE X MATERIAL interaction was obtained for the meanings *elegant* and *sexy* (Figures 5g and 5h). Similar to the CULTURE X SHAPE interaction effect, differences in the materials of a product had more effect on attributing the meaning elegant to a material for Dutch participants than for Chinese participants. Finally, Chinese participants found plastic products sexier than metal, whereas Dutch participants thought that metal products were sexier than plastics.

Discussion

The results of the study supported the contention that meanings of materials in a particular context are shaped by interactions of materials with aspects of products and users. One of the most important findings of this study was that all aspects tested in this study show main effects for some of the given meanings. Naturally, the material itself affected the attributed meanings, but only for six out of the nine meanings. For three meanings, *aggressive*, *cozy*, and *ordinary*, the type of material apparently did not make a difference. In other words, plastics and metal do not differ with respect to these three meanings.

The product aspects, SHAPE and FUNCTION, have a similar and relatively strong effect on attributing meanings to materials, with respectively four and six significant main effects. This finding indicates that the type of product and the way a material is shaped in a product have a big impact on what a material expresses. The two user aspects studied, GENDER and CULTURE, only had a minor effect on material meaning, with only three and one significant main effect, respectively.

For certain meanings, such as *futuristic*, *elegant,* and *sexy,* more main and interaction effects were obtained than for other meanings (see Figure 2). Their assessment is apparently more affected by the aspects (i.e., shape, function, gender, and culture) varied in this study. This may be explained by participants' easy associations of materials (or material properties) with futuristic, elegant, and sexy products (e.g., association of aluminium or metallic colours with futuristic products). *Frivolous*, in contrast, was less affected by changes in shape, function, gender, and culture. This may be a result of the participants' unfamiliarity with the term *frivolous*. Familiarity with a term helps people to describe that term with circumstances, objects, or events which are taught them in societies or learnt by experience. Thus, a person can recall objects, events, or circumstances related to a term if he/she recognizes the term or is familiar with it. In other words, familiarity with a term brings easy associations with objects, properties, or events. Relatively few effects of the various aspects on the *aggressiveness* of materials were observed. Participants might have focused mainly on an anticipated harmful result of an interaction (i.e., a literal rather than metaphorical meaning of aggressiveness) with the lighters and the waste baskets, rather than other material and product aspects, such as shape or sensorial properties of materials. This may explain why the materials of lighters were found more aggressive than materials of waste baskets.

In the second section of this paper, we discussed the findings of a study demonstrating that women show a greater intensity of both positive and negative affective responses (Lukas, 2007). Likewise, according to another study, women are more successful than men in judging emotional meaning from nonverbal cues (e.g., facial expressions, formal properties of artefacts) even with minimal stimulus information (Hall, 1984). Our study generated similar results. Females were more sensitive to variation in the materials than men. In other words, whether a product was made of metal or plastic made a greater difference to the evaluations of females. A significant gender difference was observed for the meaning *ordinary*: females found the materials used in our study in general more *ordinary* than males. In order to find a product or a material ordinary, a user is expected to be familiar with it. In that respect, the female students in our study may have been more familiar with the products and the materials used (particularly within households). On the other hand, it is difficult to explain gender differences in attributing the meaning *aggressive* to materials. Seemingly, the potential harmful effects of the given materials were higher for males than for females; or males might have rated the aggressiveness of the materials metaphorically. In short, although we did find a few main effects for GENDER, they are not easy to explain.

A number of interesting 2-way interaction effects was found. For instance, a significant SHAPE X CULTURE interaction for the meaning *futuristic* was obtained. The Chinese participants found the materials of rounded shapes more futuristic than the materials of sharp- edged shapes. It was just the opposite for Dutch participants who, in general, appreciated metal more than plastics (e.g., metal was found sexier, more elegant, and more futuristic than plastics). The differences between the two cultures in their evaluations of metal and plastic were as predicted. However, we expected to find a more negative attitude towards plastics from Asian people. This unpredicted result may be explained by the fondness of Asian cultures for natural and

organic forms (Clemenshaw, 1989), which are mainly associated with plastics. It may also be partly explained by an increasing number of plastic products on Asian markets, which make Asian people more familiar with this material family. A particular culture might also be more familiar with a product which may affect how that culture evaluates a material embodied in that product. In informal discussions after the study, for instance, some Chinese participants indicated that they had never seen the lighters used in this study.

A crucial question stems from the overall findings of the study: were participants able to evaluate the materials of products, as a specific aspect, or did they evaluate the products in general, covering many aspects? Although they were asked to evaluate the materials of the products, it is shown that other product aspects affect the overall impression of a product. Therefore, one can interpret the main effects obtained from this study as the changes in the overall impression of the products with respect to the changes in shape, function, gender, culture, and material. In this sense, using two types of materials was a wise attempt to show how material interacts with other aspects (two-way interactions) and the effects of these interactions on certain meanings.

In this paper, we particularly focused on main material families (i.e., plastic and metal). It should be recognized that different types of a certain material family, for example polypropylene and polyethylene, can create different meanings in similar products. Exploring how different types of materials from the same material family affect the meaning attribution can be a valuable topic for future research. Another important point is that although the study was designed to see how certain aspects interact with two types of materials for expressing particular meanings, the observed differences might have been the result of the differences between particular sensorial properties. In other words, if a matte metal (or matte plastics) had been used instead of a glossy one, the results might have been different; or, instead of black plastic, if grey was selected the results again might have differed. It may also explain why plastic was found more masculine than metal in this study. People have an idea (or expectations) about a certain material-product relationship. In a study conducted by Ludden, Schifferstein, and Hekkert (2008) we see that designers use these expectations in order to surprise people. For example, if people see a 'tea cup' made of a material they are not used to (such as velvet), they are surprised. For this study, a special attempt was made to select 'ordinary' versions of products. Therefore, we selected a certain type of plastic and metal as people are accustomed to plastic or metal waste baskets which are not painted with flashy colours and which are not surprising due to extraordinary material properties. In another study, we explored how glossiness and colours may play an important role in how people appraise materials and products (Karana, Hekkert, & Kandachar, 2009).

It should be recognized that even though we made a speculative discussion on the findings of this study on the basis of common knowledge, a full explanation of why, for instance, a woman and a man attribute different meanings to materials, is hard to give. In this paper, our main concern was to provide practical knowledge for the reader who is primarily interested in materials in design. While doing so, we showed the effects of some product and user aspects on the meaning we attribute to materials, but did not elaborate on the cognitive processes involved in meaning attribution or engage in philosophical discussions on meaning theories. Future explorations with more emphasis on meaning theories and the cognitive processes in materials experience can give an important extension to all material related studies, as well as to the work reported in this paper.

Conclusion

The study reported in this paper supports our assumption that people's understanding of a material's meaning is grounded in certain aspects mainly related to the product that the material is embodied in, the material itself with its descriptive physical and sensorial properties, and the user who experiences the material. The study aimed to investigate the effects of shape and function as product aspects, and gender and culture as user aspects, on the attribution of certain meanings to two material types: plastics and metal. The effect of function, shape, and culture on meanings of materials implies that other types of products, shapes, and cultures, which were not included in this study, might generate different results.

In addition, we encounter a particular material in different contexts in daily life. In literature, it is emphasized that context is limitless in size, and therefore it is recommended to communicate with people and find out in which context their artefacts are used and what those artefacts mean to those people in their contexts of use (Krippendorff & Butter, 2008; Poole & Folger, 1988; Van Rompay, 2005). Meanings we attribute to a porcelain tea pot would be different, depending on whether it is in our own kitchen, in our grandparents' kitchen, on a console in a living room, in an antique shop's window, under dim lighting in a restaurant, or on a picnic table, etc. (Karana, 2009).

Summarizing, the meaning of a material can change in different products; it can be different for different people of different cultures, in different contexts, or at different times. Therefore, it is difficult to generalize the findings of the study presented in this paper in order to propose definite ways for creating particular meanings through materials. However, this study shows that the concept of meaning requires understanding of how people experience materials in daily life instead of making material decisions based on gut feelings.

References

1. Arabe, K. C. (2004). Materials' central role in product personality. *Industrial Market Trends*. Retrieved March 2, 2004, from http://news.thomasnet.com/IMT/archives/2004/03/materials_centr.html
2. Ashby, M. F. (2005). *Materials selection in mechanical design* (3rd ed.). Oxford: Butterworth-Heinemann.
3. Ashby, M. F., & Johnson, K. (2002). Materials and design: The art and science of material selection in product design. Oxford: Butterworth-Heinemann.
4. Blank, P., Massey, C., Gardner, H., & Winner, E. (1984).

Perceiving what paintings express. In W. R. Crozier & A. J. Chapman (Eds.), *Cognitive process in the perception of art* (pp. 127- 143). Amsterdam: North Holland.

5. Brewer, J., & Bassoli, A. (2006, May). *Reflections of gender, reflections on gender: Designing ubiquitous computing technologies.* Paper presented at the Gender and Interaction, Real and Virtual Women in a Male World Workshop, Venice, Italy. Retrieved May 15, 2006, from http://www.karmanet-design.com/avi2006.pdf
6. Chen, X. (2005). Relationships between product form and brand: A shape grammatical approach. Leeds, UK: The University of Leeds.
7. Chung, M. C., & Ma, Y. C. (2001). Expressing the expected product images in product design of micro- electronic products. *International Journal of Industrial Ergonomics, 27(4)*, 233-245.
8. Clemenshaw, D. (1989). *Design in plastics*. Rockport, MA: North Light Books.
9. Dormer, P. (1990). *The meanings of modern design: Towards the twenty-first century*. London: Thames and Hudson.
10. Hall, J. A. (1984). *Nonverbal sex differences: Communication accuracy and expressive style*. Baltimore, MD: The Johns Hopkins University Press.
11. Hsiao, K. A., & Chen, L. L. (2006). Fundamental dimensions of affective responses to product shapes. *International Journal of Industrial Ergonomics, 36*(6), 553-564.
12. Johnson, M. (2007). *The meaning of the body: Aesthetics of human understanding*. Chicago: The University of Chicago Press.
13. Karana, E. (2004, July 12). *The Meaning of the material: A survey on the role of material in user's aluation of a design object*. Paper presented at the 4th International Conference on Design and Emotion, Ankara, Turkey.
14. Karana, E. (2009). *Meanings of materials* [Doctoral dissertation]. Delft, The Netherlands: Delft University of Technology.
15. Karana, E., & Hekkert, P. (2008). Attributing meanings to materials. In P. M. A. Desmet, S. Tzvetanova, P. Hekkert, & L. Justice (Eds.), *Proceedings of the 6th International Conference on Design and Emotion*. Hong Kong: Hong Kong Polytechnic University Press.
16. Karana, E., Hekkert, P., & Kandachar, P. (2007, October 13). *Sensorial properties of materials for creating expressive meanings*. Paper presented at the 1st Kansei Engineering and Emotion Research Conference, Sapporo, Japan.
17. Karana, E., Hekkert, P., & Kandachar, P. (2009). Meanings of materials through sensorial properties and manufacturing processes. *Materials and Design, 30*(7), 2778-2784.
18. Karana, E., & Van Kesteren, I. (2008). Materials affect: The role of materials in product experience. In P. Desmet, J. Van Erp, & M. A. Karlsson (Eds.), *Design and emotion moves* (pp. 221-245). Cambridge, UK: Cambridge Scholars Publishing.
19. Karana, E., Van Weelderen, W., & Van Woerden, E. (2007, September 6). *The effect of form on attributing meanings to materials*. Paper presented at the ASME International Design Engineering Technical Conferences and Computers and Information in Engineering Conference, Las Vegas, NV.
20. Krippendorff, K., & Butter, R. (2008). Semantics: Meanings and contexts of artifacts. In H. N. J. Schifferstein & P. Hekkert (Eds.), *Product experience* (pp. 353-376). Amsterdam: Elsevier.
21. Lefteri, C. (2001). *Plastics: Materials for inspirational design.* Hove, East Sussex, UK: Roto Vision.
22. Ljungberg, L. Y., & Edwards, K. L. (2003). Design, materials selection and marketing of successful products. *Materials and Design, 24*(7), 519-529.
23. Ludden, G. D. S., Schifferstein, H. N. J., & Hekkert, P. (2008). Surprise as a design strategy. *Design Issues, 24*(2), 28-38.
24. Lukas, K. (2007). Equal pay day was in February: Part-time working men should demand justice, too. *National Review*. Retrieved April 24, 2007, from http://article.nationalreview.com/?q=MWFmYmFmMThhZjhhOGVjM2Y4MTE5ZGQxMWM0M2M0ZGI=
25. Mono, R. (1997). *Design for product understanding: The aesthetics of design from a semiotic approach*. Stockholm: Skogs Boktryekeri AB.
26. Muller, W. (2001). *Order and meaning in design.* Utrecht, The Netherlands: Lemma Publishers.
27. Oehlke, H. (1990). In search of the semantics of design objects. In S. Vihma (Ed.), *Semantic vision in design* (e1-e12). Helsinki: Publications of the University of Industrial Arts UIAH.
28. Pedgley, O. (2009). Influence of stakeholders on industrial design materials and manufacturing selection. *International Journal of Design, 3*(1), 1-15.
29. Petiot, J. F., & Yannou, B., (2004). Measuring consumer perceptions for a better comprehension, specification and assessment of product semantics. *International Journal of Industrial Ergonomics, 33*(6), 507-525.
30. Poole, M. S., & Folger, J. P. (1981). Modes of observationand the validation of interaction analysis schemes. *Small Gropu Behavior, 12*(4), 477-493.
31. Soentgen, J. (1997). Materials: The fascination. *Formdiskurs, 3*(2), 42-55.
32. Van Kesteren, I. (2008). *Selecting materials in product design* [Doctoral dissertation]. Delft, The Netherlands: Delft University of Technology.
33. Van Rompay, T. (2005). *Expressions: Embodiment in the experience of design* [Doctoral dissertation]. Delft, The Netherlands: Delft University of Technology.

Appendix 1. 7-point scales with Dutch translation.

To what extend does the **material** of the product express the given **meaning**?
*In welke mate drukt het **materiaal** van het product de gegeven **betekenis** uit?*

	3	2	1	0	1	2	3	
Cozy *Knus*								Aloof *Afstandelijk*
Elegant *Elegant*								Vulgar *Vulgair*
Futuristic *Futuristisch*								Nostalgic *Nostalgisch*
Toy-like *Als speelgoed*								Professional *Professioneel*
Frivolous *Losbandig*								Sober *Ingetogen*
Agressive *Agressief*								Calm *Kalm*
Ordinary *Gewoon*								Strange *Vreemd*
Sexy *Sexy*								Not sexy *Niet sexy*
Masculine *Mannelijk*								Feminine *Vrouwelijk*