DEFINING USER-INTERACTION ASPECTS FOR MATERIALS SELECTION: THREE TOOLS

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Materials selection activities can be improved by tools that are used in a design brief meeting between product designers and clients. These tools, in broad outlines, can help clients to express what kind of user-interaction they want to create with the product and its materials. Furthermore, the tools support product designers to translate these desired user-interactions in a material profile. This profile is then used in the information searches about candidate materials for the new product. In this paper, we show the design steps taken to create three tools for these purposes and the results of these steps. Furthermore, we present the results of a study that evaluated the usability and the achievements of these tools. The tools were used in this study by product designers and clients in two fictive design briefs.

INTRODUCTION

Product designers working for design agencies discuss the objectives of the project with the client at the start of a project. Product designers begin their search for candidate materials based on these discussed objectives (Ashby, 1999, van Kesteren et al, 2006). In current materials selection, not only functional aspects of materials are considered, also user-interaction aspects such as aesthetics, perceptions and emotions, are considered (Ashby and Johnson, 2002; van Kesteren et al, 2005). This implies that these aspects need to be specified in the requirements as well. However, Ferrante, Santos en de Castro write about materials and aesthetic design: “apparently this is a subjective area, difficult even to qualify …” (2000). Specifying the requirements on user-interaction aspects of materials is difficult as these aspects are often subjective, however, is needed for an efficient materials selection. Furthermore, people are tended to talk about function rather than about aesthetics of products (Denton and McDonagh, 2006, Karana and van Kesteren, 2006). Especially for non-designers it is difficult to talk about user-interaction aspects. However, in user-centred design it is required to discuss user-interaction topics in addition to functional topics. User-interaction topics include the specific interaction requirements of the target group such as usability and product experiences. Previous research shows that product designers encounter that clients are often not able to specify the user-interaction aspects of materials they desire in a new product (van Kesteren et al. submitted). Consequences are that product designers start a search based on criteria that can be interpreted in different ways. They use their experiences to come to material candidates, which they then discuss with clients. Product designers often mentioned that in these discussions it becomes clear that the client desires other aesthetics and perceptions than initially mentioned. It is unwanted that product designers are on the wrong track too long, or need to start from the beginning when new options need to be searched for. This leads to unnecessary delays and costs in the

materials selection process and thus in the total design project. Our aim is to find ways to diminish these unnecessary delays.
This paper presents and evaluates three materials selection tools for defining user-interaction aspects. Product designers can use the tools together with clients during the formulation of materials requirements. They support this activity by assisting the client to talk about user-interaction. From this, product designers can define the desired material features and start their materials searches based on these features. The tools are highly interactive and use product examples, material samples and directing questions to create a consensus between client and product designer about the desired user-interaction aspects of materials.

DEFINITIONS OF USED WORDS

User-interaction aspects of materials. Aspects of materials that influence the use and experiences of a product. For example, shininess can influence how well you can read from a display (use aspects) and colours are a very strong aspect to influence product experiences.
Material features. An aspect of a material that contribute to a product's functionality, usability or experiences. Examples from Ashby and Johnson (2002) are: Slippery, Strong, Heavy, Elastic, FDA approval, corrosion resistant. Features are relative to others and do not necessary include numbers.
Sensorial attributes. Characteristics of materials that can be sensed by one of the five senses. Examples of these properties are hardness, thermal conductivity, colour, optical quality, texture, pitch and odour.
Material properties. Properties that describe the technical profile of a material. It includes the physical, mechanical, thermal, electrical and optical properties. A characteristic of an attribute is that it can be measured and represented by a number (Ashby, 1999).

GENERAL OUTLINE OF THE TOOLS

Product designers experience the least changes in their materials selection process when they have discussed the requirements with the client in the beginning of a project. Clients are able to give their requirements on technical aspects; however, in a previous study we found that they are not always able to specify themselves about user-interaction aspects. In the desired situation product designers are able to discuss user-interaction aspects in the beginning of a project with a client.

The idea is to offer product designers tools that aims at reducing a change in project objectives and helps to formulate clear and complete material requirements. The tools can generally do so by supporting three steps, namely 1) definition step, 2) translation step, 3) search step.
In the *definition step* the client and the product designer define the requirements for a material search based on a mutual understanding about the interaction requirements of the target group. The method helps the client to talk in terms of user- interaction aspects of materials, e.g. by a set of questions offered by the method. In addition, it helps to decide what the decisive user-interaction aspects the product designer needs to focus on in his materials searches are. This part of the method is used during the design brief meetings. After these meetings, the product designer evaluates the proposed aspects. The aspects offer clues for the scope of user-interaction aspects of materials that create the desired product experiences and use: they represent the required materials features in terms of user-interaction aspects, e.g. sensorial attributes. This step results in a set of materials features on user-interaction aspects.
The *translation step* is performed by the product designers. They translate the user-interaction features into technical materials properties with the help of a checklist or properties sheet[1] that is offered by the method. The product designer then combines the materials features on user-interaction with the functional and other aspects (e.g. costs, manufacturing, environmental issues) needed in the project. The translation step results in the materials requirements for the project.
The final step is the *search step*. The product designer utilizes the user-interaction features together with the list of properties to find and compare material candidates and to choose materials. He contacts experts, manufacturers and materials suppliers in this step. The reason for using the user-interaction features in combination with the material properties is first to enable materials experts to give a specialized advise, which they can because they are able to provide information on material properties. The second reason is to provoke information providers to give background information on their recommendations based on the user-interaction features. This makes that product designers can revaluate recommendations when they

1 The properties sheet is currently in development and gives the mechanical, optical, thermal and electrical properties that are connected with sensorial materials properties. For example, the sensorial attribute glossiness or scattering is connected with the materials properties: reflection coefficient, surface roughness, orientation of pigments and the index of refraction.

encounter changes in project objectives. This step results, via several iterations, in selected materials.

EXPECTED BENEFITS

The expected benefits of the UCMS method are summed below.

- The method helps clients to talk about user-interaction aspects so they can be more involved in the formulation of material requirements about these aspects then they are now.
- The defining step of the method results in consensus between client and product designer about user-interaction aspects in early stages in the materials selection. The product designer knows which features to focus on in his materials searches. This will result in less major changes later in the project.
- Criteria about user-interaction aspects are formulated as desired material properties. This means that they can be combined with physical aspects. Information providers can than recommend materials to create a user-interaction based on their properties.
- The methods do not direct to materials, but to material features and attributes that form a material profile. With this it is possible to search available materials. An advantage is that new materials have a chance of being considered in addition to conventional materials. When a method directs to materials directly this is less possible.

THREE PROPOSED TOOLS

In this section, we present three concepts for the definition step in the method. The aim of the definition step is to assist product designers and clients in defining how materials can create a desired user-interaction in the design brief. The results of this step are material features on user-interaction aspects that can be used in the translation step. Idea A and B concentrates on the experiences aspects of products and idea C on sensorial attributes of experiences and use.

A. 'PICTURES' TOOL

Idea

Example products are strong means to communicate about experiences. When a product designer wants to create certain experiences, he can use existing products and the materials these products are made of as examples. Together with a client he can select those aspects of the example products of which they think create the desired experiences. The idea is to offer product designers a set of images that can be used for this purpose.

Pascalle Govers developed a product personality scale (2004). Product personality in this scale refers to the character of a product. This scale consists of 20 product personality terms that are visualized with pictures (table 1). These pictures show situations and objects, not necessarily products. For the 'Pictures' tool a similar set of images was made, but than of existing products. The material features of these products form a bridge between the desired experiences via the personality and the materials characteristics for the new product. We expect that especially clients can better point out what they want in example products than they can talk in terms of material features directly.

Table 1 Twenty terms of product personality as defined by Govers (2004)

Product personality terms			
Cheerful	Cute	Obtrusive	Boring
Open	Idiosyncratic	Dominant	Aloof
Relaxed	Provocative	Untidy	Serious
Pretty	Interesting	Childish	Honest
Easy-going	Lively	Silly	Modest

Development

To create uniformity in product examples a product category was chosen, namely consumer electronics, in which most products can be characterized. Numerous pictures of products were selected from different internet stores. These pictures were categorized into the 20 personality terms in two steps. In the first step, we defined five main groups in which we categorized the products. These groups were: calm, pleasant, happy, expressive and provocative. In the second step the products were categorized per personality term. For every term three products were selected. The categorization of the products was then evaluated by 5 design students[2].

Evaluation

Design students were asked to group the selected products in the personality categories. They first categorized one of the groups themselves and then discussed the categorization with the other students. Their second assignment was to translate the product characteristics into material features.

Based on the evaluation we decided to omit two terms and combine two terms for the following reasons. The term 'pretty' appeared to be more subjective than the other terms. It is more related to the product itself than the materials. The same holds for the term 'idiosyncratic'. We omitted both terms in the final set. The terms 'serious' and 'boring' appeared to have the

[2] Students of the Master program in Industrial Design Engineering at the Delft University of Technology in The Netherlands.

same products that were associated with these terms. Especially the materials aspects of these products were similar. We decided to replace these two terms with the term ‘business like’. Also the terms ‘provocative’ and ‘lively’ were combined into one term, namely ‘lively’. To finalize the tool two aspects were added; 1) details of the materials the products were made of and 2) a list of materials features that were corresponding in the product examples belonging to a term. Furthermore, the appearance of the tool was determined, namely a set of cards with on the front side product examples and on the backside the details and material features (figure 1).

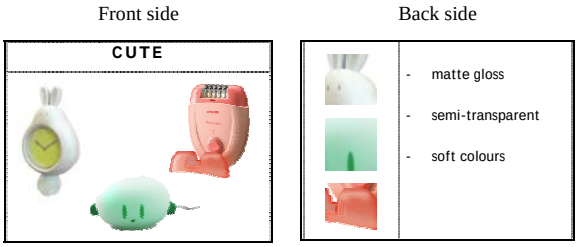

Figure 1 One of the 16 cards belonging to the 'Pictures' tool

Instruction for use

The tool consists of a set of 16 cards that all represent a different personality, e.g. lively, dominant or childish. The front side of the card helps to visualize the personality (figure 1). The backside of the card helps to translate the product characteristics into material features. It shows details of the products and the material features of these products in some keywords. While defining a design brief, clients can show which aspects of the products are representative for their desired product personality and which are not. In the following phase, product designers can discuss the material features that are related to the selected personalities. Questions that the product designer can ask the client are for example: “These products are semi-transparent, is that what you had in mind too?” The product designer can start the translation step based on these features.

B. ‘SAMPLES’ TOOL

Idea

Materials samples are widely used in materials searches. They are used as communication tool and to compare and test materials candidates. For example, materials samples from suppliers show different colours or different transparencies of their material portfolios. The idea is to use samples in the defining phase of materials selection, thus to formulate materials requirements. The existing sample sets from suppliers are too detailed to use for this purpose: they only vary on some material features. A set of samples that represents a wide range of materials features is expected to support the defining phase. These samples can help to discuss which materials best fit the desired experiences and use. Especially tactile aspects can be discussed with physical samples.

Development

The tool will offer a wide range of material features in a set of materials samples. The number of samples is limited to the practical issues of storage, bringing it to client meetings and using it in a discussion. We aimed at selecting a maximum of 15 samples that contain a combination of sensorial attributes. Together in the set, all different varieties of sensorial attributes are present. Other considerations of developing the set were using colour and shape. To create uniformity we decided to eliminate colour except for the natural materials colour and use similar shaped samples.

Two sets of samples were made that were evaluated by a group of design students. Both sets were developed in a different way. For set 1 a matrix was made with sensorial attributes of materials and the variations in these aspects. For example, the sensorial attribute ‘transparency’ knows the variations: transparent, semi-transparent and opaque and the sensorial attribute ‘gloss’ knows the variations: high gloss, gloss and matte. For each variation a material sample was selected from different material databases (www.materialexplorer.com, private collection, collection of the faculty of Industrial Design Engineering). The samples selected in this step represented one variation of a sensorial attribute. The next step was to reduce the number of samples. For every selected sample all sensorial attributes were noted. It was then possible to select the samples that together represented all variations in sensorial attributes. Set 1 was then evaluated.

For set 2, samples were selected to represent certain experiences. For this, a selected group of product personality aspects of Goverts (2004) were used (table 1). The aspects were selected based on being positive experiences. The samples were selected from different materials databases. For every personality term two or more samples were selected. The sensorial attributes of every sample were noted so that the product designer can use these to find materials with the same sensorial attributes as the discussed samples. Set 2 was then evaluated.

Evaluation

A group of students[3] evaluated the two materials sets. The aim was to find out whether the samples were grouped logically and whether set 1 or set 2 was more attractive to use. For every sample of set 1 the students were asked to describe the sensorial attributes of the sample. Thereafter, they placed the samples in the same matrix that was used to create set 1 and discuss why they placed the samples as they did. Finally they selected a set of samples that represented the different variations of sensorial attributes. For set 2 the students were first asked to name one or more materials per used personality term. Thereafter, they used the set of samples to categorize them in the personality terms. The last task was to select the sample that represented the personality term best.

Both sets were used by the students to design a lamp with a 'cute' personality. This was done to evaluate which set was most attractive to use. They found the set based on personality terms more inspiring to use. They could use both the personality as the sensorial attributes in this set. The students commented that the samples of the personality set were more clear about how to use them, namely in the analysis phase and not as a final selection of these materials for the product. We therefore decided to use this set as final concept for the material sample set tool.

Instruction for use

The 'Samples' tool consists of eleven material samples that are selected to represent a different personality (figure 3). Together with the samples a card is provided. The product designer can find the following aspects on this card: 1) the personality terms and definitions, 2) a picture of the sample that was selected for that personality, 3) sensorial attributes of the sample.

The samples are used during a design brief meeting. The product designer and client can select a combination of samples that represent a desired personality. The product designer can then start the translation step based on the sensorial attributes of the samples.

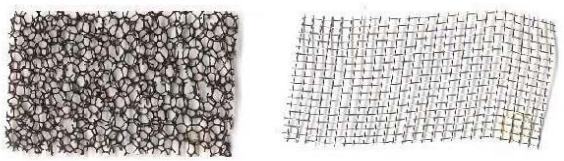

Figure 2 Two of the eleven materials samples from the 'Samples' tool.

[3] Students of the Master program in Industrial Design Engineering at the Delft University of Technology in The Netherlands.

C. 'QUESTIONS' TOOL

Idea

Materials, together with the shape, form the interface of a product. Through this interface, a person can experience the product's personality and use the functionality of the product (Fenech and Borg, 2006). A person's senses form his interface. Through these he can achieve and evaluate his goals and experiences a product. Senses and materials interact with each other when a person interacts with a product. The idea is to translate desired experiences via the senses into sensorial attributes of materials with the help of a questions list.

Development

The aim of the tool is to discuss the sensorial interaction with the product. It will do so by offering topics that refer to aspects of the interaction. The selection of these topics and the formulation of the questions in these topics were performed in the following way.

First topics of the interaction were defined and discussed with two experts[4]. The topics were product experiences, being the emotional, associative en perception responses to the product; the functional use and the distinctiveness of a product compared to other products. A set of questions was made for each topic. Second, a structure was developed to organize the questions. This structure should be easy to remember and follow a natural way of having a conversation rather than providing product designers with a questionnaire for the client. A familiar way of organizing for example product requirements is via a process tree or life cycle analysis (Roozenburg and Eekels, 1995). In a process tree all phases of a product life cycle come forward, from designing to disposal. It forces product designers to consider the consequences of their design for every phase. One of the phases is the 'use' phase. We base the organization of the questions on this phase. We created six sub phases which are presented in table 2. In sub phases 'first contact' and 'try out phase' the topic of distinction comes forward. The functional use topic is placed in the 'usage' sub phase. In the rest of the phases product experiences topics are discussed.

After selecting the topics, questions and structure, everything was combined and formatted on an A4 paper. This preliminary design of the tool was discussed with experts again and fine-tuned in several steps. The discussed design was then used by four

[4] Geke Ludden, PhD candidate in Surprise in Product Design, Marieke Sonneveld, PhD candidate in Tactile Experiences.

design students[5] to evaluate the tool's usability.

Evaluation

The tool was used in a workshop with students that were in the middle of their design assignment. At this point they had formulated an idea to add product experiences to a regular leek by a product. The next step was to materialize this product. To start this materialization they were offered to use the tool. After a short explanation the students' ideas were discussed one by one. One student acted as a 'client' (the idea owner) and the other students used to tool to specify the user-interaction aspects and the related materials characteristics of the product. The researcher acted as a designer too and added questions to the conversations. The students evaluated the tool as very helpful to organize thoughts and not to forget anything. The tool forced them to think about the sensorial attributes and provided arguments for their choices. It provided a new angle of looking at things. However, the students needed training to use the tool. The questions and phases were not intuitive and the researcher helped them a lot in the first discussions. The students suggest providing more examples in the instruction of the tool. Another drawback was that the questions did not direct to the sensorial attributes that are needed to start a search: conversations stayed on a product experiences, functional use or distinctiveness level. By changing the order of the questions and use another word for sensorial[6] we expect that this problem is diminished.

Instruction for use

The tool consists of a list of questions (table 2) and a checklist of sensorial attributes (table 3). The list of questions is organized according to 'the process tree of use'. The product designer and the client project their minds in the interaction that the user has with a product in a specific phase. The tool works best when the questions are changed a bit to fit the specific design problem. Of course, it is possible to add questions. The discussion should always end with the question: "Which sensory aspects play a role in this?" The answers on this question, provides the understanding about the sensorial aspects of a product. The sensorial attributes are noted on the checklist. The checklist can be filled in during the discussion and can be used to summarize the desired sensorial attributes that form the basis for the translation step.

[5] Third year product design students of the Gerrit Rietveld Academy in Amsterdam, The Netherlands.

[6] The Dutch words 'zintuigelijk' and 'sensorisch' are both translations of the English word 'sensorial'. We use the word 'zintuigelijk' in the final version of the method.

Table 2 Questions in the 'Questions' tool

Phase	Questions
First contact	
Distinctiveness	How will the product attract attention? How does the product differentiate itself? *Compared to existing similar products, not similar products, and the environment?* → **Which sensory aspects play a role in this?**
Try out	
Distinctiveness	How will the product convince when trying it out? *Compared to existing similar products, not similar products, and the environment?* → **Which sensory aspects play a role in this?**
Transport	
Product experiences	Which feedback will the product give during transport? → **Which sensory aspects play a role in this?**
Unwrapping	
Product experiences	Which lasting experiences will the product evoke → **Which sensory aspects play a role in this?**
Usage	
Functional use	Which interaction takes place in using the product? How does the product provide feedback? *What can disturb the interaction? What can intensify the interaction? What can disturb the feedback?* → **Which sensory aspects play a role in this?**
Rest	
Product experiences	How will the product convince to be used again? How will the product fit in its environment and with related products? How will the product say good bye? → **Which sensory aspects play a role in this?**

Table 3 *Sensorial attributes in the checklist*

Checklist with sensorial attributes		
Reflection	**Pressure**	**Sound**
reflective – not reflective	denting – not denting	muffled – ringing
glossy – matte	soft – hard	low – high pitch
transparent – opaque	fast – slow dampening	soft – loud
no brilliance – brilliance	massive – porous	
rough – smooth		**Smell and taste**
regular – irregular		natural odour – no
texture	**Force**	odour – fragrant
	stiff – flexible	fragrance
Colour	ductile – tough	flavour
hue of colour	brittle – tough	
one colour – many	light – heavy	
colours		**Temperature**
colourless – full colour		warm – cold
dark – light	**Friction**	
durable – changeable	sticky – not sticky	**Light radiation**
pattern	dry – wet – fat	low – high light
	rough – smooth	emission

EVALUATION

The next step in the development of the tools is to evaluate the usability of the tools in design brief meetings. The following topics will be studied.
The tools differ on the amount of visualisation that is required to use the method. The 'Pictures' tool is the most concrete of the three. Client and product designer can discuss about products with the help of concrete

examples. The client can directly react on the characteristics of these products and compare them with the product he has in mind. The 'Samples' tool requires more visualisations and mental translations than the first tool. The look and feel of the material samples needs to be translated to the new product via the sensorial features that the sample has. Explaining what you feel is difficult and the terminology of e.g. tactile aspects is limited. However, look and feel is an important factor when interacting with products. The 'Questions' tool requires the most visualisation of all three. Client and designer need to imagine all things they discuss. Product designers are used to understand subjective terms, to visualise them and to translate them into concrete product ideas. However, clients are not used to do that. The tools are designed to assist both product designers and clients, so they should help the client with visualising the things that they want. However, if the methods show examples that are very concrete, product designers can feel restricted in their creativity. They might feel that the tool directs them towards single solutions, which is unwanted. The tool should thus increase creativity by providing new directions and ideas, but should also help to converge to material features that can be used for materials searches. The questions that still remain are which of the tools is most effective in the design brief and how the tools affect the creativity of product designers.
The tools focus on different senses. The 'Pictures' tool focuses on visual attributes. This concerns mainly the tactile attributes that you can also see, like softness. The 'Samples' tool focuses on tactile attributes; it stimulates to feel the materials. Colour is even omitted so that it does not distract from feeling the materials. The 'Questions' tool focuses on all senses; although in different phases of the interaction other senses can be more important than others. For example in the first contact phase, more distance senses are used and in the trying out phase more proximate senses (Fenech and Borg, 2006). Whether a combination of tools is better to discuss all senses or that only using one tool is sufficient, still needs to be studied at this point.
The tools aim at creating a consensus between product designer and client about user-interaction aspects of materials. We expect that the tools create this consensus. An important question however is, whether the tools indeed lead to a consensus to such an extent that the product designer can start a materials search based on this consensus. We evaluated the tools in a fictive design brief situation to answer this question and the other questions that came forward in this section.

USABILITY STUDY IN DESIGN BRIEF

AIM AND METHODOLOGY

To understand the tools' achievements in design brief meetings we evaluated the tools in a real life setting. The desired achievements of the tools were a high certainty to start an effective materials search, to have a high consensus between client and product designer about the important sensorial attributes that create the desired experiences and to base the search on sensorial attributes of materials.
We invited professional product designers and professional clients to use the tools in design brief meetings for two fictive design assignments that we created. Furthermore, we invited students who either did or did not study at a product design education to do the same. The last group acted as clients. We could therefore not only evaluate the tools, but also compare the influence of the participant's experiences on the usability and achievements of the tools.
The questions that were studied are:

1. What do the tools achieve in the design briefs and how do they differ?
2. How usable are the tools for clients and product designers?
3. How do the tools influence the creativity of the product designers?

Procedure

The participants of the study used all three tools to be able to compare them. Furthermore, they used no specific tool to compare their own approaches with the created tools ('own method'). The participants discussed two different design assignments in product designer/ client couples. Per assignment two tools, or one tool and the own method, were used for ten to fifteen minutes. The order of the tools used was randomized. The total session took 2 hours. The first assignment was a cutlery set with an outdoor look for daily use. The second assignment was a product for a new concept based on the Polaroid camera, but than with moving pictures instead of stills. This assignment was termed 'Poloroid video'. The participating clients were provided with instructions about the assignments. Herein, a fictive company profile was given, as well as the problem definition and task for the designer.

Profiles

The consensus between client and product designers was measured at three different points, namely before and after the use of every tool. We surveyed the participants' ideas about the desired materials for the new product at these points. Two questions were asked per profile. First the participants were asked to indicate

their certainty about the product designer's ability to start an effective material search at that point. Second the participants were asked to describe the material aspects of the new product. After the three profiles the participants filled in an extra profile. On this profile they were asked to pick a maximum of five sensorial attributes that they think are important to base the materials search on. The profile mentioned the sensorial attributes (table 3).

Questionnaire

After the two design brief discussions the participants were asked to fill in a questionnaire. The aim of this questionnaire was to evaluate the different tools on usability and creativity topics.

RESULTS

The tools achieved an increased certainty about the ability to start a material search (table 4). However, the 'Samples' tool and 'Questions' tool are least effective in increasing the certainty. The 'Pictures' tool and the 'Questions' tool led to most consensuses between client and product designer. All created tools stimulate to define in terms of sensorial attributes. The 'Questions' tool leads to sensorial attributes mostly. The 'Pictures' and 'Samples' tools did stay on perceptual level in one third to one half of the cases, which needs to be improved to make it effective tools.

Table 4 Summary of the results

Aspect \ Score	**high**	**medium**	**low**
Increased certainty	Own method	Pictures	Samples and Questions
Consensus	Own method, Pictures and Questions	Samples	
Sensorial attributes	Questions	Pictures and Samples	Own method

In general we saw that the product designers were able to use the tools after reading the introduction. They adjusted the tools to their own approaches. For example, some product designers used the 'Pictures' tool to make categories of wanted and unwanted personalities together with the client (figure 3). Others made a selection before showing the cards. The 'Samples' tool invited to touch the samples and to explore them (figure 4). Some couples grouped the samples as well during the discussion.

The tools influence the creativity of the users; however, it is hard to say if the tools improve or restrict creativity of a person. We found a lot of variation in the participants' judgements about this issue. In general we found that professionals are stimulated in their creativity and students are restricted in their creativity. The 'Pictures' and 'Samples' tools score better on this issue than the 'Questions' tool.

Figure 3 Product designer and client grouped the pictures to define the desired personality aspects

Figure 4 The 'Samples' tool invites to touch and explore the desired material properties

RECOMMENDATIONS PER TOOL

At the end of the questionnaires, the participants were asked to note their recommendations for the tools. We summarize them per tool.

Pictures

Although the tool was generally very well understood and judged as usable and inspiring, the following adjustments can be made to improve the translation of personalities to sensorial attributes of materials. The backside of the card did offer translations of the personalities and pictures shown, but did not lead to describing the material profile in sensorial attributes. These backsides were not always used by the participants. More emphasize should be made on this side, for example by providing a checklist on which all the mentioned properties are presented. The product designer can than use this checklist to summarize the outcomes of the discussions. A simple checklist with the general sensorial attributes can also help, as not every designer agreed on the clues given on the backside of the cards.

Some participants advised to use only product examples and no personality terms, however, we recommend using the terms because they ease up the discussion, even when clients and designers do not agree on the terms.

Samples

The participants evaluated the 'Samples' with more variation than the other tools. It seems that using materials samples is more related to personal approaches than the other tools. In any case, the 'Samples' tool can be optimized by using the following suggestions. The samples help to select the kind of materials that are desired for the new product, but the discussions often ended with the selection with one or two samples. The purpose of the tool was in addition to look up the sensorial attributes that were represented in the sample to make a translation step. The samples

could be looked up in a card with all the samples on it. We suggest making the connection between the samples and information closer, for example by putting the information on the backside of the sample. The use of a checklist with sensorial attributes to sum up the discussions is also advised.
The samples that are now present in the set are not judged as very inspiring by the participants. Also some samples were missing in their opinion. We suggest to put effort in selecting a new set of samples with the same background ideas, namely to represent a wide variety of sensorial attributes, but to find more extreme samples. The material characteristics that the participants want to add are transparency differences, more plastics, soft materials, stone or ceramics, metals, fibres and gels.

Questions
Many participants judged the 'Questions' tool as less usable in its current form. However, the 'Questions' tool was mostly directing to sensorial attributes, compared to the other tools. We do not recommend to abandon the tool for this reason, but to improve it with the help of the following suggestions. The questions were now given as one list, but can be more effective when the phases are separated on different cards. The order of the phases can than be changed. Although it is still important to discuss all relevant phases, the discussions can follow a more natural sequence than with a pre-defined order of questions. The next suggestion is to add pictures of situations to the question cards. It is then easier to imagine the new product in the different phases. For example, the first contact phase can be illustrated by a picture of a shop. Some participants suggested using the 'Questions' tool at a later stage in the design process. We do not recommend that. As soon as the project objectives are defined, it is wise to consider the materials objectives as well. We do recommend that the product designer prepares him or herself by reformulating the questions before the actual meeting with the client.

RECOMMENDATIONS IN GENERAL

Combination of the tools
We expect that the tools can be improved by making a combined form. Although the participants prefer to use a combined form with the 'Pictures' and the 'Samples' tool, we expect that starting with the 'Questions' tool is the most beneficial. The 'Questions' tool was more directing to sensorial attributes than the other tools. In addition it led to a high number of similar properties to start a materials search on. The uncertainty caused by the 'Questions' tool can be reduced by using the 'Pictures' tool or 'Samples' tool to support the discussions per user-interaction phase of the 'Questions' tool. When the 'Pictures' and 'Samples' tool focus on different sensorial attributes, the tools can really add up to each other.
The results showed a wide variety in opinions about usability and creativity of the tools. Not only, did we find differences between professionals and students, and between clients and product designers, we also found differences within the groups. This means that one tool does not suit all. A combination of tools may meet the needs of more users; however, product designers should then be able to select and use only one part of the combined tool. The tool is than expected to be effective for different product designers, working with different clients and in different projects.

Material profiles in terms of sensorial attributes
As the results showed, not every tool directed to a material profile described as sensorial attributes. Although the tools aimed at translating perception terms into sensorial attributes, especially the 'Pictures' and 'Samples' tool led to material profiles described in perception terms. We expect that although client and product designer mention the same perception terms, they still might translate the terms differently into materials characteristics, which is unwanted. The 'Pictures' and 'Samples' tools seem thus to lack a clear translation step.
The 'Questions' tool resulted in a material profile in sensorial terms. In this tool the translation step was indicated by the last question for every discussed phase, namely "Which sensorial attributes play a role in this?" Furthermore a checklist of sensorial material aspects was provided to summarize the discussions. Although not every product designer used this checklist, it helped to direct the discussions to sensorial attributes. A similar translation step can make the 'Pictures' and 'Samples' tool more directing to sensorial attributes than they are now.

Professionals and students
Students and professionals differ in their experience with the execution of materials searches for design projects and the background of these projects. Students have almost no experience with projects for clients and with design brief meetings. Despite these differences, we expected that the tools were usable for both professionals and students. However, the results show that both groups react differently on the tools. Students have more difficulty with the tools than the professionals. The students find the tools more

restricting their creativity and have more trouble using them than professionals. Some students were very explicit in their disinterest in using the tools for future projects.

An explanation might be that students did not come across the problems in materials searches that the tools try to diminish. They therefore did not understand the effort needed to diminish these problems, and therefore were less willing to use the tools. Furthermore, Ahmed et al (2003) found that novice designers were less experienced with using design strategies, such as this tool requires. Based on the differences between students and professionals we chose one target group for the further developments of the tools, which will be the professional product designers.

CONCLUSIONS

Methods that support product designers and clients with defining the desired materials features on user-interaction aspects can prepare the product designer for his materials search. We presented three tools for the defining step in such a method. The tools were evaluated in design brief meetings with product designers and clients. The tools were effective in different ways. The 'Pictures' and 'Questions' tools led to a high consensus between product designer and clients and the 'Questions' tool did this by directing to sensorial attributes. Based on these sensorial attributes product designers can effectively start their materials searches. The 'Pictures' tool was very user-friendly and together with the 'Samples' tool they were stimulating creativity of client and product designer. The 'Questions' tool is not evaluated as user-friendly or promoting creativity by product designers in its current form.

To optimize the tools we suggest combining them so that the advantages of every tool can be used by product designers. With this combination they can focus on user-interaction aspects in the design brief discussions. In addition, we suggest emphasizing further developments on the converging step in the tools. Although the tools helped product designers with defining user-interaction aspects, they still translate only a low percentage of these aspects into sensorial attributes. Starting a materials search would thus still be difficult. However, when the tools are further developed, product designers can benefit from using the tools when searching for materials.

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