# Investigating the Haptic Aspects of Verbalised Product Experiences

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The human senses play an important role in people's understanding and experience of products. The overall aim of this explorative study was to further investigate users' haptic product experiences in respect of how they are verbalised and how they relate to visual product experiences. The pilot studies revealed an important result, showing the participants' difficulty in verbalising product experiences. A mediating tool was therefore introduced to trigger the information. The main results of the study are that haptic product experiences appeared to contribute to all experience dimensions, but especially those concerning the dimensions "interface qualities" and "objective/measurable". The results indicate that the information received from one sense created expectations for experiences through other senses and the information perceived through the second sense was used to confirm or modify anticipated experiences. The less prior knowledge participants had of the particular product, the more important the additional information delivered through the second sense appeared to be. Finally, haptic product experiences appeared to be related to a few haptic product properties, but more systematic studies need to be carried out to confirm these results and to identify the effect of the product properties on the intensity of different haptic product experiences.

***Keywords*** **–** Haptic Product Experiences, Visual Product Experiences, Product Properties, Product Design.

***Relevance to design practice*** **–** Haptics play an important role in people's experience of products. To address haptics in a systematic way in the design process, further knowledge is needed on what constitutes these experiences, how users describe them and how they relate, for example, to visual experiences.

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## Introduction

The human senses play an important role in people's understanding and experience of products. We see, hear, smell, and touch the artefacts around us in order to learn more about them, but also to experience the sensations per se. With an increasing emphasis on designing products that meet not only utilitarian, but also affective, epistemic and hedonic requirements, a growing interest has developed in sensory design or design which specifically takes the human senses into consideration (e.g., van Egmond, 2008; Cardello & Wise, 2008; Malnar & Vodvarka, 2004; Schifferstein & Desmet, 2008).

Vision has often been described as the most important, dominant sense, but recent studies indicate that the other senses are as important in the way we experience products, or even more important. For instance, a study by Schifferstein (2006) showed that the relative importance of different senses depends upon the type of product. While vision may be regarded as the most important sense in experiencing a lamp for example, smell may be the most important in experiencing a laundry detergent, and touch the more important sense in experiencing when watering a plant or using a kitchen utensil such as a whisk (Figure 1).

The recognition of the importance of touch, or rather the haptic sense, in people's interaction with and experience of products suggests that designers should address touch in a systematic way in the design process. A systematic approach depends, however, on fundamental knowledge of what constitutes

**Figure 1. We touch and through touching we experience and learn for example about different artefacts.**

the haptic product experience and access to methods and tools that can support the verbal elicitation of users' experiences and design requirements.

In regards to the first prerequisite, the research carried out by Gibson (1962), Lederman and Klatzky (1987), Klatzky, Lederman and Matula (1991) and Klatzky, Lederman and Matula (1993) provides an important basis for understanding how

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people explore products and the role of haptics in recognizing and judging the properties of objects such as their size, shape, texture and hardness. However, existing research does not address product experiences as such. Overall, the investigation of haptics focuses mostly on touch and texture. For example, Heller (1982) discusses the perception of texture through vision and touch. Hollins, Faldowski, Rao, & Young (1993) look at the perception of texture by touch only. Picard, Dacremont, Valentin, & Giboreau (2003) consider descriptions of tactile sensations of everyday textures from memory based on tactile stimulus. Picard (2006) examines vision and touch as perceptually equivalent for texture information. Bang (2007) discusses tactile and visual exploration of fabrics in order to investigate emotional utility values. Karlsson & Valverde (2007) investigate the relationship between surface structures and surface preferences. In addition, Peck and Childers (2003; 2006) investigate touch as a determinant for purchase and purchase decisions. However, studies specifically addressing haptic product experiences appear to be rare. An exception is a study by Schifferstein and Cleiren (2005), but the results presented concern the number of product details perceived and communicated by the participants, not the character of the experiences. Another exception is the work by Sonneveld (2007) who proposes a framework consisting of five domains based on users' descriptions of pleasant and unpleasant tactual experiences. It describes haptic product experiences in terms of movements, tactual properties, physical sensations, affective behaviour and 'gut feelings'.

In regards to the second prerequisite, to systematically address haptics in the design process, an interview study with representatives of product development companies identified a need for a better understanding of haptic product experiences, as well as for methods and tools to address haptics in product development and design (Isaksson, 2004). According to the interviewees, a problematic factor was consumers' inability to verbalise and thus communicate their requirements regarding product qualities perceived through the haptic sense, that is, "haptic product properties". A language was said to be lacking. Schifferstein and Hekkert (2008) later conclude that although haptic experiences are part of everyday life, people do not talk about these experiences and seem to lack a vocabulary to do so. An example of a tool developed to support the design process is Sensotact (Bouche & Crochemore, 2004), but the focus is touch and tactile properties rather than haptics. Sensotact does not take into account all experiences perceived by the tactile and kinaesthetic parts of haptics in a dynamic relation. Another tool is the Tactual Experience Guide (Sonneveld, 2007), which, it is argued, offers a structure to help guide users through the haptic experience. Overall, however, there is limited knowledge of the impact of haptics on people's product experiences and the methods and tools by which it can be addressed in product development.

Given this background, this exploratory study sought to investigate users' haptic product experiences and specifically their verbal descriptions of their haptic product experiences to help build a basis for a more structured approach to haptics in product design. Earlier studies propose that users lack a language to communicate haptic product requirements and experiences. As such, this study aimed to further investigate what characterises users' verbalisations of haptic product experiences. It asked whether users can describe their haptic experiences. If so, how they describe their haptic experiences and whether this differs from how they describe their visual experiences, or the combination of visual and haptic experiences.

The haptic sense is argued to play an important role in users' product experience. In developing further knowledge on the role played by the haptic sense in product experience, the study also considered the type of product experiences to which the haptic sense contributes. Are the product experiences the same across the senses (here visual and haptic) or are there differences? Do experiences change when information from one sensory channel is complemented by information from another, for instance, when seeing a product after being able to touch it only and vice versa?

Earlier research concludes that users can perceive and discriminate between different product properties, but do the properties play any part in user experience? Do users explain their haptic product experiences in terms of product properties? What product properties contribute to what experiences?

## Study Design

We addressed the questions through a study carried out in a controlled environment. We exposed participants to different products and allowed them to explore the products visually and haptically as well as to describe their experiences by means of adjectives.

### Participants

We recruited twenty participants for the study of whom 11 were women and 9 were men. Their ages ranged from 20 to 57 years (average age 39.7). The participants were recruited by an

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advertisement in a local newspaper with the intention of obtaining a theoretical representation of a consumer market. The specific selection was then defined by age only. The participants had to be 20, but no more than 60 years old, the reason being that the sensitivity of the skin decreases as one grows older (Harding, 2004).

## Selection of Products

The products used for the study were limited to four. We selected them according to three criteria: (i) products for which the haptic sense can be considered important; (ii) products representing different shapes and (iii) products that to a certain degree require different types of exploratory procedures (cf. Lederman, 1987) when explored and used. The four products chosen were a coffee mug, a telephone, a coffee pot and a hammer (see Figure 2).

**Figure 2. The coffee mug, telephone, hammer and coffee pot used in the study.**

Each product is handheld, with a size that allowed exploration behind the screen to be used in the study (see Figure 3). The results of Schifferstein's earlier study (2006) on the perceived importance of different sensory modalities in product usage influenced the selection of products.

**Figure 3. The setup where the participants could only touch the product, Part C.**

## Pilot Tests

We completed three pilot tests before deciding on the final product selection and testing set up and procedure. The pilot tests lead us to replace one product, but mainly influenced procedural changes in how to obtain the participants' experiences through verbalisation. In the pilot tests, a different coffee mug was used than the one shown in Figure 2. The original mug had to be replaced as it had such a strong brand identity, both visually and haptically, and the participants' interests focused on this issue instead of on the actual task.

It also became obvious that some procedural changes had to be made in response to participants' difficulty in spontaneously describing their visual and haptic experiences of the products. The participants mentioned a few words only during each part of the trial, mostly related to objective and measurable aspects, such as "heavy", "grey", "small", "plasticky", etc. The interpretation was that some kind of support was needed, since the experiences investigated were believed to concern more than these type of aspects. Support was found in the notion of "users' lack of a haptic language" as touched on by Isaksson (2004) and Schifferstein and Hekkert (2008), although it was not known to what extent.

## Data Collection

We collected data through verbal protocols, specifically by asking the participants to "think-aloud" during the trials and though short structured interviews, one after each of the three sub-sections (see Procedure). The verbal data were audio-recorded. Data were also collected through observations of the participants' behaviour when interacting with the products. The complete study was performed in Swedish with Swedish-speaking participants. The verbal information presented in the paper is therefore a translation from Swedish into English.

The procedure we chose was to firstly let the participants describe their experiences spontaneously and secondly through the use of adjectives. However, to ensure that more than objective and measurable aspects were considered, five "character traits", referred to as Experience Dimensions (EDs), were used as triggers or mediators. Similar procedures and tools have been developed, for instance, for evaluating the impression of architectural environments (Küller, 1975) and for obtaining semantic differences between characters of objects (Osgood, Suci, & Tannenbaum, 1957). We based the five EDs on a linguistic classification of adjectives proposed by Krippendorff (2005). This includes: "objective/measurable", "evaluative/aesthetic", "social status and positions", "emotional" and "interface quality". The different EDs were listed and their respective meanings explained to the participants using the example of a fire-extinguisher (see Figure 4). The list of EDs without illustrating adjectives was then used as a mediating tool during the trial.

In addition, we collected information on different "haptic product properties" (HPP) from the literature (Heller & Schiff, 1991; Klatzky & Lederman, 2003). Hubka and Eder (1988) define a property as any characteristic of a product that belongs to it and characterizes it; the desired properties are the most important aspects of a technical system (a product of human art

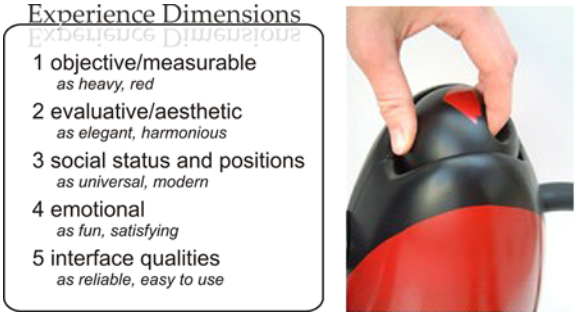


**Figure 4. A fire-extinguisher was used as an example.** Possible product experiences were described in terms of the adjectives "heavy, elegant, modern, fun, and simple to use".

and workmanship). We produced a list of such haptic product properties (nouns, not adjectives) and their associations to inform the participants on the issue of haptics, its definition and its possible relationship to a product's physical properties (see Table 1).

Furthermore, we created a matrix to support a structured elicitation and categorization of the information. The matrix, which was blank from the start, was used to help the participants relate the adjectives verbalised with specific product properties. The test leader listed the adjectives mentioned by the participant during the study to the left in the matrix. After each part of the trial, we asked the participants to explain what aspect(s) (i.e. haptic product properties) of the product they thought had produced the experience. Table 2 shows a fraction of such a matrix.

## Procedure

Each session followed the same procedure. We firstly introduced the participant to the purpose of the study, that is, to examine their respective experiences of a defined set of products. However, a specific human sense was not mentioned since the aim was to create as normal a situation as possible when the products were shown to the participants. Each trial consisted of three parts: A, B, C, each part repeated twice. All participants followed the sequence: A – B – A – B – C - C. Furthermore, all participants were exposed to all four products, but in random order. Table 3 illustrates the sequence of each trial (from top to bottom).

In **Part A**, we asked the participants to describe their perceived experiences when looking at the product in front of them. They were not allowed to touch it. Firstly, we asked them to spontaneously describe their experiences and only secondly to do so in terms of adjectives. All participants were at this stage given

**Table 1. The list of "haptic product properties" (HPP) used in the trials.**

| "HPP" | Associations |
|---|---|
| size | volume, dimensions, proportions |
| shape | configuration |
| border | contour |
| point | tip, peak |
| corner | crook |
| nook | cranny |
| protuberance | bulge |
| orientation | support for usage |
| balance | between parts, equilibrium |
| weight | mass, load |
| material | |
| resistance | in a button or hinge for example |
| stiffness | rigidity |
| structure | pattern, texture |
| resilience | flexibility |
| hardness | softness |
| temperature | |

**Table 2. Examples of adjectives mentioned by one participant and their relationship to HPP as suggested by the participant.** The adjectives were elicited during haptic exploration of the hammer.

| Adjectives | Haptic product properties (HPP) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Size | Shape | Contour | Weight | Structure | Temperature | Material |
| rubber(y) | | | | | x | | x |
| steel-like | | | | | | x | x |
| heavy | | | | x | | | |
| robust | x | x | | x | | | |
| balanced | | x | | x | | | |

**Table 3. The sequence A-B-A-B-C-C was followed by each participant, here participant 1, 2 and x, with product examples.** Participant 1 started with the mug, participant 2 started with the hammer, and so on.

| Type of exploration | | Participant 1 | Participant 2 | Participant x |
|---|---|---|---|---|
| A | Visual | Mug | Hammer | Pot |
| B | Visual and haptic | Mug | Hammer | Pot |
| A | Visual | Phone | Mug | Hammer |
| B | Visual and haptic | Phone | Mug | Hammer |
| C | Haptic | Hammer | Phone | Mug |
| C | Haptic | Pot | Pot | Phone |

a short introduction to what adjectives are and to the different categories (or EDs) including examples (see Figure 4). Lastly, they were encouraged to consider all EDs and to add additional adjectives if relevant.

In the initial phase of **Part B**, the participants were still only looking at the product, but were now asked to describe, in terms of adjectives, to anticipate their haptic experience when touching it. In this part they were also introduced to the concept of haptics. They were encouraged to repeat adjectives mentioned previously if they found them also to be important for the expected haptic experiences. Secondly, they could place their hands on the product and examine it without restraints. Again, they were asked to firstly spontaneously describe their experiences and then to do so in terms of adjectives. Part B ended with a request to the participants to relate and explain what specific haptic product properties constituted each adjective they mentioned. Here the matrix was used (see Table 2). The test leader asked for example: *"What haptic product properties contributed to your experience of "old-fashioned"?* We then repeated Parts A and B for a second product (e.g., the telephone) before moving on to Part C of the study. At this stage, the participants were asked to reflect on if and how they felt that their visual experiences harmonised with their haptic experiences, and additionally if the haptic experiences added anything to their visual experiences.

In **Part C**, the third product (e.g., the hammer) was introduced to the participants. They were initially only allowed to touch and explore the product behind the screen (see Figure 2). However, the participants were told in advance what kind of product they had to expect behind the screen as it was assumed that the participants might otherwise have spent time exploring the product in order to determine the object as such, rather than considering their experiences of interacting with it. Once the participants had placed their hands on the product they were encouraged to describe their experiences, firstly spontaneously, then to do so using adjectives. In this part of the trial, we also asked the participants to relate their experiences (i.e. the adjectives verbalised) to specific 'haptic product properties'. Finally, they could look at the product and reflect upon whether its visual appearance was what they had expected or not. Part C was then repeated for the fourth and last product (e.g., the coffee pot) to be evaluated.

Part A/B was designed to reflect the way people normally interact with artefacts in daily life, as well as not to focus on the haptic sense specifically from the start. Part C was added in order to investigate the participants' haptic experiences without interference from visual impressions.

### Analysis

The audio recordings from the sessions were examined, transcribed and the content analysed. Each single adjective mentioned by the participants was written down, synonyms, but not repeated adjectives counted (i.e. a verbalisation "smooth, soft" counted as two adjectives while "smooth, smooth" counted as one). The main author then classified the adjectives according to the structure proposed by the EDs. Table 4 shows a sample of the analysis.

To verify the classification, a sample of approximately 10 % of the total number of adjectives verbalised by the participants was handed out to five different reviewers with instructions to classify the adjectives according to the EDs. The reviewers also received the definitions of the separate EDs. The overall agreement between the main author's and the reviewers' classifications was approximately 90%. Regarding the remaining 10%, a consensus decision was taken in collaboration between the main author and the reviewer(s) before the final categorisation was made. Student's t-test was used to test if there were any significant differences between the EDs in terms of number of adjectives.

Finally, the verbal statements, gathered in the structured interview completed after each part of the test, were compiled and compared across participants and products to identify similarities and differences.

## Results and Analysis

The section is structured as follows. Initially, an overview of the results is provided. The results are then elaborated according to the setup of the study (i.e. Parts A-B-C). In the final section, we present additional results that reflect on the study as a whole.

### Verbalisations of Experiences

The total number of adjectives elicited in the 20 sessions was 788. Table 5 provides an excerpt of the most frequently verbalised adjectives.

According to the categorisation made in the analysis, the participants verbalised more adjectives describing their haptic experiences compared to those describing their visual experience only, their expectations of haptic experiences, or describing the combination of visual and haptic experiences (see Figure 5). The lowest numbers of adjectives mentioned were those describing the participants' expectations of haptic experiences. An explanation provided by the participants was that: "*It feels like I have already mentioned so many* of *the adjectives*" (referring to the visual exploration in Part A).

**Table 4. A few examples of adjectives mentioned by the participants and their subsequent classification by the author according to the EDs.**

| Examples of adjectives | Classification according to the EDs |
|---|---|
| stable, smooth, round, fragile, robust | Objective |
| ugly, proportional, balanced, elegant, beautiful | evaluative and aesthetic |
| relaxing, safe, nice, boring, inviting | emotional |
| old-fashioned, cheap, classic | social status |
| difficult to clean and/or use, explicit, comfortable | interface qualities |

## Visual Experiences (Part A)

Figure 6 illustrates the distribution of adjectives used to describe the participants' visual experiences according to the EDs. The results show a fairly homogenous distribution of adjectives according to the different types of EDs with a slight emphasis on adjectives describing "social values" (for example "cheap", "masculine", "modern", "neutral", and "ordinary") and "interface qualities" (for example "useful", "comfortable", "intelligible", "sustainable" and "obvious"). However, no statistical difference was found.

**Table 5. An excerpt of the most frequently mentioned adjectives, per product and study phase.** The adjectives are presented in alphabetical order.

| Product | Adjectives verbalised during visual exploration | Adjectives verbalised during visual/haptic co-exploration | Adjectives verbalised during haptic exploration |
|---|---|---|---|
| coffee/tea pot | balanced | comfortable | Accessible |
| | boring | functional | Boring |
| | cheap | mass-produced | Cheap |
| | elegant | robust | Disgusting |
| | durable | "plasticky" | Graspable |
| | male | stable | Light |
| | modern | | Modern |
| | practical | | "plasticky" |
| | public | | Simple |
| | ugly | | Stable |
| hammer | adapted | comfortable | Accessible |
| | boring | heavy | Classic |
| | dangerous | mass-produced | Heavy |
| | explicit | rubbery | "girly" |
| | functional | surgical | Graspable |
| | male | soft | impractical |
| | reliable | unbalanced | Ordinary |
| | simple | unergonomic | Simple |
| | standard | | Robust |
| | practical | | understandable |
| mug | beautiful | inviting | Boring |
| | boring | neutral | Cold |
| | comfortable | robust | comfortable |
| | elegant | simple | Classic |
| | explicit | usable | Heavy |
| | durable | | Satisfying |
| | light | | Smooth |
| | ordinary | | Soft |
| | uninviting | | Stable |
| | usable | | unbalanced |
| telephone | boring | comfortable | complicated |
| | classic | clumsy | Clumsy |
| | clumsy | heavy | Heavy |
| | evident | explicit | Nostalgic |
| | functional | unpractical | old-fashioned |
| | important | stable | Relaxing |
| | old-fashioned | warm | Reliable |
| | safe | | Safe |
| | simple | | Slow |
| | standard | | Ugly |

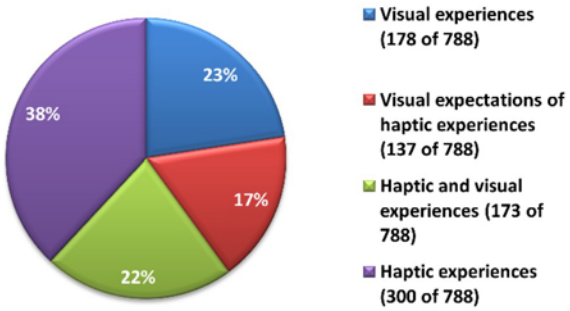


**Figure 5. Distribution of adjectives collected during all different stages.**

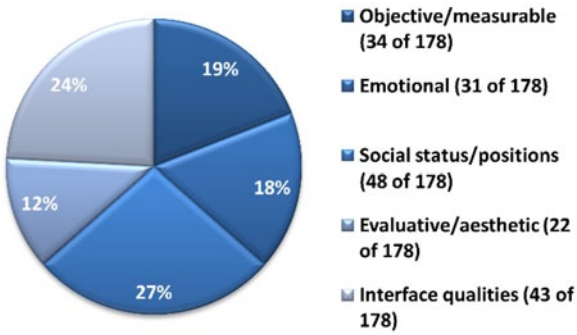


**Figure 6. Distribution of the adjectives used to describe the visual experiences during Part A.**

## Visual Expectations of Haptic Experiences and Simultaneous Visual and Haptic Experiences (Part B)

When the participants were asked about their *anticipated* haptic experiences, the distribution of the adjectives changed noticeably. Seventy-four of the adjectives now verbalised (or 54% compared to 19% for visual exploration) were categorised as "objective and measurable" and 41 adjectives (or 30% compared to 24% for visual exploration) were classified as referring to "interface qualities". Only 7 adjectives (or 5% compared to 12% for visual exploration) were classified as referring to "evaluative and aesthetic" aspects, 7 as "social values/positions" (or 5% compared to 28% for visual exploration) and 8 as referring to "emotional" (or 6% compared to 17% for visual exploration). This result was despite all participants being encouraged to elaborate and add further adjectives in this part of the session.

When the participants were allowed to explore the product haptically, the shift described above was further emphasised (see Figure 7). Some adjectives mentioned were unique to the visual-haptic co-exploration (e.g., "square", "warm"), but a number of the adjectives mentioned were the same as those generated in earlier parts of the test, that is, adjectives describing the visual impression of the product were repeated in order to describe the haptic impression. Many adjectives were used to confirm, but also to modify previous impressions. For instance, a participant who had described the product as "light" would now state that it was "lighter" (than expected). Approximately 1/6 of the adjectives could be described as such *modifiers*.

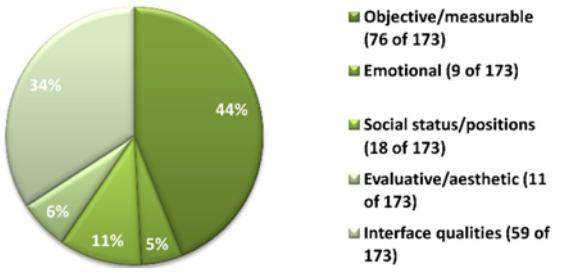


**Figure 7. Distribution of adjectives chosen to describe the visual and haptic experiences, Part B.**

## Haptic Experiences (Part C)

Figure 8 summarises the distribution of adjectives elicited based on haptic exploration only. Some adjectives were unique to the haptic sense (e.g., "cold", "heavy", "smooth"), but it was noted that the participants used adjectives to describe an impression that can only be experienced visually also to describe their haptic experiences (e.g., "glossy" to describe "smooth").

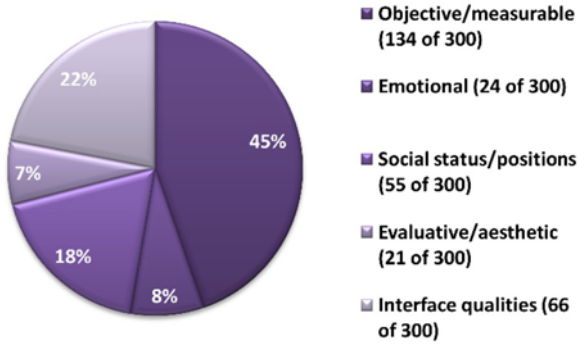


**Figure 8. Distribution of the adjectives chosen to describe the haptic experiences, Part C.**

Categorised according to the five EDs, the distribution of adjectives during the haptic exploration (Part C) did not differ from the distribution of adjectives elicited during the visual exploration (Parts A/B) of the test with one exception (Figure 9). A large proportion of the adjectives, almost half, was categorised as referring to "objective and measurable" aspects (e.g., "heavy", "cold", "robust", "plasticky", "stable", "curly", "rough" and "small"). In addition, the adjectives used to describe the haptic experiences tended to be very detailed, explaining, for example, how parts and material features were correlated, compared to the adjectives used to describe visual experiences.

The only statistically significant difference between the number of adjectives elicited during visual and haptic exploration respectively concerned the objective/measureable ED ($p$=0.012).

## Comparison Across Products and Experience Dimensions

Table 6 illustrates the distribution of adjectives elicited during the visual and haptic exploration respectively, per ED and per

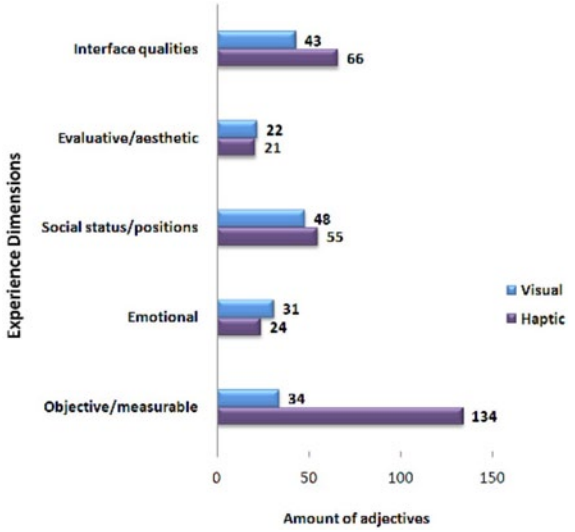


**Figure 9. Comparison of results for haptic and visual experiences for each ED.**

product. The differences in output between the visual and haptic conditions are consistent across the products, with the exception of one artefact, the telephone, which was an older type of stationary phone. All participants became somewhat sentimental when responding to this object. They could easily describe how they had used it and how it felt to use it, referring to its interface qualities. It was also noticed that a saturation level was quickly reached in terms of number of adjectives. Overall, it appeared that the more familiar the product in front of the participants, the less energy they used to describe it.

## Experiences and Product Properties

During the sessions, the participants were asked to try to relate the different adjectives they had used to describe their haptic explorations to specified haptic product properties in a matrix. According to the results, a particular adjective was sometimes related to one property, but very often to several properties. For example, one of the participants said they experienced the coffee pot as "graspable" because of its shape *and* its size. Overall, the property "shape" was the most frequently mentioned, followed by "size" and "weight" (see Table 7). Other listed properties were mentioned more occasionally.

## Additional Reflections

After completing the different parts of the test and towards the very end of the trial, the participants were asked to reflect on the different ways of confronting the products (visually and haptically), as well as how these added to their experiences. Table 8 presents some of the comments.

Several participants believed it was easier to gain a complete picture of the product when firstly just looking at it. They

**Table 6. Comparison across products and experience dimensions for visual (V) and haptic (H) experiences.**

| | *Hammer* | | *Mug* | | *Pot* | | *Telephone* | |
|---|---|---|---|---|---|---|---|---|
| | H | V | H | V | H | V | H | V |
| **Objective/measurable** | 38 | 7 | 43 | 9 | 33 | 12 | 20 | 6 |
| **Emotional** | 2 | 5 | 10 | 6 | 6 | 10 | 6 | 10 |
| **Social status** | 12 | 18 | 14 | 9 | 16 | 10 | 13 | 11 |
| **Evaluative/aesthetic** | 3 | 3 | 5 | 7 | 8 | 3 | 5 | 9 |
| **Interface qualities** | 16 | 13 | 10 | 9 | 30 | 5 | 10 | 16 |

**Table 7. Examples of adjectives mentioned by the participants and their proposed relation to certain haptic product properties.**

| Haptic product property (HPP) | Number of times the property was mentioned | Adjective describing haptic product experience |
|---|---|---|
| **shape** | 172 | beautiful, comfortable, heavy, stable, graspable |
| **size** | 105 | robust, big, ugly, graspable |
| **weight** | 81 | different, robust, nice |
| **material** | 80 | comfortable, stable, boring |
| **structure** | 52 | rough, simple, cheap |
| **temperature** | 40 | colour(full), cold, warm, |
| **balance** | 30 | heavy, unbalanced, modern |

**Table 8. Participants' comments on additional experiences from the visual and haptic senses.**

| What did the visual experience add to the haptic experience? | What did the haptic experience add to the visual experience? |
|---|---|
| - I thought it was a completely different colour! | - It feels good to touch it after just seeing it, you can verify if your presumptions were right or not. |
| - It looks much prettier than I thought. | - It gives you a more precise feeling of its weight, graspability etc. |
| - As expected, nothing there that surprised me. | - I was too familiar with this product so touching it did not add anything further. |

appeared to have more faith in their vision and thought they could rely on their previous knowledge of what the products would feel like when touched. Other participants thought that exploring the product first by touch was the better option, as they believed they were otherwise too influenced by their visual impressions.

If they first looked at the products and then touched them, almost all participants claimed that touching added something to their visual experience. Either the participants were surprised or their expectations were confirmed. For instance, fifty percent of the participants commented that their experience of the hammer's weight and balance changed when they touched it after only seeing it. Furthermore, in Part A of the test many participants described the coffee pot as having a certain heaviness, but also being easy to use and pour. When they were allowed to touch it and explore it haptically, most of them commented immediately on how light the pot felt even though it was still very convenient to handle. The coffee pot was also considered visually quite ugly and cheap-looking by most of the participants, but it felt very practical as soon as they touched and interacted with it. Comments on the tea/coffee mug split the participants into two groups: one group thought that the second sense added something to the experience and the other did not. Many participants thought that the mug looked expensive, but felt cheaper. Others thought it was lighter and more comfortable to hold than expected. Almost all participants said they were too familiar with the telephone to talk about it and describe it freely. They nevertheless mentioned quite a large number of adjectives, but then related to the EDs "emotional", "evaluative and aesthetic" and "social values/ positions".

If the participants first explored the products haptically and were then allowed to see what they had been touching, the results were slightly different. Overall, most participants were more satisfied with their initial haptic experiences and did not seem to have the same need to add to, or modify their initial descriptions as when they explored the object first visually and secondly haptically. There were some typical comments and modifications. For example, when allowed to see the products, their colours surprised the participants. One third of the participants had imagined the coffee pot to be red, not black, when touching it, although they knew it is impossible to "feel" a colour. One of the participants who described the pot as red attributed the experience to the surface temperature. Other aspects observed were the product's brand and field of application, as well as details of the product's shape. One participant said, "Now I understand the purpose of the shape. It is very functional, but I found it a bit odd". Finally, when allowed to see the products, the participants added comments about whether the products were visually aesthetically pleasing. Such judgments were not made based on the information received, but by the haptic sense only.

# Discussion

## A Haptic Product Language

We initially assumed that people would have difficulty expressing requirements for haptic product qualities and further that a language is lacking for this (Isaksson, 2005; Hekkert & Schifferstein, 2008). These assumptions found support in the pilot study, which indicated a need to prompt the participants for them to be able to verbalise their haptic product experiences. The need for prompting also related to verbalising visual experiences. The explanation may thus not be an incapability to describe haptic experiences as such, but rather that many users may not reflect actively on these issues. For this reason, the EDs were introduced as a mediating tool. However, as well as offering support, such a tool could restrict or direct the participants in a certain, not desired, direction.

The result of the study is evidently the consequence of the study design, including the choice of procedure, the decision to introduce the EDs and the choice of products. The effects of the mediating tool was anticipated and desired. A comparison between the results from the pilot studies and the main study shows that the type of verbalised experiences changed from a very narrow focus on "objective/measurable" to include other EDs. The specific adjectives used to initially explain the different EDs may have triggered the participants to mention a certain type of experience. However, we did not consider providing no adjectives to explain the EDs as an alternative. Instead, the study design tried to reduce any negative effects by choosing, as an example, an uncommon product with no similarity to the ones used in the study; by mentioning only two adjectives per ED so any effect that they may have had on the number of experiences mentioned per ED should be balanced; by presenting the EDs without explanations during the sessions; and by always first urging the participants to spontaneously describe their experiences before reminding them of the EDs. Any effects on the specific adjectives mentioned is considered minor; the adjectives actually verbalised were by no means limited to the adjectives used as examples, or their synonyms. The analysis did not consider the specific adjectives per se, only the category and number of adjectives per ED. Instead, we believe the type of products chosen played a more important role in the type of experiences verbalised. The products included in the test were everyday consumer products used to accomplish everyday tasks. The telephone resulted in a slightly different pattern of experiences compared to the other products. It is possible that if the products used had been, for instance, a teddy bear or a gun, the experiences would have had another character.

The initial supposition found further confirmation in that the participants, when describing haptic product experiences, sometimes used adjectives that referred to 'visual experiences'. This may reflect a lack of a language, or a lack of a specific terminology, but it may also be a result of the visual sense instructing the haptic sense when both are present. Sight has been claimed to direct exploratory behaviour for the other senses (Heller, 1982; Klatzky, 1993). The visual sense is most often described as the dominant one, sight having the possibility of perceiving information from a distance unlike the haptic sense, which requires proximity to the environment or object (e.g., Karlsson, 1999; Blücher & Graninger, 2002). If, as a consequence, the vocabulary describing visual impressions is more advanced than that describing haptic impression, a haptic impression of "smooth" may well be described as "glossy".

At the same time, the study contradicted our initial assumption in that the participants, when prompted, verbalised their haptic experiences. In fact, the number of adjectives generated to describe these experiences exceeded that of the visual experiences. The number could be the result of the procedure followed, during which comparatively more time may have been spent on eliciting haptic product experiences. However, the documentation indicates the opposite, more time being spent on verbalising visual experiences. Another interpretation is therefore that the participants thought that the visual experiences were more obvious to the test leader than the haptic experiences, that is, the test leader saw what they saw, but did not feel what they felt, for which reason they did not have to communicate their visual experiences to the same degree as their haptic. For example, the participants who in Part A visually explored the coffee pot did not mention its metal lid even though the visual cue was quite evident, whereas the participants exploring it haptically in Part C of the trial did so. Whatever the case, based on the result, it can be assumed that users can verbalise their haptic product experiences, if provided with the necessary support.

## Characteristics of Verbalised Haptic Product Experiences

One of the questions posed concerned the characteristics of users' haptic product experiences. According to the results of the study, the haptic sense contributed to all five types of EDs (cf. Krippendorff, 2005), but so did the visual sense. However, the haptic experiences were to a higher degree classified as related to "interface qualities" and, in particular, to "objective/measureable" experience dimensions. Again, the procedure followed could provide an explanation here. All participants completed the first part of the trial according to the order (1) watch, then (2) touch. Having initially described their visual experiences, they could have been more eager to describe their "new" experiences, which could have been experiences related to these EDs specifically. On the other hand, the sequential order, which meant that the participants shifted to haptically exploring a completely new product during the last part of the trial, should have compensated for such an effect. The interpretation is instead that the haptic experiences were, indeed, dominated by experiences in terms of "interface qualities" and "objective/measurable" aspects given the presented products. Earlier studies identify such differences in the way people verbalise sensory information and talk about sensory experiences. For instance, in a study on fabrics, participants who touched different fabrics without seeing them were more likely to describe their experiences focusing on texture, fibre content, fabric characteristics and weight, whereas participants who touched and saw the fabrics were more likely to use terms related to end use, appearance and fabric name (Burns, Chandler, Brown, Cameron, & Dallas, 1995).

## Interdependencies between Senses

The study illustrated the interdependence between the senses when the participants described the assumptions they made regarding the products' haptic product properties by visual exploration and vice versa. For instance, visual impressions resulted in anticipations for haptic impressions regarding a product's weight and structure. The haptic impressions, on the other hand, created anticipation of a product's colour for example. The information received through one of the senses thus appeared to create an internal representation, or mental imagery of the product that included properties referring to another sense. Katz and Krueger (1989), Kosslyn (1994), Klatzky (1993) and Reisberg (1992) have also found such interdependence between haptic and visual imagery.

When the participants were allowed to add the second sense, whether visual or haptic, the information received from the second sense seemed to be used in particular to confirm or modify the anticipation created by the first. The less familiar the participants were with the product, the higher the uncertainty regarding the expected experiences and the more important confirmation through the second sense appeared to be. Gibson (1962) demonstrates this urge to reach an understanding of an unknown object and the role that different human senses may play in this exploration. His studies found that when people encounter an unknown object, they instinctively try to determine its identity and its potential usefulness. This may be an explanation for the participants' apparent need for confirming information. However, it appeared that the information sought was primarily instrumental in its character, i.e. goal-driven evaluative rather than autotelic, i.e. hedonic-driven response seeking (cf. for example McClelland, Koestner, & Weinberger, 1989; Peck and Childers, 2003). This may further explain the relatively high number of adjectives related to the "objective and measurable" ED. At the same time, Klatzky (1993) proposes that an individual recognises a product; this recognition may trigger the retrieval of information about its properties stored in memory, which may suffice in a situation where information from one sense is lacking. This was evident in the instance of participants recognising the telephone.

Overall, anticipation and confirmation or modification of impressions appears to play an important part in product experiences. For instance, as soon as the participants picked up the coffee/tea pot they commented on the lightness of its weight compared to their expectation. The estimation of the weight based on visual exploration was thus not confirmed, but rather modified by the haptic experience, the incongruence between the senses resulting in some surprise. Ludden (2006) and Ludden and Schifferstein (2007), for example, investigate congruence and incongruence between the information provided by different senses. According to Ludden (2006), congruence, but even more so incongruence between senses may result in positive product experiences. However, it may also result in negative experiences, depending on the type of product and incongruity between which senses. Visual–tactual incongruities may be a particularly effective strategy, but incongruities between other senses may not (ibid). The study presented here did not investigate whether the participants' experiences were positive or negative. The results here emphasize the need for further research on how the different senses work together when people evaluate products, as well as the importance for designers to consider congruence and incongruence between haptic and visual product experiences.

### Product Expressions

Anticipation or expectation of sensory information is created for example by earlier product experiences (Ludden, 2006). However, a complementary explanation may be found in product semantics (Monö, 1997; Wikström, 2002) and the notion that a product, through its Gestalt, expresses certain qualities, properties or features. Using Karjalainen's terminology of explicit and implicit design features (Karjalainen, 2004), it appears necessary from a sensory point of view to differentiate between sense-explicit and sense-implicit features. For instance, if there is a red, ball-shaped product, the round shape is explicit for both senses. The weight of the ball is, on the other hand, perceptible by the haptic sense only although, its colour is perceptible only by the visual sense. The weight of the product can also be experienced by the visual sense, but in this case it is implicit and communicated through certain visual design cues. For instance, the coffee/tea pot used in the study was described as "heavy". It could be claimed to express certain heaviness where the attribute "heavy" is generated by the configuration of colour, shape and material. The conic form shape of the pot with a wide bottom and smaller neck (see Figure 2) indicates that it has a low weight in relation to its horizontal dimensions, making it appear as stable and safe. In addition, the metallic details of the pot could suggest an inner shell of metal although there is, in fact, no such metal shell. Furthermore, the black colour could be a factor further contributing to the expression of "heaviness". These explicit and implicit features could help explain the difficulty for the participants discriminating between and describing by sense-specific adjectives the information retrieved through the different senses.

### Experiences and Product Properties

Finally, the study made an attempt to allow the participants to link their haptic experiences described by adjectives to specific haptic product properties. Establishing such a relationship is fundamental to product design. According to the results, roughly the same haptic properties seemed to be important across products and across participants. The most frequently mentioned product properties concerned the geometry of the product, that is, its shape and its size. Weight and material were also considered important, as was surface texture, but less so than expected given the substantial research on touch and texture (e.g., Bouche & Crochemore, 2004; Klatzky & Lederman, 2003). Indeed, it is possible that haptic product experiences have their origin in the mentioned basic product properties. This would imply that the properties that people discriminate the best, such as surface texture, may not necessarily be the most important ones to consider when designing a product to elicit a certain experience. More fundamental studies need to be completed to determine the origin of haptic experiences for other types of products. For instance, it may be that tactile qualities and surface textures play a more important role in the experiences of larger products and products with larger surfaces. Furthermore, many of the verbalised experiences appeared to be based on integrated perceptions of different product properties rather than individual ones. Future studies need to investigate whether or not a change in a single product property, for example in a product's shape or weight or texture, results in different experiences. The interaction effects between different properties also need further investigation.

## Conclusions and Implications

The overall aim of the study was to further investigate users' verbal descriptions of their haptic product experiences, more specifically how people describe these experiences and how they relate to visual product experiences.

A key issue was whether users can describe their haptic experiences. The findings from the pilot and the main studies imply that people can verbalise their haptic product experiences. Analysed from a quantitative perspective, the participants used twice as many adjectives to describe their haptic experiences compared to the number they used to describe their visual experiences. However, the study also showed that some type of mediating tool may be necessary to trigger the information. This leads to a need for the development of methods and tools to elicit users' haptic requirements in products and to evaluate a product's "haptic design". The mediating tool used in the study may be a possible option or at least a first attempt. If product development companies explore their existing products through the approach used in this study, it could provide them with a custom "haptic dictionary". Such a dictionary could, for instance, provide a basis for formulating haptic requirements for new products.

A second set of questions concerned the terms people use to describe their haptic experiences and whether this differs from how they describe their visual experiences, or the combination of visual and haptic experiences. The users described their experiences in terms of a large number of adjectives. Some adjectives mentioned were unique to each sense, but a number of the adjectives mentioned were the same; adjectives describing the visual impression of the product were repeated to describe the haptic impression and so forth. Classified in terms of the experience dimensions chosen as a basis for the study, the users' haptic product experiences concerned all experience dimensions: "objective/measurable", "emotional", "social status", "evaluative/aesthetic" and "interface qualities". The primary one, however, was the dimension "objective/measurable". The only statistical difference between the described visual and haptic experiences concerned this dimension.

Do experiences change when information from one sensory channel is complemented by information from another, for instance, when seeing a product after being able to touch it only and vice versa? The results of this study demonstrate the interdependence between the senses. In the study, information received through one sense created certain expectations for experiences through another sense and the participants searched for information from the second sense to further understand what they perceived from the first. Thus, the information perceived through the second sense was used to confirm, explain, but also to modify anticipated experiences. The less knowledge the participant had of a particular product, the more important the additional information appeared

to be. The congruence or incongruence between the senses may result in an overall positive or negative product experience. It is evident through this study, as well as earlier studies, that product designers must address this issue in a systematic way. To provide the necessary support, however, more fundamental knowledge must be developed on the role played by the individual sense in people's product experiences, as well as on the interdependence between the senses.

Finally, can users explain their haptic product experiences in terms of product properties? What product properties contribute to what experiences? Based on the result of the study, haptic product experiences appear to be related to a few haptic product properties (shape, weight, material, structure, temperature and balance), most often to an interplay between several of these properties. Furthermore, the study implies that the product properties that people are most adept in perceiving and discriminating between may not necessarily be the most important ones to consider when designing a product to elicit a certain experience. To guide product design work, more systematic studies need to be carried out to identify the actual effects of basic product properties such as weight or size on people's haptic product experiences, as well as any interaction effects between different product properties.

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