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MAPPING HAPTIC PROPERTIES IN PRODUCT DEVELOPMENT WORK

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1. Introduction

By investigating a physical object with our hands, we can perceive the nature of its surface as a three-dimensional and tangible form. In industrial design work it is important to encompass all five senses, according to Monö [1997], in order to receive a complete impression of a product; for example car interiors should have an appropriate smell, and handling the gear stick should feel precise. He also notes that the user receive a message from what the senses perceive. For example, a solid steady form gives the impression of being heavy to lift. A product that expresses high quality visually can seem confusing if it does not express the same meaning to all of the other senses. All of these statements support the assumption that it is important to have congruence between the senses. The perception of a product could otherwise be misleading and the total impression of the product can fail.

Most previous research has focused on visual product properties; however, this study concentrates on haptic product properties. Haptic means relating to or based on the sense of touch, see *http://www.m-w.com/cgi-bin/dictionary*. Revesz [1950] describes it further as an active and exploring touch, in which the skin, muscles and joints function together to obtain information. It is the sense of product form, size, texture, weight, and temperature, for example; in more complex products or interfaces, it is resistance, vibration, force, and friction. It is also useful to know that when a person tries to connect details and form an impression of an overall object, visualisation will organise the haptic information [Carterette and Friedman 1978]. This statement brings us back to the importance of congruence between the senses.

1.1 Related research

Although *haptics* is a relatively new concept in research on product design and development, it can be found in related branches of research. In human-computer interaction haptics is used mostly in virtual environments where haptic technology allows interaction with computer systems; examples include surgical training, land mine clearance training, interfaces for blind people and collaborative haptics. The technology they use can be finger based, hand based and even whole-body based force reflective systems [Stone 2001]. Other hand-and-finger-based haptic devices, which reflect perceptions such as force feedback and vibration, can be found in driver environments. The purpose of these is to utilise other senses besides vision in already overloaded visual environments. These are meant to guide the driver in using driver systems information. An evaluation study conducted by Isaksson et al. [2003] showed that consistency between visual and haptic information in this kind of system is crucial. Research was done in psychology and psychophysics on haptic exploratory procedures by hand [Klatzky 1993], and these procedures were examined in relation to consumer products [Peck 1999].

1.2 Aim of the study

The aim of the empirical study is to map the awareness and knowledge of haptic product properties in today's product development (PD) work, during the early phases of consumer PD. Since the study of these properties in PD research is an unusual and relatively new topic, it is important to examine the present situation: some awareness and knowledge may already exist as tacit knowledge. The general aim is broken down into three specific objectives:

- To map the level of awareness and knowledge of haptic properties in the PD work;
- To find out who is working with haptic product properties, or is at least aware of them; and
- To examine the need of support in this area.

1.3 Frame of reference

Haptics is an *umbrella term,* see Table 1, which covers manual exploration by people and products or machines and the interaction between them. Its function consists of acquiring knowledge of the material world and checking the correctness of the visual impressions, see Figure 1.

Table 1. Definition of haptics: adapted from Oakley et al. [2000]

The components of Haptics	
Tactile	Pertaining to the cutaneous sense of touch, specifically to the sensation of pressure rather than temperature and pain
Kinaesthetic	The feeling of motion, relating to sensations in muscles, tendons and joints
Cutaneous	Related to the skin as a sense organ, including sensations of pressure, temperature and pain
Proprioceptive	Relating to the sensory information about the position and state of the body (includes cutaneous, kinaesthetic and vestibular nerve sensations)
Force Feedback	A mechanical production of kinaesthetic information sensed by the human

Figure 1. The human haptic sense in interaction with products or systems

1.3.1 Haptics in product design

Monö [1997] states that our haptic experiences are affected to a large degree by our visual experience of products and environments, and this has also been confirmed [Carterette and Friedman 1978]. The haptic sense can replace the visual sense if needed. For example; a dash-board can be designed in a way so that knobs, levers etc. can be located and handled without looking at them. In this kind of interior the kinaesthetic sense guides the user to positions, directions etc. The designer uses several haptic product properties to achieve the intended design.

1.3.2 Haptic product properties

The haptic product properties listed below were used as the basis of this empirical study.

Surface texture – the external structure of a material or an object
Form – the three-dimensional configuration of a product
Weight – the weight of a handheld product
Size – the actual size of a product or a part of a product or system
Grip span – the entire span from grasping a product with the whole hand to grasping a pair of tweezers
Force and resistance – the force a user has to apply to overcome resistance, in knobs, levers, and doors for example
Mechanically and electro mechanically reproduced forces – as above, but mechanically and electro mechanically reproduced, for example vibration in a cell phone

The properties above are components of the two more complex properties below.
Emotional impression – the intended feeling or message a company wants to convey with their product
The use – emphasises manipulating a product by the whole body, arm, hand or fingers, i.e. perceiving a correct visual and haptic message of how to handle a technical function.

2. Method

Six companies of varying size and product complexity have participated in the empirical study. The sizes of the companies are based on the place of work, not the whole group or trust. There were three workplaces with more than 500 employees and three smaller ones with fewer than 500 employees. All of the companies develop consumer products, from handheld products to entire vehicles. The larger companies had industrial design competence in-house, while the smaller ones consulted external industrial designers.

2.1 Interview study

Brief interviews were conducted with managers and project managers. The aim was to select people who had some idea of the work with haptic product properties or had similar tasks in their PD work. An effort was made to have a mixture of occupational groups within each company or at least in the study. A requirement was that the interviewees should have recently finished or be near the conclusion of a project. The fourteen participating interviewees were three engineering designers with skills in ergonomics (both cognitive and physical) referred to as ergonomists in the text, three industrial designers (IDs) and eight engineering designers (EDs). They had experience of product development work ranging from two up to 25 years. Semi-structured interviews, approximately one hour in length, based on Kvale [1997], were conducted with these people. The interviews were documented and recorded for additional analyses.

2.1.1 The main parts of the interview study

The interview study began with a discussion of the meaning of the term haptics. After a brief introduction to the topic of this study the interviewees were given a more thorough introduction to the concept haptic product properties. Thereafter, they were asked to relate the concept to their daily work. In accordance with the interviewees' level of awareness and knowledge, of the haptic product properties were they discussed, one by one, and related to their daily work (1.3.2). Throughout, and at the end of the interviews, the need of support was discussed and documented. The most essential part of the empirical study was: to find out what they already knew about haptic concepts, haptic product properties, and their relation to their work in progress.

3. Results

The results of the interview study are greatly influenced by the interviewees' level of awareness and knowledge of haptic product properties. A few of the interviewees were acquainted with the word haptics. Some of them had heard the word mentioned in situations not related to their own work or product design. Also, some mentioned tactile as a more familiar word in relation to their work.

3.1 Level of awareness and knowledge of haptic product property concept

Introducing the interviewees to the concept of haptic product properties gave them a better idea of its true meaning, which made it easier for them to understand and relate the concept to their own work. The interviewees' awareness of the concept ranged from thinking about it once or twice to discussing it, sometimes regularly, although this was unusual. As one said: *"We talk about the impression of our products a lot. The products are supposed to visually express high quality, and therefore should they also be resistant and durable in rough environments and situations."* Half of the interviewees said they work with the overall impression of the products. A few also stated that they try not to exclude any senses. How well the products fulfil the requirement of a high-quality overall impression is mostly based on subjective estimations within the company. Representatives of all companies want to get the opinions of customers or to make studies of the customers in focus groups. The interviewees specifically pointed out that they do not work with this as a concept. Instead they work with some of the properties. One of the interviewees referred to problems they could have because they are struggling with cultural differences. It is not easy to achieve and convey an integrated impression of their products. For example a plastic material can sometimes be regarded as cheap in Sweden or Scandinavia, while in another part of the world it is not.

3.2 Awareness and knowledge of the specific haptic product properties

All interviewees felt it easier to relate to the concept of haptic product properties when discussing each of these specific properties; surface texture, form, size, weight, grip span, force and resistance, mechanic and electro mechanic reproduced forces, emotional impression and usability. All companies worked with properties in relation to their type of product. For example, weight is not of importance for someone who is designing dashboards.

At larger companies, three of six in this study, industrial designers were responsible for and working with properties such as ***surface texture, form, and emotional impression*** in a more comprehensive way. Regarding ***surface texture*** the ergonomists, engineering designers, or both were formulating requirements such as eliminating slippery or reflective surfaces. At smaller companies, everyone involved in a project worked somewhat with this property. Some adjectives that describe ***surface texture*** were mentioned during the interviews: waterproof, robust, glossy, rough, impact resistant, durable and slippery.

When it comes to ***form,*** almost all of the interviewees said it is important that their products are comfortable to hold in the hand or to handle. A telephone should be comfortable to hold against the ear. When working with this property, IDs had almost no restrictions; they did most of the work and consulted the others involved every now and then.

"The right size" for a product is essential for all interviewees. Usually, the human physical constraints set the limits for this property for everyone involved (IDs, EDs, and ergonomists). The technical capacity also restrains the lower limit of the size. Some interviewees said that, for this property, fashion can challenge the technical capacity and the human physical constraints. An example is cell phones; How small can they be?

Concerning ***weight,*** one of the interviewees said: *"Not too heavy but not too light either. Rather too heavy since too light weight products are experienced as not serious by our customers."* This was also pointed out by others. Weight is also limited by the human physique.

At larger companies; industrial designers and ergonomists are often the coordinators of ***grip span***. At smaller companies everyone working on a project is more or less involved with this property in a more general way, and IDs have a comprehensive role. Human physical constraints are what the interviewees discussed here as the most important factor to consider before decisions are taken.

Resistance was stated as a significant property for interacting with a product. All said that a person must be able to overcome the resistance; this is restricted by human physical constraints for the specific body part in action: a finger, an arm or the whole body. Despite those numerical measurements many of them mentioned the difficulty to know which components that gives "the right sensation".

Mechanically and electro mechanically reproduced forces are unknown to many. One interviewee at a larger company said that they had a specific department that was working with this type of device.

An interviewee from a smaller company said they used vibration as a one-way medium to communicate with the user.
As mentioned in chapter 1.3.2, the properties above are components of the two more complex properties below.
Emotional impression is not something many of the interviewees work with in general. Industrial designers are the only ones who seem to be familiar with this expression. They could all give some adjectives that state the company's goal for the emotional impressions of their products.
The use was not familiar to the interviewees overall in terms of the description they were given. One person said: *"To be honest with you, I do not think we are aware of that way of thinking, or at least I am not"*. Industrial designers at the large companies and the external consultants working for the smaller companies did in general work with this line of thought.
The haptic properties with which they all worked with most frequently were: resistance in knobs and switches, size, good grip, and especially surface structure. One interviewee did not think it was possible to work with only some of them, and she said: *"You have to think of all of them; if you take away one, there is no product nor functionality – then you just have styling"*.
Some additional haptic properties came up during the interviews: weight balance, stiffness and aesthetics. The interviewees also mentioned aspects important to consider for future work: to have a consistent language of design and to keep in mind the surrounding environment where these kinds of products are used.

3.3 Awareness and knowledge of the haptic product properties in relation to the interviewees' work

In general, industrial designers did work intuitively with all of the haptic properties; this is a part of their creativity process. The engineering designers and ergonomists worked with some of the properties. All interviewees used experiences from earlier projects when possible, if they remembered it or if it was documented which was rare. Mostly, however, they stated a subjective opinion with help from colleagues. The surface texture and resistance in push-buttons were matters the entire interview group were clearly most familiar with. They used a variety of material samples to choose the best texture and resistance. When it comes to the more complex properties, emotional impression and the use, almost all of them were very inexperienced. A few of them used focus groups to examine the emotional impression of a product. Some other used sometimes focus groups to examine the use in general. Properties such as grip span, weight and size are mostly based on assumptions of human physical constraints.

3.4 The need of support and better understanding

The interviewees indicated the importance of haptics and also their lack of skills and time to carry out these ideas. Some said that first of all they need to be more aware of haptic product properties, and how these can affect their products. Another interviewee said: *"We need a tool or method as a support for our work and also as a medium for communication with other professional specialists"*. Some of the interviewees said they felt better informed just by participating in this study. Several also mentioned that issues they had never thought about before came up during the interview. For the more complex properties, emotional impression and the use, they definitely need to get information and support. For less complex properties are decisions supported and based on human physical constraints, the intuition, subjective evaluations within the company and comparison studies.

4. Discussion and conclusions

Investigation of today's knowledge base and level of awareness of haptic product properties confirms that this is an unexplored area in product development work. The companies did not have any articulated strategy about how to deal with this kind of issue and they desired support for their work. To articulate problems and talk about the work and decisions in work, accepted terms would help and support the communication between parties. Based on the insights gained from this study, is it possible to start developing useful expressions. All of the interviewees showed great interest in haptic product properties and pointed out their importance in today's PD, which indicates the direction to take.

Overall, this kind of knowledge will support PD industries in their work to guarantee the quality and total impression of products. To handle these "new" requirements, investigations must map the desired utility and functions of a product as well as what contributes to customers recognition understanding, use and enjoyment of a product. Gaining knowledge of the work with haptic product properties of today's PD will facilitate the application of new, or complement already existing, tools and methods that support the work with haptic product properties. The product developing industries need tools for defining and evaluating the desired haptic qualities. The next question is: How should this be put into practice in the PD process?

Haptic product properties can be divided in two main groups. The first is the overall impression of a product or system, by which the designer tries to convey a consistent message to the user. This is an important issue for designing quality products with a feeling of totality [Monö 1997]. Moreover it is the theme of this empirical study. Future research will aim towards more specific studies of the haptic properties *emotional impression* and *the use*.

An extension of the findings from the first group could lead to the second one. It should focus on developing haptic multi-functional devices that can reflect perceptions as force feedback, vibration etc.

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