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FENKO, Anna, SCHIFFERSTEIN, Hendrik N.J. and HEKKERT, Paul

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Which senses dominate at different stages of product experience?

Anna Fenko, Department of Industrial Design, Delft University of Technology, the Netherlands

Hendrik N.J. Schifferstein, Department of Industrial Design, Delft University of Technology, the Netherlands

Paul Hekkert, Department of Industrial Design, Delft University of Technology, the Netherlands

Abstract

In the area of product design, sensory dominance can be defined as the relative importance of different sensory modalities for product experience. Since product experience is multisensory, it is interesting to know which sensory modality plays a leading role in a particular experience, so that designers could concentrate on the creation of the most relevant product properties. It is often assumed that vision dominates other senses. In the present study, we investigated the importance of different sensory modalities during various episodes of product usage. We asked 120 respondents to describe their experiences with consumer products in the following situations: while buying a product, after the first week, the first month, and the first year of usage. The data suggest that the dominant modality depends on the period of product usage. At the moment of buying, vision is the most important modality, but at later stages other modalities become more important. The dominance of a particular modality may depend on its appropriateness for the particular task. During long-term usage, modality importance depends on product functions and the characteristics of the user-product interaction. We conclude that to create a long-lasting positive product experience, designers need to consider the user-product interaction at different stages of product usage and to determine which sensory modality dominates product experience at each stage.

Keywords

Sensory Dominance; User-Product Interaction; Product Design

Psychology is one of the disciplines that deals with human experience and might add to the understanding of human-product interaction. When designers shift their attention from product technology and functionality to product experience, it seems that the role of psychological research in design should increase. But when we look closer, it becomes clear that most of the psychological knowledge is not directly applicable to design.

Consider, for example, the studies of colour preferences. It would be helpful for designers to understand what colours people prefer and why. Plenty of psychologists have investigated this topic, starting from Guilford (1939, 1959) and Eysenck (1941). What conclusions can we make after almost 70 years of

research? Well, we can say that most people prefer blue and red and do not quite like yellow and orange. But these are Western adults. What about children? What about Vietnamese and Japanese? Children seem to be less averse to yellow than adults (Crozier, 1999), and colour preferences observed in Asian countries differ from those found in the United States (Kastl & Child, 1968; Child & Iwao, 1969). But what does this all mean for designers? Not much. Because most psychological experiments use paper colour chips as stimuli. When we look at the experiments with real products, the results are much more contradictory and confusing. A study by Holmes and Buchanan (1984) showed that although the favourite colour was blue, this was not the case for a sofa, walls, a carpet, or a chair. Yet for some items (skirt, dress, shirt, and slacks) the favourite colour was also blue. But don't even think of making a blue cheeseburger! Research has shown that people will feel sick and throw it away (Clydesdale, 1993).

Research on sensory dominance reveals a similar situation. Consumer experience with products is always multisensory. For example, when making coffee a person sees the coffeemaker, touches its buttons, hears the sound it makes, enjoys the smell of fresh coffee and, eventually, tastes the coffee. All sensory modalities contribute to this experience to some extent. But which are the most important? It is interesting to know which sensory modality plays a leading role in a particular experience, so that designers could concentrate on the creation of the most relevant product properties. Understanding the relative importance of the different senses can be useful for balancing the time and resources invested in new product development projects (Lindstrom, 2005).

A lot of experimental research in cognitive psychology demonstrated visual dominance. For example, in their classic study, Rock and Victor (1964) presented participants with an object of which the visual shape, because of optical distortion, differed considerably from its actual shape perceived by touch. The participants examined a square object by hand and at the same time saw it through a lens which compressed its visual width to one half its original size. The conflict between visual and tactual size was resolved completely in favour of visual size. Vision was so powerful that the object actually felt the way it looked and most subjects were unaware of a conflict.

Strong visual dominance over touch has been demonstrated in a variety of perceptual tasks, involving the determination of size (Miller, 1972), length (Teghtsoonian & Teghtsoonian, 1970), curvature (Easton & Moran, 1978), depth (Singer & Day, 1969), and spatial location (Hay, Pick, & Ikeda, 1965). Some studies also demonstrated visual dominance over auditory sensory signals (Bertelson, 1999). A significant bias of proprioception on the perceived position of auditory stimuli has also been reported (Caclin et al., 2002).

Unfortunately, the results of the experiments on sensory dominance performed in cognitive psychology cannot be directly applied to design. For example, in the experiments that demonstrated the complete visual dominance over touch, participants looked at the stimuli through a prism that distorts the visual image, or they touched objects partly concealed by a cloth (Gibson, 1933; Rock & Victor, 1964). Visual dominance over auditory sensory signals was also demonstrated under artificial experimental conditions of audio-visual

asynchrony (Bertelson, 1999). So the results are hardly relevant for the product usage situation.

In this paper, we are trying to integrate the results of psychological studies into design research area. We try to develop an empirical approach that fits the requirements of scientific rigour and at the same time can be applied to design practice. We use a definition of product experience as "the awareness of the psychological effects elicited by the interaction with a product, including the degree to which all our senses are stimulated, the meanings and values we attach to the product, and the feelings and emotions that are elicited" (Hekkert & Schifferstein, 2007, p.2).

Research showed that visual dominance also exists in the experience of consumer products. For example, Schifferstein and Cleiren (2005) performed a study in which they showed that consumers acquired most of the information on products by vision and touch: this information was most detailed and the subjects were surest of their judgments. The participants in their study were presented with six simple products (a marker pen, a spray deodorant, a tennis ball, a bag of crisps, a boiled egg, and a can of soft drink) via only a single sensory modality at a time. Vision and touch turned out to be approximately equally successful in providing participants with detailed information concerning a product; audition proved somewhat less useful, and olfaction provided the least detailed information. Furthermore, products perceived by vision and touch were found to be the easiest to identify and yielded the clearest memories of previous events and associations to persons and other products

Schifferstein and Desmet (2007) assessed the roles of the various senses on people's perception of different everyday products by comparing the effects of blocking one sense. They found that preventing people from seeing the products had the most detrimental effect on the amount of functional product information that they perceived. Task difficulty and task duration typically increased, up to the point at which simple tasks could no longer be completed. Interestingly, when products cannot be seen, people report that their experiences become more intense and that they start to use their other senses more.

When tactual perception was blocked to some degree (in this case by wearing very thick gloves), a substantial amount of product information was lost as well. Similar to vision, perceived task difficulty and task duration increased significantly. Tasks requiring subtle coordinated movements (such as composing an SMS message on a mobile phone) became almost impossible to perform. In addition, an emotional dimension of tactual product experiences was revealed: familiar products felt strange; they did not feel familiar anymore. It seems as if through blocking tactual perception one becomes somewhat alienated from one's own surroundings.

Furthermore, Schifferstein and Desmet (2007) found that blocking auditory perception primarily resulted in communication problems: people felt cut-off from the outside world. Blocking olfaction only led to a reported decrease in appetite for foods. Probably, consumers' emotional product experiences mainly suffer when audition or olfaction is blocked.

In general, vision provides the largest amount of information on a product within the shortest time frame. However, the dominant role of vision and, to a lesser extent, touch is likely to be mainly limited to the functional user-product interaction and to the conscious experience of that interaction. The other sensory modalities may nevertheless play important roles in terms of modulating the emotional experiences that are evoked by products (Schifferstein & Desmet, 2007).

A questionnaire study in which participants reported the importance of the sensory modalities during the usage of 45 different products (Schifferstein, 2006) demonstrated that on average the relative importance sequence of sensory modalities is vision, followed by touch, smell, audition and taste. In addition, when people were asked to rate how important they found the different modalities in their lives in general, most of them selected vision as the most important modality. However, the importance ratings for the sensory modalities differed greatly between products. For half of the 45 products, the importance of vision was lower than for other modalities. For example, audition is the most important modality for a washing machine and a coffee maker, which can be explained by the role of the sound in signalling the different stages of the process of washing or making coffee. Touch is most important for a computer mouse and a pen, and probably for any other hand tools as well. Smell plays a dominant role for a deodorant and (together with taste) for food products.

Schifferstein (2006) concluded that "the often referred to dominance of vision is likely to reflect people's overall tendency to find visual input relatively important when its role is evaluated for the ensemble of activities performed. As a consequence, the role of the senses is likely to depend on the specific products used, the frequency with which they are used, and the importance attached to the activities performed" (p. 60). Schifferstein suggested that the importance of vision in Western societies may have increased over time due to the range of products that have been created.

In the present study, we investigate the importance of the different sensory modalities during various episodes of product usage. We assume that the dominant sensory modality may vary with different periods of usage. When consumers buy a product they are likely pay attention primarily to its visual attributes. But with time, other modalities can become more important. No matter how nice new shoes look, during usage it becomes more important whether they are comfortable or not. Kitchen tools can be too heavy to use; an iron can produce a bad smell when used; new linen may be not as soft as the old, and so on.

Which sensory modalities contribute most to different stages of product experience? What determines which modality is dominant? To answer these questions, we developed a questionnaire with open-ended questions. We asked respondents to describe how important they found the various sensory modalities in different stages of the user-product interaction. Because we wanted to know the context in which the particular product experience had occurred, we asked respondents to describe the situation and their experience in their own words. To interpret the data, we combined qualitative analysis with the outcomes of the statistical analyses.

Method

Participants

The questionnaire was distributed among 120 Master students at the Department of Industrial Design, Delft University of Technology. All respondents were between 22 and 28 years of age; 42% of the participants were women.

Procedure

The questionnaire was part of a course assignment. At the beginning of this course each student selected a product that was analyzed repeatedly during the course for various assignments. Students selected a product they had used themselves and to which they had formed a positive or negative attitude. This provided a wide variety of different products and allowed us to generalize our conclusions about the influence of sensory modalities on product experience. The participants selected 65 different products (see Table 1).

Table 1. Products chosen by respondents

Categories	**Products**
Electronics and electric appliances	Alarm clock (8), MP3 player (7), camera (6), mobile phone (5), turntable (4), game computer (4), musical centre (2), computer mouse (2), printer (2), TV, minidisc recorder, speakers, laptop, tape recorder, table fan, intercom
Tools	Epilator (3), electric shaver (2), drawing tablet (2), cordless drill, electric toothbrush, razor, stapler, sewing machine, paintbrush, glue gun, sanding machine
Musical instruments	Guitar (3), synthesizer (2), digital piano
Vehicles	Bicycle (2), scooter, car (2)
Sport equipment	Sport wheelchair, snowboard, hockey stick, helmet
Kitchen appliances	Coffeemaker (5), rice cooker (2), toaster, water heater, hand mixer, sandwich maker, popcorn maker, refrigerator, BBQ, storage containers, saucepan, kettle
Furniture	Armchair (3), standing lamp, ceiling fan
Fast moving goods	Bottle of wine (2), candy, cigarettes
Personal accessories	Wristwatch (5), shoes (5), jacket, perfume, backpack, suitcase, eyeglasses, lipstick
Non-consumer products	Elevator, payment terminal

Note: Frequency is given between parentheses if >1.

Respondents were asked to assess what sensory modality was the most important for consumer experience with their product in the following situations: a) choosing the product in the shop; b) during the first week of usage; c) after the first month of usage; d) after the first year of usage. We also asked participants to explain why they thought the particular modality dominated, and, if that was the case, why the dominant modality changed over time.

Data analyses

The results were analyzed both qualitatively and quantitatively by content analysis methods usually used to analyze free and semi-structured interviews (Brannen, 1992; Krippendorff, 1980). We also noted the sequence of modalities mentioned by respondents. When only one modality was mentioned, it was

given the rating 1 and all other modalities were given 0. If several modalities were mentioned, they received ratings according to the priority given by the respondent, so that the sum of their ratings equalled 1 and the ratios between consecutive ratings were equal (1:2). For example, if two modalities were mentioned, they were given ratings 0.67 and 0.33; for three modalities the ratings were 0.57, 0.29, 0.14, and so on. The ratings were analyzed as interval variables and were subjected to repeated measures analysis of variance (Labovitz, 1970). Post hoc paired comparison tests were performed with Bonferroni adjustment.

Results

To differentiate the relative modality importance over time, we performed an overall repeated measures ANOVA with Modality and Time as within-subject factors. The results showed significant effects of both Modality ($F(4, 115) = 241.5$, $p < 0.001$, $\eta^2 = 0.15$) and Time*Modality ($F(12, 107) = 24.4$, $p < 0.001$, $\eta^2 = 0.06$). There was no Time main effect because the sum of all ratings for each respondent equals 1. Separate repeated measures ANOVAs were performed to test the effect of Time for each modality and to test the differences between Modalities at each moment of time (see Figure 1).

Analyses for the four different time episodes showed that at the time of buying, the importance of vision was significantly higher than the importance of the other modalities ($p<0.001$). Touch occupied the second position, and audition the third, with both modalities significantly different from all the others ($p<0.05$). Smell and taste played a very small role at the time of buying, and the differences between them were not significant ($p>0.20$).

After the first week of usage, vision and touch became equally important ($p>0.20$). They showed the highest level of importance and differed significantly from all the other modalities. Audition occupied the second position, smell the third, and taste was the least important at this stage. The differences between audition, smell and taste were all significant ($p<0.02$). After the first month of product usage, the differences between touch and audition and between audition and vision were no longer significant ($p>0.20$). On the other hand, the differences between touch and vision became significant ($p<0.02$). Smell and taste rated significantly less important than the first three modalities ($p<0.001$), but were not significantly different from each other ($p>0.05$). After the first year of usage the differences between vision, audition and touch were no longer significant ($p>0.20$). Smell occupied the second position, and taste was the least important; both modalities differed significantly from the rest and from each other ($p<0.02$).

Analyses for each of the modalities separately showed that the importance of vision decreased significantly from the buying stage to the first week ($p<0.001$) and from the first week to the first month of usage ($p<0.05$). The importance of vision increased slightly, but not significantly, during the first year ($p>0.05$). The importance of touch increased significantly ($p<0.001$) after buying. Subsequently, its importance remained constant ($p>0.20$). Audition increased its importance significantly from the buying stage to the first week and from the first week to the first month ($p<0.001$). After that, audition did not show a significant change anymore ($p>0.20$). The importance of smell increased significantly ($p<0.02$) after buying and then remained constant ($p>0.20$). The

time variations in the importance of taste were not significant during the whole period of usage ($p>0.20$).

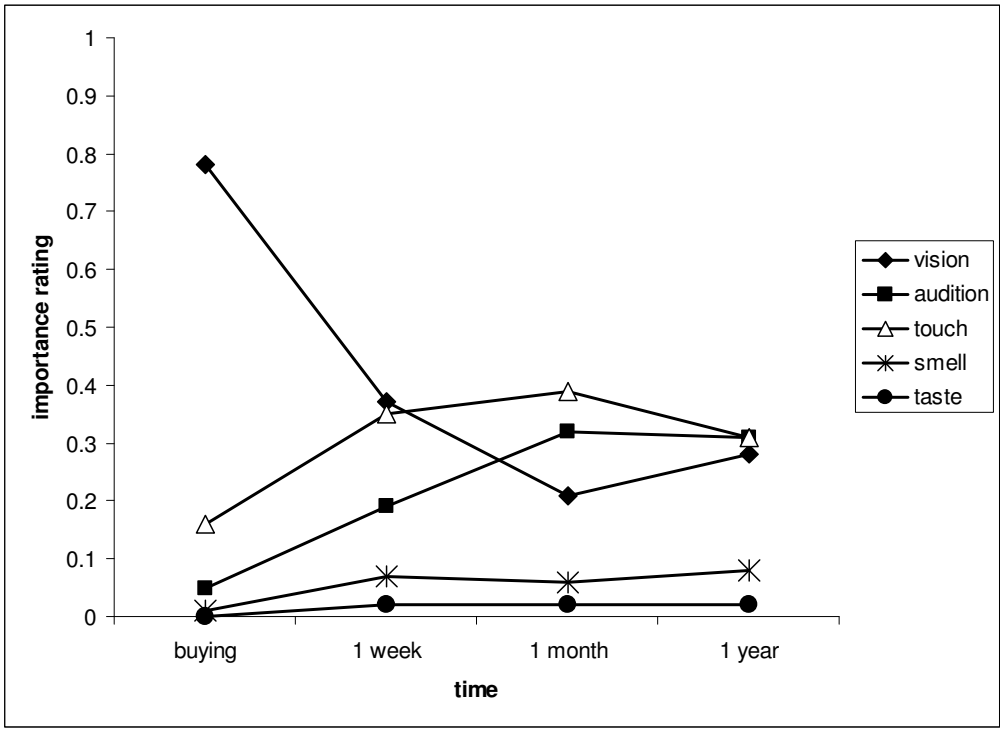

Figure 1. Changing dominant modality over time

The qualitative analysis of the students' answers helps to clarify these results. For the majority of the respondents, vision is the most important modality for choosing a product in a shop. Participants note that usually the only way to explore the product before buying is simply by looking at it. Some respondents, however, mentioned the importance of touch and audition during buying, but commented that trying a product in a shop is time consuming and sometimes unpractical: *"It is embarrassing to play all possible (musical) instruments inside a shop to hear which one sounds best."*

After the first week of usage, the importance of vision is lower than at the buying stage. Respondents indicated that *"It is important that it looks nice but how it works gets more important (sewing machine),"* and *"Consumers are getting used to or bored by the looks of the product (alarm clock)."* At the same time the importance of touch and sound increases. Touch becomes very important for everyday use: *"The touch is most important. When it is uncomfortable to wear, you will not use it (backpack)"*. Sound becomes especially important for products with an electric motor: *"The sound of the product is really annoying (printer)."*

Many respondents noted that the dominant modality depends on the primary function of a product. Over a longer period of time only the main function of a product remained important for users and this determined the dominant modality: *"The sound is dominant throughout the life of the product, because the primary function of the guitar is to produce a beautiful sound." "Touch dominates for a hockey stick because it affects its playing abilities." "The most*

important is the smell and taste of the coffee because that is what a coffeemaker is for."

Although the increases in ratings over time were not statistically significant, some answers suggested that the importance of visual and olfactory experiences increases during the first year of usage, because the product becomes old, dirty, scratchy, and acquires an unpleasant smell: *"After one year the iPod looks used, there are scratches visible on the surface." "The visual aspect becomes more important again when the boots get a little damaged."* The other reason is that after one year, fashion changes may occur and the product becomes outdated (lipstick, backpack, water heater, etc.). The user faces the choice whether to continue using a product or to get rid of it: *"After a long time it becomes more and more important if the device still appeals to you (drawing tablet)."*

Discussion

Our results show that the dominant sensory modality depends on the period of product usage and the type of product. When buying a product, vision is the most important modality, but after the first week of usage the importance of vision decreases, and touch becomes equally important, followed by audition, smell and taste. After the first month of usage, the importance of vision continues to decrease, while the importance of touch and audition continue to increase. After one year, vision, audition and touch become equally important, while smell and taste play a lesser role.

The changes in modality importance can be explained by the changes in the product-user interaction. In a shop the interaction with the product is mostly visual. But most products are bought for other purposes than visual enjoyment: they are used to cook, print, make coffee, listen to music, etc. During usage the dominant sensory modality mainly seems to depend on the primary product function: touch for hand tools, sound for an alarm-clock, smell and taste for food. The dynamics of sensory dominance depends on the specific product features, such as the electric motor that makes a distinct noise, and on the specific characteristics of the user-product interaction. For example, wearing shoes for a long time makes them more comfortable for touch but less pleasant visually (as they accumulate dirt and scratches.).

Our data suggest that any modality can dominate during product usage if it is relevant to a particular product. Vision and touch have more chances of being dominant in physical products simply because any product can be seen and touched. Audition can be dominant less frequently, because it is usually necessary to interact with the product to produce a sound. Smell is taken into consideration far less frequently because most people do not pay attention to smells unless they are very intense. That means that smell has fewer chances to be dominant in all product categories, but it can dominate in certain categories, such as food or cleaning products.

Another explanation for our results can be found in the different roles of sensory modalities. Previous research on the roles of sensory modalities in product experience (Schifferstein & Cleiren, 2005; Schifferstein & Desmet, 2007) suggests that vision gathers the largest amount of information on a product within the shortest time frame. That may explain the importance of vision in the situation of buying, when people have to compare multiple slightly different

products to make an optimal decision. After the user becomes well-acquainted with the product, the need for information decreases, which can explain the decrease of the importance of vision during usage. At the same time, during the later stages of usage the emotional components of product experience become more important. Several studies have demonstrated the role of audition and olfaction in emotional experience (Hinton & Henley, 1993; Herz, 1998; Schifferstein & Desmet, 2007). An increase of the emotional component of product experience can explain the increase of the importance of audition during usage. For example, after users gain expertise with their electric tools, they do not pay attention to their visual attributes anymore, but start to notice the sound of the motor, which they often describe as *irritating* and *annoying*. A coffee maker provides another example. Even if it makes a similar loud noise, most users describe it as pleasant, because in their memory this sound is closely connected to the pleasant smell and taste of fresh coffee.

If using a product evokes positive emotions, the chances are high that a user becomes attached to the product (see Mugge, Schifferstein, & Schoormans, 2004). It was suggested earlier that touch plays an important role in the experience of a product as familiar and somebody's own: when tactual perception is blocked, familiar products feel strange and people feel alienated from their surroundings (Schifferstein & Desmet, 2007). We can assume that tactile experience plays an important role in the development of product attachment. A good illustration is shoes: some respondents in our study admit that they postpone buying new shoes even if their old shoes look worn out, because their old shoes feel comfortable.

There are some limitations to our data because of the method we used. One of the disadvantages of questionnaire research is that respondents describe their experiences on the basis of their memory. The actual experiences during product usage could be different from what they remember. Another problem can arise because experiences of different sensory modalities may have different degrees of awareness. For example, most respondents felt it difficult to describe their olfactory experiences. The fact that linguistic categories of visual and tactile experiences are much richer and more elaborated in Western languages could explain why descriptions of other sensory experiences are less common (Hinton & Henley, 1993).

It can be also argued that to use industrial design students as subjects in research on product experience is inappropriate, as it is inappropriate to use clinical psychology students to validate personality tests. Well-informed subjects can be inappropriate indeed if experimenters are likely to conceal the real purposes of the study. However, our questions were quite direct and they did neither require nor prohibit any special knowledge. In fact, we think that using design students was an advantage, because they have better awareness of their own consumer experience than other consumer groups. Nevertheless, it would be good to gather more data for different product categories and consumer groups to validate the current outcomes.

Conclusions

Information on sensory dominance is important for product design. If designers know which sensory modality dominates the experience of the particular

product, they can concentrate on creating appropriate sensory attributes for it. Our research suggests that the dominant sensory modality depends on the period of product usage. At the time of buying vision is the most important modality, but at later stages touch and audition become equally important, followed by smell and taste. Which modality will dominate at the later stages of product usage depends on the primary function of a product and on the characteristics of the user-product interaction. To create a rich and long-lasting product experience, it is important to consider user-product interaction at different stages of product usage, and to determine which sensory experience is more important for consumers at each stage of usage.

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Anna Fenko

Anna Fenko is a PhD student at the Department of Industrial Design of the Delft University of Technology. She was born in Moscow, Russia, and graduated from the Moscow State University as a psychologist. She worked in the areas of consumer psychology, marketing and branding. In 2003-2004 she was the Fulbright visiting scholar at Jones School of Management at Rice University, Houston, USA.

Dr. Hendrik N.J. Schifferstein

Dr. Hendrik N.J. Schifferstein is associate professor at the Department of Industrial Design of Delft University of Technology. He published in Perception & Psychophysics, Acta Psychologica, Perception, Food Quality and Preference, Marketing Letters, and Journal of Experimental Psychology: Human Perception and Performance. He is co-editor of the books "Food, People and Society" (Springer Verlag) and "Product Experience" (Elsevier).

Prof. Dr. Paul Hekkert

Prof. Dr. Paul Hekkert is professor of Form Theory at the faculty of Industrial Design Engineering, Delft University of Technology and head of the section Design Aesthetics. He has published on product experience and aesthetics in major international journals and is co-editor of "Design and Emotion: The experience of everyday things" (Taylor and Francis, 2004) and "Product Experience" (Elsevier, 2008).