Sensory incongruity and surprise in product design

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Sensory incongruity and surprise in product design

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Books must be read as deliberately and reservedly as they are written
- *Paul Auster, The New York Trilogy*

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Prologue

While writing this thesis I gather information about my surroundings through each of my senses. And while doing so, I combine and integrate the information so that I can best perform this task. Alternating between the key - pad and the screen, I look where certain characters are and if my typing is correct. At the same time, my hands and wrists touch the sides of my laptop helping me to place my fingers at the right keys. The mild resistance of the keys I feel and the soft clicks I hear when I touch them tell me that I have typed a character. I have been typing for some time now, my laptop is beginning to feel warm, I hear the fan turning on, and I can smell the electronics. In similar ways, we experience products through all our senses almost continuously. In most cases, we can relate the information we obtain through the different senses to each other. Furthermore, what we perceive corresponds to expectations we have formed based on earlier use of the product or experience with similar products. Consequently, we sometimes hardly notice the sensory characteristics of the products we use.

But what happens when our expectations about the sensory characteristics of a product are somehow disconfirmed? How would people react if the information perceived through two or more senses conflicted? Will such a product evoke a surprise reaction? Will the product be more appreciated because it offers a new experience? And how will the incongruent information be used? Will the information obtained through one of the senses dominate the other sensory information? Should designers avoid designing sensory incongruity or can they use it to their benefit? This thesis bundles independent articles (Chapters 2 – 7) that study various aspects of these questions using different methods. Each of the articles was introduced and discussed from the perspective of that particular study. Inevitably, this has caused some overlap in the information provided in the different chapters. Nonetheless, to frame our research, we introduce the main themes that underlie each of our studies in Chapter 1. Furthermore, we discuss the findings of the different studies in relation to each other in Chapter 8.

Chapter 1
Introduction

1.1 Multisensory design

Information from all the sensory modalities influences how someone experiences a product. The sound of a product may tell a person something about its quality, the colour may influence the product's expression, its odor may be perceived as pleasant or unpleasant, and so on. More and more people understand how products that address each of the modalities can appeal to users through all their senses. As an example, in 2004 Magnum introduced a limited edition series of ice cream: Magnum 5 senses. Each of these five different ice creams was dedicated to one of the senses. The Magnum Sound, for example, was filled with pieces of caramelised sugar that produced a sound while the ice cream was eaten. Figure 1.1 shows the packages of the Magnum five senses ice creams on which each of the senses was visualized.

Figure 1.1 Magnum 5 senses ice creams.

As another example, some time ago, I received an invitation to the opening of a new showroom of my Alfa Romeo dealer (see Figure 1.2). It invites me to come and let my senses be stimulated. Subsequently, the invitation tells me how each of my senses will be addressed: I can see, hear, smell and feel the cars in the showroom and I can taste the drinks that will be served (and that synchronize in color with the familiar Alfa-red). These are just two of the many examples in product design and marketing (see also Lindstrom, 2005) that illustrate the growing attention for the senses.

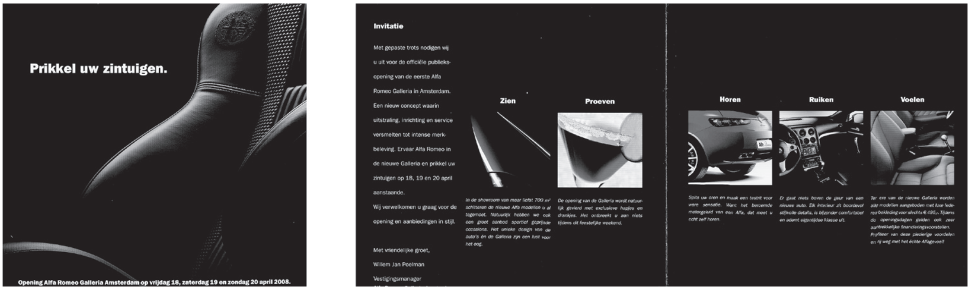


Figure 1.2 Invitation for the opening of a new Alfa Romeo showroom. The text on the left part of the figure (front) reads 'Stimulate your senses' , the text headings on the right part of the figure (inside) read: 'See', 'Taste', 'Hear', 'Smell' and 'Feel'.

However, sensory impressions obtained through hearing, seeing, touching, smelling and tasting do not always contribute to a desired end-experience in an integrated way. Janlert and Stolterman (1997) emphasized that all the senses add to the 'character of things.' On the basis of the perceived physical characteristics, such as color, size, or shape, people can infer expressive or personality characteristics of products, for example, the toughness or the femininity of a product (Govers, Hekkert, & Schoormans, 2004). Designers can manipulate a product's expression to influence the experience of a product (van Rompay, Hekkert, Saakes, & Russo, 2005). For example, a slim-shaped stainless steel lemon juicer may be experienced as luxurious and elegant while standing on the kitchen sink, but its loud and harsh sound may diminish the experience of luxury when it is used. In such cases, it will be hard to integrate the information from different senses into a coherent product experience. Instead, the information from one of the senses may clash with other sensory inputs and thereby have a major (undesirable) effect on the product experience. Hence, designing sensory experiences can be aimed at communicating a consistent message to all sensory channels, making this message a stronger one.

Another, completely opposite approach, is designing a product in a way that incongruent information is provided to different senses. Designers can use this approach to surprise consumers, to make exploring the product more challenging, and to let them discover something new. Whether they want to communicate a consistent message through all sensory channels or prefer to design for surprise, designers who intentionally try to create specific experiences for their audiences are more likely to achieve the intended effects when they think about and address each of the sensory modalities through their design. For example, a designer could decide to design a lemon juicer that communicates elegance through all the senses or he or she could decide to offer an incongruous aspect in one of the senses. The studies presented in this thesis will demonstrate that designers can benefit from designing for multiple modalities.

1.2 Sensory incongruity

The different modalities bring different types of information that is compared, combined, integrated and processed to finally form a coherent view of the object that is perceived. Although people perceive different types of sensory information through the different modalities, the information they perceive is somehow related. People (think they) know how certain things feel without actually touching them and they (think they) know how other things smell without actually smelling them.

This knowledge about sensory characteristics of objects may be due to perceptual learning. Information about the objects that surround us and that we experience continuously, is stored in cognitive schemas. Research suggests that these schemas contain multisensory information (Neisser, 1976). Thus, while they experience objects in the world, people learn to relate and integrate different types of sensory information. It has also been argued that there are innate neural connections between brain areas of the different modalities (Marks, 1978). Maurer and Maurer (1988) discussed evidence for such innate wiring and state that newborn babies do not appear to discriminate between inputs from different sensory modalities. Maurer and Maurer suggested that a lot of this sensory confusion is lost with maturation in most people. For some, however, the confusion remains into maturity. For these people, called syneasthetes, the interrelation of the senses is very obvious. They see, for example, colors for sounds or numbers. Syneasthetic perception occurs when stimulation of one modality leads to automatic, involuntary experiences in a second modality (Cytowic, 1989). Although only a small number of adults demonstrate synaesthesia, many people may still have residual connections between input from different sensory modalities (Zellner and Kautz, 1990). Merleau-Ponty (1962) has argued that synaesthetic perception is not a phenomenon that occurs for some people only. In a way, he says, people all experience the interrelations between the senses, whether it be through learned association or through some form of syneasthesia. For example, the form of objects stands in a certain relation to their specific nature, and appeals to all other senses as well as sight. The form of a fold in a cotton cloth shows us the resilience or dryness of the fibre, as well as the coldness or warmth of the material.

Someone who perceives a product does not necessarily use all senses at the same time. Therefore, perceiving a product through one sense modality first can create an expectation on what will be perceived through other sense modalities. If, upon perception through a second sense, this expectation is disconfirmed, the information from the two senses is incongruent. In this way, 12 forms of sensory incongruity can occur that are defined by two parameters, (1) the 4 senses that are used to perceive the product (vision, audition, touch and smell) and (2) the order in which they are used (see Figure 1.3). Because our research does not involve food products, we will not include the sense of taste in our overview.

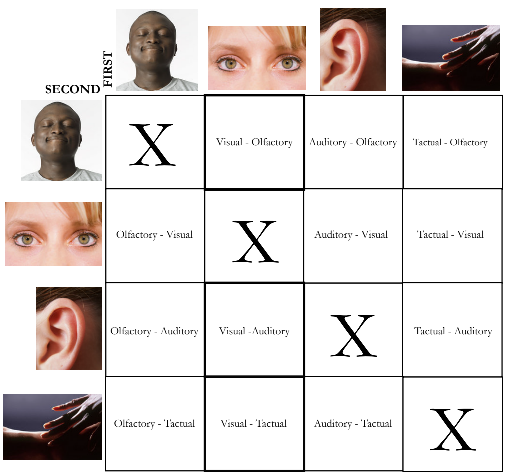


Figure 1.3 Matrix of sensory incongruity: Visual – Olfactory, Visual – Auditory and Visual – Tactual incongruity are most relevant for product design.

Some senses are more likely to be used first than others. The senses can be divided into two groups: the distance senses, which are audition, vision and olfaction, and the proximity senses, which are taste and touch. People are capable of seeing, hearing and smelling objects from a distance, but to touch or taste something people have to be in physical contact with the object. The perception of temperature forms an exception here, people can *feel* a heat or cold source from a distance. However, it is more likely that a person will perceive an object through vision, audition or olfaction first. Furthermore, people have reported that a product's appearance is often relatively more important than a product's sound or scent (Schifferstein, 2006) and among the three distance senses, vision will provide the most detailed information about a product within the shortest time frame (Jones & O'Neil, 1985; Schifferstein & Cleiren, 2005). In addition, people often do not perceive scents consciously or it may take them a while before they perceive a scent. Perceiving the sound of an object first is most likely to occur when the object is hidden or too far away to see. Therefore, the forms of sensory incongruity that start with a visual impression seem to be the most relevant for product design. These forms of sensory incongruity were studied in this thesis.

1.3 Surprise

Based on theoretical research on surprise, designer Silvia Grimaldi (2006) presented a technique for the creation of surprising objects. Amongst others, she created surprising products based on the incongruity between what an object looks like and how it feels. The first step in Grimaldi's design process involves studying what is expected of objects. Secondly, the designer has to find opposites of the expected characteristics and incorporate these into the new design. The vases in Figure 1.4 created by Madieke Fleuren form an example. These vases look like they are made of leather patches that are stitched together, however, they are made of porcelain that mimics the characteristics of the soft, supple material. Someone touching such a vase will probably be surprised by the discrepancy between what he thought he would feel and the actual experience. This may evoke curiosity about how the vase is made, which could result in further exploration of the product.

Figure 1.4 Leather vases designed by Madieke Fleuren.

Figure 1.5 shows the process of experiencing surprise through sensory incongruity. In short, a surprise-eliciting event follows four steps: first, an event is experienced as exceeding some threshold value of unexpectedness; second, a surprise experience occurs; third, ongoing activities and information processing are interrupted and attention is focussed on the unexpected event; finally, the unexpected event is analysed and evaluated and, if deemed necessary, stored knowledge is updated and a more effortful, conscious, and deliberate analysis of the unexpected event is initiated (Meyer, Niepel, Rudolph, & Schutzwohl, 1991; Meyer, Reisenzein, & Schutzwohl, 1997; Stayman, Alden, & Smith, 1992).

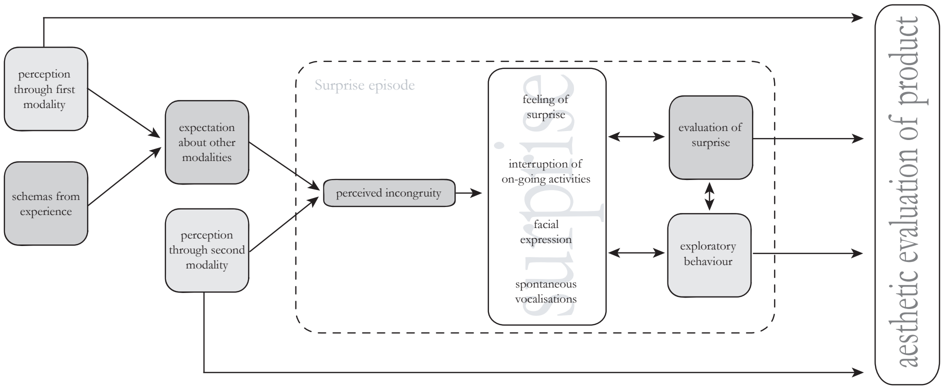


Figure 1.5 Sensory incongruity and surprise

We distinguish between a number of processes and actions in the 'surprise episode'. The 'feeling of surprise' refers to the subjective feeling of surprise. A surprising event can be evaluated as pleasant or unpleasant (generally) or as annoying, irritating, joyful, etc (more specifically). 'Interruption of ongoing activities' comprises a sudden stop of all activity, both mental and physical, and a focusing on the surprising event. The 'facial expression' of surprise is defined by three components: widening of the eyes, raising the eyebrows, and opening of the mouth (Darwin, 1873; Ekman & Friesen, 1975). 'Spontaneous vocalizations' are vocalizations that reflect the unexpected nature of the surprising event and that are made almost unconsciously, e.g., "Oh!". The 'Evaluation of surprise' is a subjective evaluation of what the surprising event means to the person who is experiencing it. 'Exploratory behavior' refers to actions that are used to gain information about the unexpected event and to lower the heightened arousal level (Berlyne, 1966).

While the first four of these processes together form the manifestations of a surprise reaction, the last two reflect cognitive and behavioral reactions towards the surprise experience. The double-headed arrows within the surprise episode in Figure 1.5 indicate that these processes and actions may alternate or may occur simultaneously (Lewis, 2005; Scherer, 1982; Smith & Ellsworth, 1985). The outcome of the surprise episode is likely to affect the overall evaluation of a surprising event.

Emotion theorists have put forward different views on surprise. Some of the researchers adopting a categorical approach to emotions regarded surprise as one of the 'basic emotions' (Ekman and Friesen, 1971; Izard, 1977; Plutchik, 1980). They distinguished surprise from other emotions based on its unique manifestations (e.g., facial expression, and feeling of surprise). Russell (1980) organized emotions on two dimensions, arousal and pleasantness. He classified surprise as an emotional state high in activation and neutral in valence, i.e. neither unpleasant nor pleasant.

Another group of theorists have used appraisal theories to explain the differences and similarities between emotions. They see emotions as the result of an individual's evaluation and interpretation (appraisal) of events in the environment (Smith and Ellsworth, 1985; Scherer, 1987; Roseman and Evdokas, 2004). Lazarus and Smith (1988) see true appraisal as the assessment of the implications of events for an individual's goal commitments. Most appraisal models suggest that combinations of several different appraisal types eventually cause an emotion. Surprise has been associated with appraisals of unexpectedness, pleasantness, novelty, motive consistency, and complexity (Smith and Ellsworth, 1985; Roseman et al., 1996; Reisenzein, 1999).

For our purposes, appraisal theory is valuable because it explains how emotions can be elicited. For surprise elicited by products, Desmet (2002) defined different appraisal patterns for pleasant surprise and unpleasant surprise. Both appraisal patterns consist of the combination of an appraisal of novelty (in terms of suddenness and unexpectedness) combined with one of three other appraisal types ('motive (in)compliance', '(un)appealingness', and '(il)legitimacy') and that determine whether the surprise will be experienced as pleasant or unpleasant. The patterns of appraisals Desmet defines to distinguish pleasant surprise from unpleasant surprise are similar to the patterns he defines for the product emotions amusement and disappointment respectively.

The combinations of multiple appraisals Desmet defined for pleasant and unpleasant surprise and the overlap with the appraisals he defined for amusement and disappointment are in line with theories in which surprise is seen as the first stage in a sequence of appraisals. The evaluation of the environment is a dynamic and continuous process. Events evaluated as relevant to a person are evaluated further. In this way, emotions result from appraisal structures rather than from single appraisals (Silvia, 2005a). Several researchers (Scherer, 1987; Meyer et al., 1997) have argued that when a sequence of appraisals starts with appraising an event as unexpected, it will result in surprise. Subsequently, the surprising event is further evaluated and a 'second' emotion is elicited. Silvia (2005b) suggests that interest can follow surprise in such a sequence of appraisals, when an appraisal of novelty is followed by an appraisal of coping potential. In Roseman's model (Roseman et al., 1996) of the appraisal determinants of emotions, surprise is the only emotion that results from a single appraisal (unexpectedness), whereas all other emotions result from combinations of appraisals. Scherer (1987, pp15) stated that surprise is often only the precursor to other emotions.

Some authors have suggested that surprise is not an emotion. For instance, Ortony et al. (1988) suggested that surprise is not an emotion because it lacks hedonic value. However, because of its distinct manifestations (e.g., the feeling of surprise and the facial expression of surprise) others view surprise as an emotion. Of course, the answer to the question lies in the definition of emotion, an extensive discussion (see Kleinginna and Kleinginna, 1981) that we did not include here, because it does not seem particularly relevant to designers.

1.4 This thesis

This thesis discusses what happens when people perceive incongruent information through different sensory modalities. In the previous paragraphs we have outlined that product expression, product experience, and surprise are all affected by perceiving incongruent sensory information. In various experiments, we have investigated different parts of this process and how designers can and do make use of sensory (in)congruity in product design. To do so, we have used different techniques, varying from interviews with designers to focus groups, to empirical tests. In our empirical studies, we have in some cases presented people with products as they are available on the market, but we have also sometimes adapted products and created our own products with sensory incongruities.

Chapters 2 – 7 can be read as independent studies. In chapter 2, we explore the occurrence of surprise in product design and we analyze and discuss strategies that designers seem to use to design surprising products. Chapters 3, 4 and 5 consist of three studies that describe experiments on different types of sensory incongruity: visual – tactual incongruity, visual – auditory incongruity and visual - olfactory incongruity. In these experiments, the effects of sensory incongruity on surprise, on product expression and on the overall product experience and evaluation are examined. Surprise is often described as a one-time experience. However, this one-time experience may still have its effect on the long-term. For the experiment described in chapter 6, we created products with visual – tactual incongruities and we investigated what happens to people upon repeated presentation of the same, initially surprising product. We also present a two-stage model of surprise that links surprise to other emotions. The experiment described in chapter 7 builds on the studies described in chapters 3 – 6. In this experiment, we compared products incorporating the different types of sensory incongruity, and we studied part of the two-stage model: the relationship between surprise and the emotions amusement and confusion. Furthermore, the development of stimuli for this experiment serves as a case-study on how designers can create sensory incongruities in products. Finally, Chapter 8 discusses the results of the separate studies in relation to each other and the implications of our findings for product designers.

Chapter 2 was largely based on: Ludden, G. D. S., Schifferstein, H. N. J. & Hekkert P. (2008) Surprise as a design strategy. Design Issues 24 (2), 28-38.

Chapter 2

Surprise in product design

2.1 Introduction

Imagine yourself queuing for the cashier's desk in a supermarket. Naturally, you have picked the wrong line, the one that does not seem to move at all. Soon, you get tired of waiting. Now, how would you feel if the cashier suddenly started to sing? Many of us would be surprised and, regardless of the cashier's singing abilities, feel amused. The preceding story is an example of how a surprise can transform something very normal, and maybe even boring, into a more pleasant experience. Analogously, a surprise in a product can overcome the habituation effect that is due to the fact that people encounter many similar products everyday. Colin Martindale (1990) describes this effect as 'the gradual loss of interest in repeated stimuli'.

A surprise reaction to a product can be beneficial to both a designer and a user. The designer benefits from a surprise reaction because it can capture attention to the product, leading to increased product recall and recognition, and increased word-of-mouth (Derbaix & Vanhamme 2003, Lindgreen & Vanhamme 2003). Or, as Jennifer Hudson (2004) puts it, the surprise element "elevates a piece beyond the banal". A surprise reaction has its origin in encountering an unexpected event. The product user benefits from the surprise, because it makes the product more interesting to interact with. In addition, it requires updating, extending or revising the knowledge the expectation was based on. This implies that a user can learn something new about a product or product aspect.

Designers already use various strategies to design surprises in their products. Making use of contrast, mixing design styles or functions, using new materials or new shapes, and using humor are just a few of these. The lamp 'Porca Miseria!' designed by Ingo Maurer that is shown in the left part of Figure 2.1 consists of broken pieces of expensive porcelain tableware, making it a lamp with a unique shape. The idea that another product had to be destroyed to make this lamp may inflict feelings of puzzlement and amusement on someone who sees this lamp. The perfume 'Flowerbomb' (right part of Figure 2.1) designed by fashion designers Victor & Rolf is another example. The bottle is shaped like a hand grenade and it holds a sweet smelling, soft pink liquid. By combining conflicting elements in their perfume bottle, Victor & Rolf have succeeded in creating a perfume that attracts attention amidst the dozens of perfumes that line the walls of perfumeries.

Figure 2.1 Lamp 'Porca Miseria!' designed by Ingo Maurer. Photo: Tom Vack. Perfume 'Flowerbomb' designed by Victor & Rolf.

Surprise is also used in product marketing as a positive quality of products or brands. Kia, a South-Korean car manufacturer, even uses surprise as the brand's major pay-off: 'Kia, the power to surprise'. Furthermore, Swatch, the famous Swiss watch manufacturer, claims that their brand is 'always surprising' (Figure 2.2).

This chapter will outline the use of surprise in contemporary design. Based on an analysis of a set of surprising products and on discussions with the designers of some of these products, we will give insight into how and why designers create surprising products and what the effects of creating surprises are. We noticed that designers often make use of visual – tactual incongruities to create surprising products. For example, an analysis of designs in five issues of The International Design Yearbooks (Morrison, Horsham & Hudson 1999, Maurer & Andrew 2000, de Lucchi & Hudson 2001, Lovegrove &

Hudson 2002, Rashid 2003) showed that 1-6 % of these designs incorporate some form of visual – tactual incongruity. Therefore, we decided to focus our discussion of surprise in product design on this type of products.

Figure 2.2 Logo of Kia with pay-off: 'The power to surprise'. Advertisement of Swatch with claim 'Always surprising'.

2.2 Visual - tactual incongruities and surprise

Visual – tactual incongruities occur when people perceive incongruent information through vision and touch. Some object properties can be experienced through both vision and touch. People can, for example, both see and feel a texture or a shape. However, the information the two modalities provide is not always the same. Sometimes, you feel something different from what you (thought you) saw. If you feel something unexpected, you will be surprised.
We studied 101 products with visual – tactual incongruities (63 found in the IDYs and 38 found at design fairs, on the Internet, and in shops) and distinguished two types of surprising products that have different mechanisms underlying the surprise reaction. We defined these two types of surprising products as 'Visible Novelty' (VN) and 'Hidden Novelty' (HN). The distinction between the two surprise types is based on the initial sensory expectations the user forms.

Expectations can be based on different sources of information. Oliver and Winer (1987) mention three sources for expectations as conceptualised by Tolman (1932): 'memories of actual experiences, perceptions of current stimuli, and inferences drawn from related experiences such as trial of other objects. With respect to expectations about how a product will feel, taste, smell or sound this implies that a person's visual impression of a product, his/her previous experiences with that product, or experiences with similar products can be the basis for the expectation.

An expectation involves uncertainty (Oliver & Winer 1987), which depends on the source of the expectation. When the expectation is based on a memory of an actual experience, the level of uncertainty is likely to be lower than when it is based on inferences drawn from related experiences. In the latter case, the perceiver cannot be sure that the current experience is fully comparable to the related experiences and will thus be more uncertain about what to expect.

The sources for expectations and their uncertainty differ between the two surprise types. The VN surprise type consists of products that seem unfamiliar to the perceiver. Consequently, the perceiver is not able to form an expectation based on previous experiences with the product. The perceiver forms an expectation about how the product will feel based on resemblances with other products in, for example, shape or material. A high degree of uncertainty will accompany this expectation. A surprise is experienced whenever the uncertain expectation is disconfirmed. A VN product can, for example, be made out of a new material that the perceiver vaguely associates with a material he/she knows. An expectation could then be based on experiences with the known material, but the new material can have very different tactual properties.

The HN surprise type includes products that seem familiar to the perceiver, but have unexpected tactual properties. In this case, the expectation about how the product feels is based on previous experiences with a similar product. The perceiver is quite certain about his/her expectation. A surprise is elicited, because the apparent familiarity is evidently proven wrong by touching the product, disconfirming the expectation: the visual perception is misleading or the product has hidden characteristics that prohibit the perceiver from forming a correct expectation. An example of a HN product is a plastic bowl that looks like a crystal bowl. Upon seeing this product, the perceiver thinks that the product will be heavy. When the product is touched and lifted, however, the perceiver is surprised about the much lower weight of the bowl.

2.3 Design strategies

Designers seem to create products in the HN and VN type by making use of several different design strategies. We identified six different design strategies (DS): ‘new material with unknown characteristics’, ‘new material that looks like familiar material', 'new appearance for known product or material, 'combination with transparent material', 'hidden material characteristics', and 'visual illusion'.

In all six strategies, a combination of two opposites is used: something new is used ('Newness') and a reference to something familiar is made ('Familiarity'). The combination of new and familiar elements is likely to result in surprise. The familiar element of the product forms the basis for an expectation about other elements. Subsequently, the new element will disconfirm this expectation. New and/or familiar elements can be used in the visual domain in the appearance of the product (e.g., in shape, material, or type of product), and/or in the tactual domain in the material properties of the product (e.g., in weight, flexibility, or balance).

The newness of a product is likely to be relative. According to Berlyne (1971), it is highly unlikely that someone encounters an absolutely novel stimulus, a stimulus unlike anything that individual has met before. Probably, what someone perceives as new, will consist of previously experienced elements in a different combination, or will resemble familiar stimuli. This is what Berlyne describes as relative novelty. Hekkert et al. (2003) found that people prefer products with an optimal combination of typicality and novelty. Their findings are consistent with the design principle called MAYA (most advanced, yet acceptable) by designer Raymond Loewy (1951). Analogously, people will prefer products that have a combination of both familiar (i.e., typical) and new (i.e., novel) elements.

The next sections discuss how these two elements are present in each design strategy. In addition, we present examples of products that could have been designed following that strategy. The design strategies can result in the two different types of surprising products discussed. Four strategies can lead to a product in the VN type. One of these strategies can also lead to a product in the HN type and the two other strategies can only lead to a product in the HN type. Figure 2.3 illustrates the relationship between the six design strategies, newness and familiarity, and the two types of surprising products.

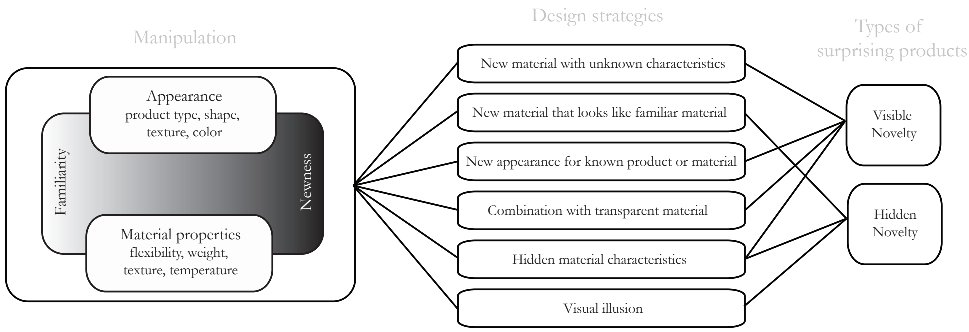


Figure 2.3 Relationships between design strategies, their underlying dimensions and resulting types of surprising products.

Design Strategies 1 and 2: New materials

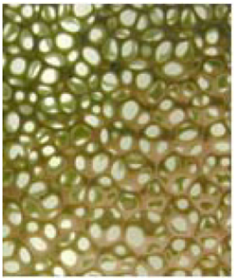
New materials are likely to have new and unknown characteristics that can lead to new visual and/or tactual experiences. According to Ezio Manzini (1989) more and more surprising products have gradually occurred on the market due to a 'loss of recognition' since the introduction of plastics. Many new plastic materials possess unknown material characteristics. Upon seeing these materials, people experience uncertainty about their feel characteristics because they do not know them. Upon touching the materials they might be surprised by their feel. For example, the much lighter weight of many plastics combined with their strength relative to previously known materials like steel and wood surprised many people when plastics were first introduced.

The development of smart(er) materials also offer wide opportunities for designers to explore new sensory experiences (Verbücken 2003). An example of the use of a smart material is a water kettle made out of a thermochromic material that changes colour when its temperature rises. Through this material, the kettle 'warns' the user when it is hot. Several companies and institutes, such as Material Connexxion, Materia and Innovathèque assist designers in their search for new and innovative materials.

When observing a new material, a perceiver will form a feel expectation based on resemblances with familiar materials. When the new material looks exactly like a known material, these expectations can be certain. If not, they will be uncertain. These two cases yield very different design approaches and are, therefore, discussed as two separate design strategies.

Design Strategy 1: New material with unknown characteristics

The foam developed for Prada depicted on the left in Figure 2.4 is a structure with large holes, which make it look like it is flexible. However, when seen in a large construction, it also resembles hard plastic because it seems to hold a certain weight. Someone who sees this foam may not be certain about how it feels. The same holds for the cloth depicted on the right in Figure 2.4: it looks like flexible plastic but reflects the light slightly differently, leading to an uncertain expectation. In reality, the cloth has feel characteristics different from plastic: it feels soft, very similar to silk. A new material with unknown characteristics will lead to a product in the VN type, because someone who sees the material is uncertain about how it will feel.



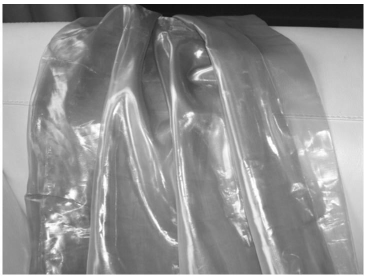


Figure 2.4 Examples of products corresponding with DS1, new material with unknown characteristics. Foam for Prada, designed by OMA. Polyamide/ viscose cloth, designer unknown.

Design Strategy 2: New material that looks like familiar material

If someone sees a new material and is, nevertheless, certain about how it will feel, he or she can be surprised upon touching the product. Apparently, he or she had incorrectly identified the new material as a familiar material and is surprised that this material feels different. Designers often deliberately use this effect when they create a generally well-known product out of another material. This design strategy always leads to products in the HN type. After all, for a surprise to occur the product must look exactly like a familiar product. Examples of products that are in correspondence with this strategy can be found in Figure 2.5.

The vase on the left looks like a crystal vase. Its shape and the decorations on the surface are highly similar to those used for traditional crystal vases. However, this vase is made out of plastic, which results in entirely different feel characteristics: this vase is much lighter than the crystal vase it resembles. The lamp on the right looks like it is made out of matt glass. Again, it resembles typical glass lamps in shape and surface texture. This lamp is actually made out of flexible polyurethane rubber and it feels much more flexible than a lamp made out of glass.

Figure 2.5 Examples of products corresponding with DS2, new material that looks like familiar material. Polycarbonate vase, designer unknown. Lamp 'Flexlamp', designed by Sam Hecht.

Design Strategy 3:
New appearance for known product or material

Using a new appearance for a familiar product or material can lead to an uncertain, incorrect feel expectation. If the new appearance resembles another well-known product or material, a designer creates a deliberate reference to a familiar thing. Since the new appearance is immediately visible, this leads to an uncertain feel expectation and thus to a VN type product.

The tiles on the left in Figure 2.6 are made out of ceramics like most tiles. However, using a new shape (resembling the shape of a softer material) for this product results in the uncertain expectation that these tiles may feel soft. The tiles actually feel hard, like other ceramic tiles.

Alternative or new production techniques can also be used to create new shapes for known materials. The lamp on the right in Figure 2.6 is made using a 3D printing technique, creating a new shape for a lamp and for the material, polyamide. The lamp looks like it is made out of cloth or paper and may be expected to feel light and flexible. However, it feels solid, heavy and not flexible.

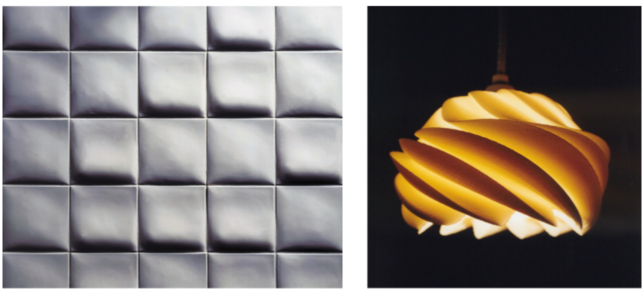


Figure 2.6 Examples of products corresponding with DS3, new shape or product for known material. Tiles 'Tactiles', designed by Baukje Trenning, produced by Koninklijke Tichelaar Makkum. Lamp 'Konko', designed by Willeke Evenhuis & Alex Gabriel.

Design Strategy 4: Combination with transparent material

A new combination of a familiar material with an (also familiar) transparent material can produce conflicting information about feel characteristics, leading to an uncertain feel expectation. A combination with a transparent material can, therefore, lead to a product in the VN type.

The benches on the left in Figure 2.7 are made of a combination of soft foamy cushions and a hard plastic cover. The cushions are associated with softness, leading to the expectation that the cover is soft too, and that the cushions will be felt when sitting down. However, the hard cover makes the bank feel completely rigid.

The natural acrylics range of Pyrasied Xtreme Acrylic (Zijlstra 2005) is another example of a new combination of materials. In this range of acrylics, natural materials are combined with transparent plastic (see picture on the right in Figure 2.7). Someone who sees this material may not be sure whether or not the natural material, in this case bamboo, can be felt. In reality, only a smooth plastic surface can be felt.

Figure 2.7 Examples of products corresponding with DS4, new combination of materials. Tables 'Apple', designed by Ilaria Marelli. Courtesy of designer. Natural Acrylic, designed by Pyrasied Xtreme Acrylic.

Design Strategy 5: Hidden material characteristics

Some of the materials used in a product may be hidden. By hiding these materials, relevant feel characteristics cannot be observed. The feel expectation is based only on the visible materials, thus leading to an incorrect feel expectation. This expectation can be either uncertain or certain, depending on how familiar the product looks. Consequently, this strategy can lead to either a product in the VN type (see first example) or in the HN type (see second example).

The chair on the left in Figure 2.8 looks like it is made out of paper, which is uncommon for a chair. This appearance may lead to the uncertain expectation that this chair is very light. However, beneath the paper there is wood, a much heavier and more rigid material.

The bench on the right in Figure 2.8 is from Bisazza's 'Soft Mosaic Collection'. The bench looks like it is made out of glass tiles. Someone who sees this bench will probably be certain that it feels hard and rigid. However, beneath the small tiles, there is a soft foam-type underlay. The bench, therefore, yields when sat upon.

Figure 2.8 Examples of products corresponding with DS5, hidden material characteristics. Chair 'Bastian', designed by Robert Wettstein. Bench from Bisazza's 'Soft Mosaic Collection', designed by Jürgen Mayer.

Design Strategy 6: Visual illusion

Visual illusions can be used to form a misleading appearance. Artists have used visual illusions like trompe l'oeils for a long time. Applied in product design, similar techniques can lead to certain, but false feel expectations.

The cupboard on the left in Figure 2.9 has a printed laminate that makes it look like there is a cove in the cupboard, which in reality does not exist. The glass bowls on the right in Figure 2.9, named 'Solid, solid+liquid and liquid' look like they are all hollow shapes when viewed from above. However, some of the bowls actually have an almost flat upper surface.

It must be noted that a visual illusion is often solvable by using vision only, mostly by changing viewing position. However, when a visual illusion is solved by touching the product, a visual – tactual incongruity is perceived.

Figure 2.9 Examples of products corresponding with DS6, visual illusion. Cupboard 'Yourside', designed by Markus Benesch (Money for Milan). Bowls 'Solid, solid+liquid and liquid', designed by Monique Borsboom.

2.4 Surprise as a design strategy

Considering the frequent use of visual – tactual incongruities in product design and the variety of strategies that designers seem to use to create them, one might conclude that designers think of creating surprises as an effective strategy to create interesting and original products. However, from discussions designers, some of whom designed products we used to illustrate the design strategies, we learned that this was not always the case. The surprises they had created were sometimes only the by-product of other aims, like searching for new experiences, using new materials or techniques, or creating conflict within a product. This illustrates that designers were not always aware that they were creating surprises.

We would like to stress that understanding the mechanism of surprise and being aware of the impact a surprising product may have is useful for designers. After all, if designers understand how a surprise can be brought about, they will be able both to avoid surprise when they do not want to evoke them and to effectively use surprises to their benefit in other cases. This is important because using surprise as a strategy to create interesting and original products may not always have the desired effect. Although most designers who make use of surprise think that people appreciate the surprises their products evoke, by its nature, using surprise can be dangerous too. Besides evoking pleasant and/or new experiences, unexpected events can also lead to disappointment and users may even feel misled or fooled upon experiencing a surprise. In addition, some designers remarked that they were disappointed because the surprise seemed to distract potential users from another message they wanted the product to communicate. Furthermore, although discovering a surprise in a product may initially be experienced as pleasant, the effect of this surprise may be negligible or even unpleasant in the long term.

So far, knowledge about people's reactions (both on the short and the long term) to surprising products is limited. In general, in marketing research, surprise was found to be positively related to satisfaction with the product (Vanhamme & Snelders 2001). More specifically, our research on surprising products suggests differences in people's reactions to VN and HN products (Ludden, Schifferstein & Hekkert 2009). People tended to use more exploratory behavior while interacting with VN products, possibly because they enjoyed exploring these products or because they wanted to discover the exact material properties of these products. It is possible that they needed more time in order to understand the origins of their surprise reaction. On the other hand, for HN products, it seems that the experienced surprise upon touching the product is immediately understood and further exploration or cognitive effort is unnecessary. This may partly explain why people experienced VN products as more interesting than HN products.

Apparently, using different design strategies can lead to surprises that are appreciated differently. It should be noted that it is also possible to use a combination of design strategies in one product. For example, the bench in Figure 2.10 seems to comprise elements from DS 5, hidden material characteristics and DS 3, new material that looks like familiar material. The bench is made out of polystyrene, which is covered in knitted cloth and then vacuumed and hardened with wax. As a result, the polystyrene is completely hidden. The combination of materials with the new shape makes the bench look like it is made out of a familiar soft material, like foam rubber. In reality, the bench feels hard.

Figure 2.10 Bench 'Shrunken furniture', designed by Bertjan Pot.

The type of product in which a surprise is created also seems to influence people's appreciation of the surprise (Ludden, Schifferstein & Hekkert 2006). In products with a complicated functionality that requires full attention from the user, a surprise will probably not be appreciated. However, in products that people can use without any cognitive effort, for example a vase, a surprise may be welcomed by the user.

Further research into people's appreciation of surprises in products has to provide more definitive conclusions on how and when surprise can effectively be used as a design strategy. This research has to be aimed at providing detailed knowledge into what causes a positive or negative surprise. For example, the relative pleasantness of the expected and the actual feel characteristics, as well as the product attribute the surprise is experienced in (e.g., weight, flexibility), may both affect the evaluation of the surprise. Future research in these directions can help in understanding how to use surprise in product design more effectively.

Chapter 3 was largely based on: Ludden, G. D. S., Schifferstein, H. N. J. & Hekkert P. (2009) Visual - tactual incongruities in products as sources of surprise. Empirical Studies of the Arts, (in press).

Chapter 3
Visual - tactual incongruity

3.1 Introduction

We perceive the world around us and the objects in it with all our senses. When we perceive objects through vision and touch, in some cases we can use both senses to perceive the same property of an object. We can, for example, both see and feel a surface or a shape. However, the information the two modalities provide is not always the same. Sometimes we feel something different from what we (thought we) saw. Artists have been using the different information vision and touch can provide for centuries in creating trompe l'oeils. Upon perceiving a trompe l' oeil, an observer may want to touch the suggested three dimensional shapes, which subsequently may result in a surprise reaction, because the perceived shapes are actually a two dimensional surface. Possibly, this discovery may cause the observer to feel disappointed, because the suggested shapes are not real. However, the observer may just as well experience admiration, because the artist succeeded in making the 3D shapes look realistic. This example illustrates just two of the possible outcomes of a surprise reaction.

Currently, more and more product designers experiment with designing products that provide incongruent information to vision and touch. Creating such products enables these designers to evoke interest for their products, and to let people experience something new (Ludden, Schifferstein, & Hekkert, 2007). Chapter 2 shows examples of such products.

Several authors have studied in what respect the information perceived through vision and touch differs. For instance, researchers have investigated which modality is more accurate in perceiving certain object characteristics such as shape and texture (Ballesteros, Millar, & Reales, 1998; Heller, 1992; Lederman, Thorne, & Jones, 1986; Ludden et al., 2007; Rock & Victor, 1964). Others have studied how and when information from vision and touch is integrated (Gepshtein & Banks, 2003; Heller, 1982; Jones & O'Neil, 1985; Martino & Marks, 2000; Spence, 2002). In some of the work dealing with visual – tactual incongruities a conflict between visual and tactual information was experimentally created by having participants look at objects through optical elements (Rock & Victor, 1964) or by presenting them with virtual stimuli (Ernst & Banks, 2002). Other researchers used simplified physical stimuli such as raised dot or line patterns (Ballesteros et al., 1998; Lederman et al., 1986) and samples of abrasive papers (Heller, 1982). Using these simple and/or artificial stimuli has an advantage in that they are easy to control and manipulate. A disadvantage is that it can be difficult to extrapolate the findings to real-life objects (Berlyne, 1971), such as products. Furthermore, in spite of the attention investigators have paid to the differences between and the integration of visual and tactual information, people's emotional reactions to perceiving incongruent information through vision and touch have hardly been studied.

We expect that people will feel surprised when they experience incongruent information. From design research we know that surprise is mentioned by participants as an emotion elicited by products (Desmet, 2002; Richins, 1997). The surprise people experience will most likely influence their behavior, their reactions towards the product and their evaluation of the product. Therefore, knowledge about what people experience when they perceive differences between visual and tactual information in products is valuable for designers.

Perceptual incongruity

To understand what happens when a person perceives incongruity, we have to define what perceptual incongruity is and we have to understand how it is produced. When someone perceives an object, perception through vision mostly precedes touch, because visual perception is possible from a greater distance than tactual perception. Furthermore, upon seeing an object, an expectation will be formed about how the product will feel.

Expectations can be based on different sources of information. Oliver and Winer (1987) mention three sources for expectations as conceptualised by Tolman (1932): memories of actual experiences, perceptions of current stimuli, and inferences drawn from related experiences such as trial of other objects. Accordingly, expectations about how a product will feel, taste, smell or sound may be based on someone's visual impression of a product, on his/her previous experiences with that product, or on experiences with similar products. This indicates that the familiarity of a product is of importance in the creation of an expectation. Consequently, Oliver and Winer state that an expectation involves uncertainty. The uncertainty about a following perception is likely to depend on the source of the expectation. When the expectation is based on a memory of an actual experience, the level of uncertainty is likely to be lower than when it is based on inferences drawn from related experiences. In the latter case, the perceiver cannot be sure that the current experience is fully comparable to the related experiences and thus will be more uncertain about what to expect. The preceding indicates that the familiarity of a product influences the certainty of the expectation that is formed about the product's tactual characteristics. When the product looks familiar, this expectation will be more certain than when the product looks unfamiliar.

See Figure 1.5 for a representation of the process of seeing an object, forming an expectation about how it feels, touching it and perceiving incongruity. Because an expectation is disconfirmed in this process, the perceived incongruity can lead to surprise, as Figure 1.5 shows. This figure also represents an overview of the processes involved in surprise reactions evoked by products with visual – tactual incongruities. In this chapter, we do not intend to test all these different relationships empirically. We will test and discuss the relationship between perceived visual – tactual incongruity and the various manifestations of surprise. Furthermore, we will test and discuss the effects of the certainty of the expectation on the manifestations of the surprise reaction.

Measuring surprise

Given the different spontaneous reactions that can occur during a surprise episode, this opens up the possibility to measure surprise using various types of methods. However, there has been some debate on which would be the best method to measure surprise.

Vanhamme (2000) concluded that verbal reports and facial expressions were the most appropriate variables for use in research on surprise. However, Reisenzein (2000) and colleagues (Reisenzein, Bördgen, & Holtbernd, 2000) caution against using facial expressions as indicators of surprise and explored other indicators, such as the analysis of vocal expressions, as well. Furthermore, several researchers have suggested that the relationship between emotion and facial expressions simply is not fixed (Kappas, 2002) and that we should not expect emotions to 'produce a corresponding set of facial signals' (Russell, Bachorowski, & Fernandez-Dols, 2003).

Another way to measure a surprise reaction may be through the analysis of exploratory behavior because people can use exploratory procedures to find out what the specific properties of a product are (Lederman & Klatzky, 1987). In addition, various self-report measures may be obtained from the participants, e.g. on surprise intensity and pleasantness.

Because it is yet unclear how surprise is measured best, we will explore and compare multiple measures of surprise in our experiments.

Types of surprising products

From an analysis of contemporary design (Ludden et al., 2007), we distinguished two types of surprising products, 'Visible Novelty' (VN) and 'Hidden Novelty' (HN). Both evoke a surprise reaction, even though the mechanisms that underlie these reactions are different.

Products in the VN type do not seem familiar to the perceiver; their novelty is noticed immediately. Because the perceiver cannot form an accurate expectation about how the product will feel based on previous experiences with similar products, this expectation is uncertain. Eventually, upon touching the product, the uncertain expectation may be disconfirmed, resulting in a surprise reaction. In the HN type, the novelty is hidden and the product seems familiar to the perceiver. This results in a high degree of certainty about expectations on how the product will feel. However, upon touching the product, the product feels different from what was expected, resulting in surprise.

Due to the differences in familiarity/certainty that underlie the expectations formed, user responses to the different types of surprising products may differ. For example, products of the VN type may evoke more curiosity, because an uncertain expectation is formed. These products may also be appreciated more, because they offer the opportunity to explore and to discover something new. On the other hand, products in the HN type may result in a stronger surprise reaction, because users were quite certain about their initial expectation. However, they may also evoke disappointment, because the user felt misled or fooled.

The present studies

In two experiments we investigated user responses to VN and HN products and compared these to user responses to products without visual – tactual incongruities. First, we checked the assumptions made in defining the types of surprising products and tested whether selected products belonged to the types we selected them for. Nine products were selected as stimuli for our experiments. In Experiment 1, users' reactions to the surprising products were explored. Because of the many and sometimes conflicting points of view on measuring surprise, we used different measures of surprise reactions: subjective self reports, observation of exploratory behavior and analysis of vocal expressions. Experiment 2 used an additional measure of surprise, observation of facial expression, to study the surprise evoked by a subset of 6 products. Together, the two experiments provided insight into people's reactions to products with visual – tactual incongruities, as well as a comparison of the methods that can be used to measure surprise.

3.2 Experiment 1: types of surprising products, exploratory behavior and vocal expressions

In experiment 1, we used three ways of measuring surprise (self reports, observing exploratory behavior, and assessing vocal expressions) to explore the differences in the evaluation of various types of surprising products presented in a naturalistic user-product interaction setting.

Method

Participants

Sixty undergraduate students (36 male and 24 female, aged 17-27, mean 22.3) in Industrial Design Engineering participated in the study. Participants were paid for their participation.

Stimuli

Three products were chosen from six different categories (vase, lamp, tablecloth, bench, tile and cup), yielding a selection of 18 different products (Ludden, Schifferstein, & Hekkert, 2004). Within each category, a HN product and a VN product were compared to a third type without visual – tactual incongruities, a 'No Novelty' (NN) product. Using these three types (VN, HN and NN) enabled us to test effects of perceptual incongruity (comparing VN and HN to NN) and effects of differences in familiarity/certainty (comparing VN to HN) on surprise.

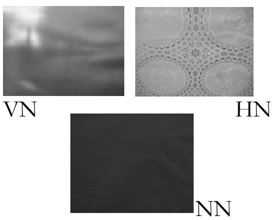
We first tested whether the selected stimuli belonged to the type we selected them for. In this stimulus selection procedure the 18 stimuli were evaluated in two conditions, a 'See'-condition and a 'See and feel'-condition. Unless indicated otherwise, all responses were recorded on 9-point scales with scale end points 'do not agree at all' and 'agree completely'. We used multiple items per variable to obtain more reliable responses (e.g., Churchill, 1979). In the 'See'-condition, participants looked at the products and subsequently evaluated them on Familiarity and Certainty. Familiarity was measured using three items: 'I have seen this (product) before,' 'This (product) looks familiar,' and 'I know many things that resemble this (product).' Certainty was measured using three items; including 'I am certain about how the (product) feels' and 'I am curious about how the (product) feels.' The third question ('How certain are you that you answered the question about the product's material correctly?' on a scale with end points 'very uncertain' and 'very certain') was directly related to a question where participants could select the material of the product from a list of 11 options. In the 'See and feel'-condition, participants looked at the products, touched them, and subsequently evaluated them on Certainty and Surprise. Certainty was now measured using two items: 'When I saw it, I was certain about how the (product) would feel' and 'When I saw it, I was curious about how the (product) would feel.' Three items measured Surprise: 'The (product) felt exactly as I expected when I saw it,' 'I am amazed about how the (product) feels' and 'I am surprised about how the (product) feels.'

All responses on scales were coded 1-9. The responses on the items 'I am curious about how the (product) feels,' 'When I saw it, I was curious about how the (product) would feel' and 'The (product) felt exactly as I expected when I saw it' were reversed. Per variable, responses were then averaged over items. Internal consistency of the resulting scales was evaluated using Cronbach's α ($0.76 < \alpha < 0.95$).

VN Vase: Red and white vase, by Hella Jongerius, porcelain. Because of the visible seams, it looks like it is made of soft plastic, rubber or paper, but it feels less flexible and heavier.

HN Vase: no name, polycarbonate. The shape and decoration of the vase HN is similar to that of a typical crystal vase, but it feels much lighter.

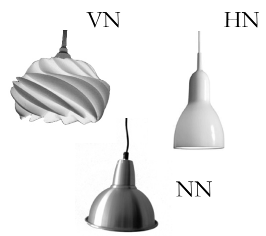
NN Vase: Vasen, by Åsa Gray, glass.



VN Tablecloth: no name, polyamide/ viscose. The way the light reflects on the material makes it look like sticky plastic, but it feels smooth and soft.

HN Tablecloth: no name, polyethylene. Resembles a traditional lace tablecloth, but feels less soft and stickier.

NN Tablecloth: no name, cotton.



VN Lamp: Konko, by Willeke Evenhuis & Alex Gabriel, polyamide. The curved shape and fine texture make it look like cloth or paper, but it feels inflexible, rougher and heavier.

HN Lamp: Softlamp, by Arian Brekveld, polycarbonate. It resembles common ceramic lamps, but it feels flexible.

NN Lamp: Foto, by IKEA, aluminum.

Figure 3.1 Stimuli and specifications. (VN = Visible Novelty, HN = Hidden Novelty, NN = No Novelty)

We tested whether the three types differed as predicted and whether the selected products indeed belonged to the type they were selected for. Eventually, a set of 9 stimuli was selected, consisting of a product of each type in 3 categories: vase, lamp and tablecloth (Figure 3.1). Table 3.1 lists F-tests, mean scores and standard deviations on Familiarity, Certainty and Surprise per product for the reduced set of 9 stimuli. We found main effects of Type of surprising product on all 4 variables ($35.25 < F(2,177) < 72.66$, $p<0.001$. As expected, products in the HN (6.8) and VN (6.7) type scored significantly higher on Surprise than products in the NN (2.7) type. HN (5.7 and 6.4 / 6.1) products scored significantly higher on Familiarity and Certainty (two scores, one for each condition) than products in the VN type (3.0 and 4.5 / 3.8) (paired comparisons with Bonferroni adjustment for multiple comparisons, all $p < 0.05$).

These 9 products were used to obtain product sets containing one product from each type and one from each category. Using all possible permutations, we finally obtained six different product sets.

Table 3.1. Means (M) and Standard Deviations (SD) per Product Obtained in the Stimulus Selection Procedure

	'See' condition				'See and feel' condition			
	Familiarity		Certainty		Certainty		Surprise	
Product (all N = 20)	M	SD	M	SD	M	SD	M	SD
VN Vase	2.7	1.0	4.5	1.5	4.1	2.5	5.1	2.6
HN Vase	5.9	2.2	7.3	1.4	6.3	2.2	7.2	1.5
NN Vase	7.2	1.4	7.9	1.0	8.3	0.8	1.5	0.8
VN Tablecloth	3.8	2.0	5.4	1.8	4.6	1.8	6.4	2.1
HN Tablecloth	6.6	2.0	6.1	2.1	6.2	1.6	6.0	2.4
NN Tablecloth	5.4	1.6	6.3	1.4	6.1	1.1	3.6	0.9
VN Lamp	2.5	1.6	3.6	1.4	2.6	1.4	6.4	1.9
HN Lamp	4.6	1.6	5.7	0.9	5.9	1.8	7.2	1.9
NN Lamp	7.2	1.0	7.1	1.1	7.5	1.3	2.3	1.6

Procedure

Each participant evaluated one set of three products. Before each trial, one set of products was placed in a room. Products were displayed in a way normally encountered in a home interior. Hence, a vase was placed on a table, a tablecloth was spread over a table and a lamp was hung. All products were covered with white cotton sheets. When participants entered the room they were asked to stand at the start position. A microphone was then clipped on, and the participants were instructed to perform simple tasks, during which they were asked to talk aloud. The participant first read the task aloud from a card, after which the product was uncovered and the participant walked over to the product.

Participants started with a practice task in which they performed a task for a thermos flask ('remove the cover of the thermos flask and place it back again'). This practice task was given to the participants to verify that they understood the instructions correctly and to practice talking aloud while performing a task. Participants were aware that the first task was a practice task.

The tasks for the three product categories were constructed in a way that participants would have to touch the products while performing the task.

The task for the vases was: 'Place the flowers next to the vase, in the vase. Then place the vase in the center of the table.' The task for the lamps was 'Turn the light bulb next to the lamp in the lamp fitting. Let the lamp hang down again carefully.' The task for the tablecloths was 'Fold the tablecloth and place it back on the table, folded.' To allow for exploratory behavior, participants were told that they were in no rush performing the tasks.

Video recordings were made while participants performed the tasks. Participants were unaware of the fact that these recordings were made and were asked for their permission to use the video recordings after all tasks were performed. All participants agreed to this.

After each task (including the practice task), the participant filled in a questionnaire. Unless indicated otherwise, responses were given on 9-point scales. First, we asked participants: 'Evaluate how difficult you found the task you just performed' on a scale with endpoints 'not hard at all' and 'very hard'. Subsequently, they answered the 5 questions used for Certainty and Surprise in the 'See and feel'-condition in the stimulus selection procedure. Finally, participants answered the following question about the beliefs they had about the visibility of their surprise reaction: 'Evaluate how well it could be seen that you were surprised' with endpoints 'could not be seen at all' and 'could be seen well.' Participants were instructed to answer this question only if they had experienced surprise, however small. Fifteen additional questions about the participants' opinion of the product were asked. These were not analyzed further.

After filling in the questionnaire, participants were asked to stand at the start position again to perform the next task, and so on. The order in which the participants evaluated the products was randomized and differed between participants.

Data analysis

We constructed scales for Certainty and Surprise in a similar way as in the stimulus selection procedure. Responses on the Certainty and Surprise scales were subjected to between-subjects analyses of variance (ANOVA) with Type of Surprising Product and Product Category as explanatory variables. Because each participant evaluated only a subset of the products, we could not use within subjects ANOVAs. Therefore, we disregarded that each participant had evaluated three products and we analyzed the data as if each person had evaluated one product only. Paired comparisons with Bonferroni adjustment for multiple comparisons were used to examine differences between the types of products.

The video recordings made during the execution of the tasks were analyzed with the help of observation software (The Observer 5.0, Noldus, Wageningen, The Netherlands). Two observers individually rated the videos made during the experiment using two categories of independent variables: exploratory procedures and vocal expressions.

To code exploratory behavior, we used the six exploratory procedures (EPs) Lederman and Klatzky (1987) define for substance related properties: 'tick,' 'stroke,' 'pressure,' 'enclosure,' 'holding' (i.e., lifting) and 'contact' (i.e., simply touching). EPs were only scored when the behavior was not directly related to the task the participant was carrying out. For example, we did not score 'holding' if a participant was holding a vase to move the vase as requested by the task. However, if the participant lifted the vase again (i.e., NOT related to the task) 'holding' was scored. To code vocal expressions (VEs) we used three of the categories used by Reisenzein et al. (2000): 'aha, ok' (verbal acknowledgement), 'oh, wow' (surprise vocalization), and 'haha' (laughter). We added the VE 'not expected,' to score remarks like "I had not expected this" or "It feels different from what I expected." We added the VE 'well, hmm', to score remarks indicating that the participant was unsure about what he or she felt. Other VEs were scored as 'other' and specified in notes. The 'other' VEs generally reflected the participant's opinion on the product or task and will not be discussed further.

A total of 178 videos were scored; 2 videos were lost due to equipment failure. For 57% of the videos, there was complete observer agreement; for 24 % of the videos, one observer coded a behavior whereas the other did not; for 19 % of the videos the two observers interpreted behavior differently. The two observers reviewed the videos on which they disagreed and these were discussed until consensus was reached.

Frequencies with which EPs and VEs were used were calculated per type of surprising product and per product category. For each trial, we also calculated the number of EPs (0-6) and the number of VEs (0-5) that occurred. These numbers were subjected to between subjects ANOVAs with Type of Surprising Product as explanatory variable. Paired comparisons with Bonferroni adjustment for multiple comparisons were used to examine differences between the types of products. In addition, we calculated the proportion of trials in which at least one EP or VE was used.

Results

Differences between product types

Cronbach's α values for Surprise and Certainty indicated that the internal consistency of the scales was sufficient: Surprise, 3 items, $\alpha = 0.96$, and Certainty, 2 items, $\alpha = 0.59$. The 3 x 3 ANOVA with Certainty as the dependent variable showed the expected main effect of Type of Surprising Product ($p < 0.001$, see Tables 3.2 and 3.3 for all analyses results). Paired comparisons showed that all three product types differed significantly on Certainty. As expected, the VN type scored low on this variable, whereas the scores for the HN type and the NN type were higher. The 3 x 3 ANOVA with Surprise as the dependent variable showed an interaction effect of Type of Surprising Product and Product Category ($p < 0.01$) as well as the two main effects. Figure 3.3 shows that for all product categories, the VN and the HN type scored approximately equally high on Surprise and significantly higher than the NN type. This was confirmed by three separate ANOVAs per product category, which all showed a main effect of Type of Surprising Product on Surprise ($8.5 < F(2,57) < 52.12$, all $p<0.001$). The significant interaction is due to the fact that the difference between VN and HN on the one hand and NN products on the other hand is somewhat larger for the vases than for the other product categories.

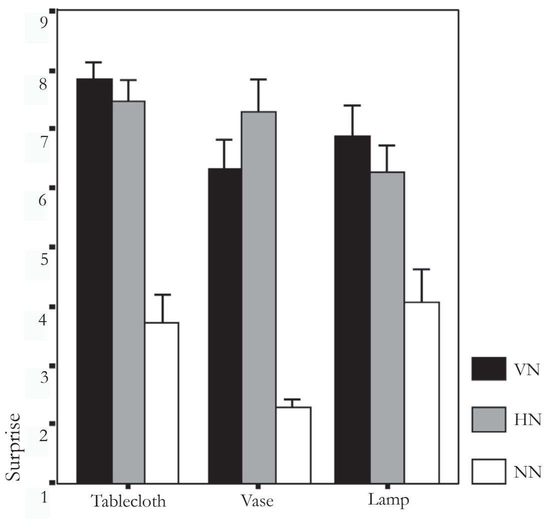


Figure 3.3 Means (+ SEs) for Surprise per Product Category and per Type of Surprising Product.

Table 3.2. F-values for Type of Surprising Product (Type) and Product Category (Category) Obtained from ANOVAs Performed on Data for Experiments 1 and 2

Experiment 1		Type (df = 2, 171)	Category (df =2, 171)	Type x Category (df = 4, 342)
	Certainty	17.4***	1.6	0.9
	Surprise	44.0***	4.5*	3.4**
Experiment 2		Type (df = 2, 234)	Category (df =1, 117)	Type x Category (df =2, 234)
	Certainty	19.4***	0.2	0.8
	Surprise	67.3***	13.7***	6.3**

Note. *p<.05, **p<.01, ***p<.001

Table 3.3. Means (M) and Standard Deviations (SD) Obtained in Experiments 1 and 2 per Type of Product

Experiment 1		VN (N = 60)		HN (N = 60)		NN (N = 60)	
		M	SD	M	SD	M	SD
	Certainty	3.9^a	2.2	5.6^b	2.0	7.1^c	1.8
	Surprise	6.8^a	2.0	6.8^a	2.3	2.6^b	2.0
Experiment 2		VN (N = 40)		HN (N = 40)		NN (N = 40)	
		M	SD	M	SD	M	SD
	Certainty	3.9^a	2.0	5.8^b	2.1	6.6^b	1.8
	Surprise	5.3^a	2.3	6.5^b	2.4	1.9^c	1.1

Note. ^{a,b,c} mean scores with different superscripts were significantly different (p < .05)

Exploratory behavior and vocal expressions

Table 3.4 shows the frequencies with which the specific EPs and VEs were used per type of surprising product. It must be noted that two out of the six EPs, ‘enclosure’ and ‘contact’ were hardly ever used (both 3 times in total, n = 178) as were the VEs ‘aha, ok’ and ‘well, hmm’ (3, and 2 times respectively, n = 178). These EPs and VEs were not included in Table 3.4. Furthermore, in about half of the observations (93 out of 178 observations) no EPs or VEs were observed at all. Therefore, Table 3.4 also lists the percentage of cases per type of surprising product in which at least one EP was used, as well as the percentage of cases in which at least one VE was used.

Results of the analysis of the number of different EPs and VEs used per trial (see Table 3.4) indicate that for VN products significantly more EPs were used than for HN and NN products. Furthermore, significantly more VEs were used for VN and HN products than for NN products. An inspection of the frequencies with which the different EPs and VEs were used suggests that the EPs 'stroke' and 'pressure' were used most for VN products, whereas the VE 'haha' tended to be used most for HN products. This suggests that the behavioral reactions to HN and VN products differ in character.

It must be noted that the use of EPs and VEs varied in frequency and type between the different product categories. For example, the EP 'stroke' was often used for the product category tablecloth (40 times), whereas it was used only 8 times for the two other product categories, lamp and vase. On the other hand, the EP 'pressure' was used 8 and 10 times for the lamps and the vases, respectively, but was never used for the tablecloths.

Table 3.4. Frequencies of Exploratory Procedures and Vocal Expressions in Experiment 1 per Type of Product

	VN N = 59	HN N = 60	NN N = 59	*F*
Exploratory Procedures (Eps)				
tick	2	2	0	
stroke	31	15	10	
pressure	14	4	0	
holding	6	9	0	
Mean number of different EPs used per trial†	1.0^a	0.5^b	0.2^b	14.9***
% Cases with at least 1 EP	59	45	20	
Vocal Expressions (VEs)				
'haha'	3	11	0	
'oh, wow'	5	4	0	
'not expected'	16	18	0	
Mean number of different VEs used per trial†	0.5^a	0.6^a	0.0^b	13.5***
% Cases with at least 1 VE	36	40	2	

Note. ***p < .001, † all SDs were about 0.1, ^{a,b} mean scores with different superscripts were significantly different (p < .05)

Measurement of surprise

We calculated the Pearson correlation coefficient over individual responses between the question about participants' beliefs about the visibility of their surprise reaction and their self reports for Surprise. Note that participants were instructed to answer the question about their belief about the visibility of their surprise reaction only if they had felt a surprise, however small. These two measures were correlated considerably ($r = 0.60$, $p < 0.01$, $n = 143$).

We also assessed the correspondence between the self reports for Surprise and the behavioral and verbal measures as reflected in the coding of EPs and VEs, by calculating point biserial correlations, r_{pb} ($n = 178$) (Chen & Popovich, 2002). Results are presented in Table 3.5. We found significant positive correlations for four EPs (tick, stroke, pressure, and holding) and for three VEs ('oh, wow', 'haha', and 'not expected'). This indicates that these EPs and VEs were used more often when a higher level of surprise was reported.

Table 3.5. Point Biserial Correlations (r_{pb}) from Experiments 1 and 2 between Self-Reports of Surprise and Exploratory Procedures, Vocal Expressions and Facial Expressions

	Experiment 1 (N = 178)		Experiment 2 (N = 119)	
	r_{pb}	p	r_{pb}	P
Exploratory Procedures (Eps)				
tick	0.14	0.05	0.11	0.21
stroke	0.31	0.00	0.18	0.05
pressure	0.20	0.00	0.12	0.19
holding	0.19	0.01	0.18	0.04
Vocal Expressions (VEs)				
'haha'	0.27	0.00	0.29	0.00
'oh, wow'	0.26	0.00	0.31	0.00
'not expected'	0.44	0.00	0.13	0.15
Components of Facial Expression (FEs)				
widened eyes			0.23	0.01
opened mouth			0.12	0.21
raised eyebrows			0.24	0.01
raised mouth corners			0.33	0.00
lowered mouth corners			0.07	0.47
lowered eyebrows			0.14	0.15

Note. df =177 for Experiment 1, *df* =118 for Experiment 2

Discussion

Our analyses show that products with visual – tactual incongruities can evoke surprise reactions. Furthermore, they show that the two different types of products with visual – tactual incongruities, VN and HN, are distinguishable and evoke different affective and behavioral reactions. This suggests that the familiarity of products and the resulting certainty of expectations influence the way in which people respond to surprising products.

The correlation between the variable Surprise in the questionnaire and the variable reflecting participants' beliefs about the visibility of their surprise reaction was high, indicating that the more participants felt surprised, the more they expected this to be visible to others. This is in line with reports by Reisenzein et al. (2000), who found that the majority of their participants (77%, 80% and 100% in separate experiments) thought that their surprise reaction was visible on their face.

We only observed exploratory behavior in a minority of cases. Nevertheless, some participants did use additional exploratory behavior, suggesting that they needed a second tactual experience to 'check' what they felt the first time. We found significant correlations with the self reports for Surprise for the four EPs that were used most. This suggests that when a higher level of surprise is felt, people are more inclined to use these EPs. Similarly, we found significant correlations for the three VEs that were used most. It seems that participants used more VEs when they felt more surprised. Nevertheless, all these correlations were quite low, which is probably due to the small number of EPs and VEs that was used (see Chen & Popovich, 2002). This suggests that the use of exploratory behavior and vocal expressions is indeed related to the subjective experience of surprise, but the absence of exploratory behavior does not necessarily imply absence of a surprise experience.

3.3 Experiment 2: facial expressions of surprise

The results of Experiment 1 show that people expect that the surprise they experience is visible to others. Similar to exploratory behavior and vocal expressions, facial expressions (FEs) may provide an objective measure of surprise. However, previous studies on surprise that used the coding of facial expression did not always yield useful results. Vanhamme (2000) and Reisenzein et al. (2000) both reported a lack of association between facial expression and other measures, such as verbal reports. They also reported that only a small number of participants showed one or more of the components of a surprise expression. Vanhamme suggested several reasons that may explain the low number of participants that showed surprise, such as the lack of sociality within the research setting that could restrain participants from showing a facial expression.

The types of surprising stimuli used in these studies are hardly comparable to the real-life products we used in our experiments. Therefore, we cannot yet rule out facial expressions as indicators of surprise in reaction to our stimuli. To compare the coding of facial expression to the measures used in Experiment 1, we set up a second experiment, specifically aimed at evaluating the usefulness of facial expressions.

Method

Participants

Participants were 40 students in Industrial Design Engineering (24 male and 16 female, aged 18-24). Participants were not paid for their participation.

Stimuli

We used the same products as in Experiment 1, but from two product categories only (vase and tablecloth). The products were used to obtain six sets of three products, containing one product from each type of surprising products. Thus, each set contained either two vases and one tablecloth or two tablecloths and one vase. Each participant was presented with one set of products. The order in which the products were offered was randomized.

Procedure

Two chairs were placed in the room at an angle of 90° between them, one for the participant and one for the experimenter. A low table was placed in between the two chairs at approximately 1 m distance from the participant's chair. A camera was hidden inside a foam model and placed between other foam models in a cupboard opposite the participant. In this way, the camera was almost invisible while it had a clear view of the participant's face.

When entering the room, the participant was asked to sit in a chair. To facilitate a social environment, the experimenter sat next to the participant. The experimenter placed the first product covered on the table, while avoiding production of any contact sounds. Vases were covered by a carton box, tablecloths were covered by a cotton sheet. Subsequently, the experimenter removed the cover and instructed the participant to look at the product for approximately 2 s, and then touch the product and lift it up. The participant was allowed to explore the product ad libitum. The product was then covered again after the participant placed it back on the table.

Subsequently, the participant filled out a questionnaire. The five questions about Surprise and Certainty from Experiment 1 were included in this questionnaire. Additionally, four questions about the color of the product and about how the participants felt about the product were used as fillers. These questions were not analyzed further. After evaluating the first product, the procedure was repeated for the second and third product. The complete task was recorded on video. Performing the three tasks took approximately 10 min.

Data analysis

All video recordings were edited, so that each film clip started when the product was uncovered and ended when the participant placed the product back on the table. This film clip was copied and converted to slow motion, resulting in short film clips that showed the same moment two times, once at true speed and once in slow motion. Using these edited videos, two observers individually coded the occurrence of the three components of a facial expression of surprise as described by Ekman and Friesen (1975) and used by Reisenzein et al. (2000) and Vanhamme (2000). For each film clip, coders decided whether or not they had seen movement in three different elements of the participant's face that were expected to reflect a surprise reaction; (1) eyebrows (coded raising or lowering), (2) mouth (coded opening or closing), (3) eyes (coded widening or narrowing). We added a fourth facial element, to be able to see whether or not participants felt joy: Coders decided whether or not they had seen movement in (4) mouth corners (coded up or down). If observers saw different components of facial expressions (FEs) following each other, they indicated the order in which they were observed.

A total of 119 videos were scored; 1 video was lost due to equipment failure. Observer agreement was complete in 40.2% of the videos. For 26.5% of the videos, one of the observers coded movement in the face whereas the other did not, and for 33.3% of the videos, both observers coded different movements. With a procedure similar to the one used in Experiment 1, one data set was created on which both observers agreed.

The film-clips were also used to code exploratory behavior. The EPs and VEs defined in Experiment 1 were used. Two observers individually scored the videos. Observer agreement was complete for 48.7% of the videos. For 25.6% of the videos, one observer coded a behavior whereas the other did not and for 25.6% of the videos the two observers interpreted behavior differently. Again, one data set was created on which both observers agreed.

Statistical analyses were similar to those used in Experiment 1. In the analysis of FEs, a distinction was made between components of surprise (SFEs) and other facial expressions. In addition, we calculated the number of different SFEs (0-3) that were used per trial and that was used as the dependent variable in a between subjects ANOVA.

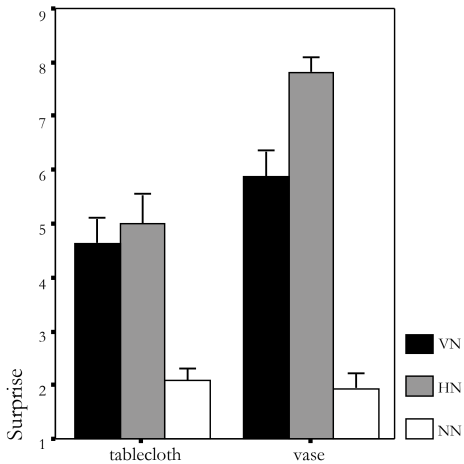


Figure 3.4 Means (+ SEs) for Surprise per Product Category and per Type of Surprising Product from Experiment 2.

Results

Differences between product types

Similar to Experiment 1, Cronbach's a for the two scales of Experiment 1 revealed that the internal consistency of the scales was sufficient: Surprise, 3 items, a = 0.93; and Certainty, 2 items, a = 0.67. We used 2 x 3 between-subjects ANOVAs with Product Category and Type of Surprising Product as explanatory variables and Certainty and Surprise as dependent variables to check our manipulation (results are reported in Table 2). The analyses show a main effect of Type of Surprising Product on Certainty, which is due to higher Certainty scores for HN and NN than for VN products. We found an interaction effect and two main effects for Type of Surprising Product and Product Category on Surprise. Analogous to Experiment 1, Surprise responses to VN and HN products are consistently higher than to NN products, as can be seen in Figure 3.4. This was confirmed in two separate ANOVAs run per product category, which showed main effects of Type of Surprising Product ($13.25 < F(2,57) < 65.0$, all $p<0.001$). The only deviation with respect to the results from Experiment 1 was a significant difference between HN and VN products on Surprise (Table 3.3), which is mainly prominent for the vases (see Figure 3.4). A lower score on Surprise was found for VN products, as hypothesized earlier.

Table 3.6 Frequencies of Using Exploratory Procedures, Vocal Expressions and Facial Expressions in Experiment 2 per Type of Product

	VN N=40	HN N = 40	NN N=39	F
Exploratory Procedures (EPs)				
tick	10	5	4	
stroke	30	24	14	
pressure	5	2	2	
holding	5	10	3	
Mean number of different EPs used per trial†	1.3^{a}	1.1^{ab}	0.6^{b}	6.5**
% Cases with at least 1 EP	85	75	51	
Vocal Expressions (VEs)				
'haha'	3	9	1	
'oh, wow'	0	6	0	
'not expected'	3	5	0	
Mean number of different VEs used per trial†	0.2^{a}	0.5^{b}	0.1^{a}	9.4***
% Cases with at least 1 VE	15	40	5	
Components of Facial Expression of Surprise (SFEs)				
widened eyes	4	6	1	
Opened mouth	6	10	3	
raised eyebrows	3	5	1	
Mean number of different SFEs used per trial†	0.3^{ab}	0.5^{a}	0.1^{b}	3.7*
% Cases with at least 1 SFE	25	38	8	
Other components of facial expression (FEs)				
raised mouth corners	10	19	5	
lowered mouth corners	6	4	3	
lowered eyebrows	12	5	0	

Note. $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$, † all *SD*s were about 0.1, ^{a,b} Means with different superscripts were significantly different ($p < 0.05$)

Exploratory behavior and vocal expressions
Table 3.6 shows the number of EPs and VEs that were used for each type of surprising product as well as the mean number of EPs and VEs that was used per trial. Similar to what we found in Experiment 1, the EPs 'enclosure' and 'contact' and the VEs 'aha, ok' and 'well, hmm' were hardly ever used (1, 3, 0 and 3 times, respectively). Therefore, these were not included in Table 6. Table 3.6 also lists the percentage of cases per type of surprising product in which at least one EP, or one VE was used.

Notably, participants seem to have used EPs more often than in Experiment 1. However, differences between the types of surprising products are largely the same. The F- test (reported in Table 3.6) shows that for VN products significantly more EPs were used than for NN products. Furthermore, significantly more VEs were used for HN products than for VN and for NN products.

Facial expression
Table 3.6 also contains the frequencies with which the components of facial expression of surprise were used, as well as the mean number of SFEs used per trial per type of surprising product. The percentage of cases in which at least one SFE was used is also given. Individual elements of facial expressions of surprise were seen in about one third of the cases with surprising products. A full expression of surprise, i.e. raised eyebrows, widened eyes and opened mouth, was seen in two cases only (once for a HN product and once for a NN product). In 13 cases (3 for VN, 7 for HN and 3 for NN) two components were observed simultaneously. In total, raised eyebrows were seen in 9, widened eyes in 11 and opened mouth in 19 cases. The F-test shows that for HN products the components of facial expression of surprise were used more often than for NN products (see Table 3.6).

Frequencies for three other components of facial expression that were originally not defined as components of the surprise expression are also listed in Table 3.6: raised mouth corners (i.e., smiling), lowered mouth corners, and lowered eyebrows (i.e., frowning). The frequency count suggests that these other FEs were more often observed for HN and VN products than for NN products. Raised mouth corners were seen in 34 cases, most often for HN products. Lowered eyebrows were seen in 17 cases, most often for VN products. Narrowed eyes and closed mouth were hardly ever seen (in total in 0 and 5 cases respectively) and are therefore not listed in Table 3.6.

For 17 cases observers reported that they had seen two consecutive components of facial expression. In all these cases, the first expression was one of the components of surprise and the other was either raised mouth corners or lowered eyebrows. Again, most of these cases comprised HN (10 cases) and VN (5 cases) products.

Measurement of surprise

Similar to Experiment 1, the different measures of surprise in this experiment were compared by calculating point biserial correlations (n = 119) between the subjective responses on the variable Surprise and the coded behavior (see Table 3.5). We found significant positive correlations for the EPs stroke and holding, and for the VEs 'haha' and 'oh, wow.' Two of the three components of facial expression that were expected to reflect a surprise reaction (widened eyes and raised eyebrows) correlated significantly with the subjective responses, whereas the third (opened mouth) did not. We also found a significant correlation of raised mouth corners with the subjective responses on the variable Surprise.

Discussion

In correspondence with the results of Reisenzein et al. (2000) and Vanhamme (2000), we hardly ever observed a complete facial expression of surprise. In addition, we found one of the three components in only a low percentage (< 37.5%) of cases in which a surprising product was presented. Furthermore, correlations of components of facial expressions with the subjective measures for surprise were low, if significant. Apparently, although participants subjectively define the experience they feel as surprise, and although they think others can see this surprise, it is not always visible to others through their facial expression. Possibly, participants thought that others would be able to see their surprise reaction, because they felt movement in facial musculature, whereas this movement was too subtle to be actually visible. Alternatively, participants may have expected that their surprise reaction was visible through other behavior than their facial expression. For example, participants may have felt that they froze for a moment when they were surprised and may have expected this to be visible to others.

Several reasons can account for the absence of a facial expression of surprise. Possibly, the surprises evoked by our stimuli were not sufficiently intense. It could also be argued that the display of surprise was suppressed because the surprise immediately evoked other emotions. From the analysis of the videotapes, it seemed that instead of or immediately after raising their eyebrows, widening their eyes or opening their mouths to express their surprise, participants showed interest or puzzlement by lowering their eyebrows (i.e., frowning), or joy by raising their mouth corners (i.e., smiling) (Darwin, 1873; Ekman & Friesen, 1975). These subsequent emotions may thus have interfered with the facial expression of the initial surprise reaction.

3.4 General discussion

Figure 1.5 depicts the different elements that a surprise experience can comprise and describes the mechanism of surprise through visual – tactual incongruity. Our experiments were aimed at testing the predicted surprising effect of visual – tactual incongruities (comparing VN and HN products to NN products), at testing the effects of familiarity/certainty on the surprise reaction (comparing VN products to HN products) and at measuring and comparing the different elements of a surprise reaction.

It must be noted here that participants were students in Industrial Design Engineering. Possibly, they differ from the general population in their knowledge on and interest in materials' sensory characteristics. We have tried to limit possible knowledge effects by selecting mainly first year students as participants. Probably, their knowledge of material properties was for the most part comparable to that of the average consumer. However, our participants may have had a higher level of interest in products in general or in their specific material properties. To some extent, this may have had an effect on our results. For example, it is not unlikely that the average consumer would be less interested in exploring the products presented than our participants were.

Nevertheless, the differences in reactions found for the different types of surprising products remain of interest. Both experiments suggest that products with visual – tactual incongruities evoke surprise reactions and that, to some extent, VN and HN products are distinguishable and evoke different affective and behavioral reactions. This suggests that the familiarity of products and the resulting certainty of expectations influence the way in which people respond to surprising products. These results show that it is worthwhile to study people's affective reaction to incongruent information perceived through vision and touch, next to studying the integration process of combining visual and tactual information.

Measuring surprise

We measured several processes and actions that may take place during a surprise reaction. Some of these measures proved to be more valuable than others. The self-reports of Surprise clearly differed between surprising (HN and VN) and not surprising (NN) products, suggesting that these measures were relevant. However, measures of behavior that were expected to reflect a feeling of surprise (coding of exploratory behavior, vocal expressions and facial expressions), provided less clear results. This was mainly caused by the relatively low frequency of occurrence of the observed behavior. Additionally, correlations between self-reports and exploratory behavior, vocal expressions and components of facial expression were low to moderate. Therefore, we conclude that observing exploratory behavior, vocal expressions or components of facial expression are less sensitive measures of surprise than self-reports

Nevertheless, these measures do give insight into the different ways in which people react to surprising events. For example, participants seem to use more exploratory behavior when they report a larger felt surprise, in particular when they are confronted with a product that looks unfamiliar (VN). This exploratory behavior provides additional information about the way users interact with products when they are surprised. The difference in interaction is likely to affect users' evaluation of these products. Similarly, analysis of components of facial expression seems to provide us with information about people's evaluation of the surprising products. Our finding that participants may show a sequence of facial expressions, starting with a surprise component, followed by smiling or frowning is in line with Silvia's (2005) 'sequential process of appraisal.' Applying his views to products with visual – tactual incongruities implies that a vase with unexpected tactual characteristics can be appraised as surprising upon touching the product and can next be appraised as interesting because the user wonders what material has been used. The suggestion that a surprise reaction to a product has two stages was further developed into a model in which surprise (first stage) can lead to different emotions (second stage) (see Chapter 6)).

Visual – tactual incongruity and surprise

Our experimental procedures were designed so that we could compare responses to products with visual – tactual incongruities (HN and VN) to products without visual – tactual incongruities (NN). For HN and VN products, higher levels of surprise were reported than for NN products. This is in line with our prediction that the surprise has resulted from visual – tactual incongruity, as described in the introduction and depicted in the left part of Figure 1.5.

Reactions to products of the VN and HN type also appear somewhat different. Results of Experiment 2 suggest that there are differences in the frequencies of components of facial expression for HN and VN products. Additionally, our results suggest that participants used more exploratory behavior while interacting with VN products (Experiment 1), and more vocal expressions when interacting with HN products (Experiment 2).

Possibly, people explored VN products more, because they enjoyed exploring these products or because they wanted to discover the exact material properties of these products. Possibly, they needed more exploration to understand the surprise. On the other hand, for HN products, it seems that the experienced surprise upon touching the product is immediately understood and further exploration is unnecessary. With HN products people seem most surprised and the increase in the VE 'haha' and the FE 'raised mouth corners' for HN products suggests that these types of products are the most powerful in making people laugh.

Our findings suggest that the way in which people respond to surprise through visual – tactual incongruity is not uniform. Product designers will be better able to design interesting, amusing, fascinating or otherwise pleasantly surprising products if they understand how these different reactions are brought about.

Chapter 4 was largely based on: Ludden, G. D. S. & Schifferstein, H. N. J.(2007) Effects of visual - auditory incongruity on product expression and surprise. International Journal of Design, 1(3), pp 29-39.

Chapter 4
Visual - auditory incongruity

4.1 Introduction

In one of his symphonies, later nicknamed the "surprise symphony" (Symphony No. 94 in G Major), the famous composer Joseph Haydn used a loud "surprise" chord after a relatively tranquil opening. Following the chord, the music immediately returns to tranquility. Haydn incorporated a surprise in this music piece to make it sound new and interesting to the public (Griesinger, 1963). This anecdote illustrates the importance of sound patterns in perceiving music. More specifically, it illustrates how a sound that listeners are not expecting to hear can influence the listeners' experience of a piece of music.

As in music, patterns in the sounds of everyday products are important for the perception of these products. After all, every time people with normal hearing use products, they hear sounds. Whether or not the perceived sounds are as expected will influence how people evaluate the products. For example, a product that makes an unexpected irregular sound may lead the user to suspect that the product is not functioning well. Nevertheless, for a long time, the design of product sounds was neglected in the product design process, because designers and engineers were focusing only on reducing the sound level rather than on the specific characteristics of sounds (Özcan & van Egmond, 2004).

Traditionally, studies on auditory perception have not focussed on everyday sounds, such as product sounds. However, this area has gained attention recently. In an overview of research on everyday sounds (Giordano, 2003), most studies were found to investigate the recognition of sound source features, such as shape, material, and hollowness. For example, Kunkler-Peck and Turvey (2000) found that participants were able to identify shape and material properties at levels above chance upon hearing impact sounds. Lederman (1979) compared the effectiveness of tactile and auditory information in judging the roughness of a surface. Judgments on the basis of auditory information were similar, but not identical, to corresponding judgments for tactile information. When both sources of information were available, subjects tended to use the tactile cues. Zampini and colleagues (Zampini, Guest, & Spence, 2003; Zampini & Spence, 2004, 2005) showed that sound characteristics can influence the perceived tactual characteristics of products. In their study, participants heard real-time manipulated sound through headphones as they used the products. By increasing the overall sound level and/or by amplifying the high frequencies of product sounds, electric toothbrushes were perceived as less pleasant and rougher, sodas as more carbonated, and potato chips as crisper and fresher.

Next to physical characteristics, such as color, size, or shape, people also perceive expressive or personality characteristics of products, for example, the toughness or the femininity of a product (Govers, Hekkert, & Schoormans, 2004). Janlert and Stolterman (1997) emphasized that all the senses add to the 'character of things.' Hence, besides enabling people to identify certain material properties of objects, sounds can also influence their perceived expressive characteristics. With respect to visual appearance, the car on the left in Figure 4.1 may be perceived as cute, whereas the car on the right may be perceived as tough. Similarly for sounds, a product that makes a very soft, high-pitched sound may be perceived as cute, whereas a product that makes a rattling, low-pitched sound may be perceived as tough.

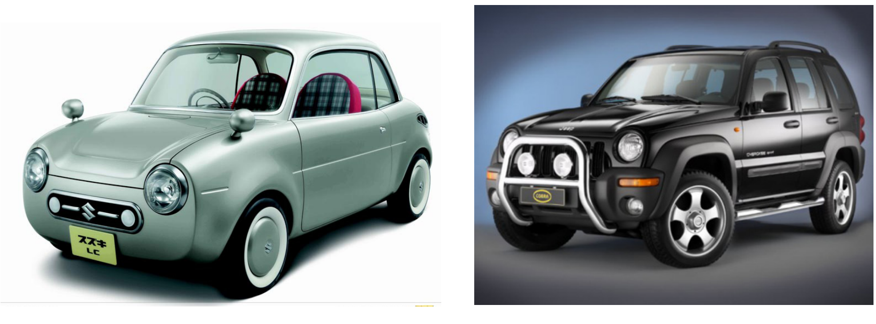


Figure 4.1 A 'cute' car (left) and a 'tough' car (right).

Designers can manipulate a product's expression to influence the experience of a product (van Rompay, Hekkert, Saakes, & Russo, 2005). For example, the flimsy sound of a car door closing may lead to low expectations of the car's driving characteristics. Lageat et al. (2003) investigated the perceived luxury of sounds produced by lighters. For a classic flip-open lighter, they found that luxury was associated either with sounds that were matte, even, and low in pitch, or with sounds that were clear, resonant, and clicking. Harley Davidson even tried to register their engine sound as a trademark (Lyon, 2003; Sapherstein, 1998) in order to maintain an exclusive 'Harley Davidson experience.'

Designers are usually aware of the effect of a product's appearance on its expression but are generally much less concerned with how a product's sound influences this expression. This may lead to a perceived mismatch between the visual and auditory expression of a product. As a result, the total product experience may not be the one that the designer tries to achieve. In addition, a sound that is not congruent with a product's appearance may cause a surprise reaction. For example, a small vacuum cleaner that generates an incredible amount of noise during usage may surprise users. Similarly, a pink hair dryer with rounded curves that expresses softness may surprise users when its sound is rattling and rough.

In this paper, we study the effects of (in)congruent sounds on product expression by examining people's reactions to the sounds of electronic products. Upon seeing the product, the perceiver will form an expectation of how the product will sound when it is turned on. Such an expectation may not always be equally accurate. For electronic products, the sound is often a result of many interacting mechanical parts, which makes it hard to predict the exact sound properties. Tolman (1932) states that expectations can be formed based on "memories of actual experiences, perceptions of current stimuli, and inferences drawn from related experiences such as trial of other objects." In the case of unfamiliar electronic products, previous experiences with similar products will largely determine whether someone can form an accurate expectation. Later, when the actual sound of the product is heard, this actual perception will be compared to what was expected. In those cases where the deviation between the actual perception and the expectation is large, a surprise reaction can occur, which can comprise multiple physiological and behavioral reactions (Ludden, Schifferstein, & Hekkert, 2007).

The present study

The present study comprises three separate tests. Together, they tested whether the expressions of product sounds contribute to the expressions of products. Furthermore, they investigated how sensory (in)congruity between a product's appearance and its sound is evaluated. Finally, the experiments show several steps that are likely to occur when designing product sounds, such as adjusting previously designed sounds to implement them into a product and determining its effect on the product's expression. As such, our experiments serve as a case-study that provides insight into the product sound design process.

We manipulated sounds of electronic products so that they were either congruent or incongruent with the visual expression of the product. We chose to use electronic products, because people claim that the sound is relatively important for such products during usage (Schifferstein, 2006). Therefore, we expect that sound characteristics will have a large influence on the expressions of these products. In addition, it is relatively easy to manipulate the sounds of these products.

We selected products from two product categories, two juicers and two dust busters. These two product categories were chosen, because they contain products with a wide range of different expressions. From these categories, we selected pairs of products with contrasting expressions: flimsy versus robust for juicers and tough versus cute for dust busters (see Table 4.1). We selected these two pairs of expressions, because they were easily recognizable in the wide ranges of products and also because these characteristics were relevant for the product sound. The flimsy versus robust contrast seems particularly relevant, because several researchers have mentioned that the sound of a product has an effect on the perceived quality of that product (see e.g., Janlert & Stolterman, 1997). Furthermore, the tough versus cute contrast is often mentioned as a straightforward example of opposites in product expression (e.g., Govers, 2004). Therefore, we expected it to be easily recognizable.

We selected a juicer that was relatively small; had simple, rounded shapes; and was made out of white and transparent plastic; giving it a cheap, flimsy appearance (brand: AFK). In contrast to this product, we selected a juicer that had a tall, vertical main form; was shaped with smooth curves; and had a silver metallic and black color combination; making it look robust, stylish, and expensive (brand: Clatronic). We selected a dust buster that was relatively

big, had sharp edges, and a silver metallic color, together creating a powerful, tough, masculine appearance (brand: Hoover). We also selected a dust buster with mainly round, curved shapes and a creamy white and orange color combination, making it look cute, round, and feminine (brand: Philips Pelican).
For the first experiment, two new sounds were generated for each product, one that was expected to fit the visual expression of the product better than the actual sound and one that was expected not to fit the visual expression. In the experiment, we determined the degree of fit between the sounds and the visual appearance of each product. In the second experiment, we re-created the fitting and non-fitting sounds using a comparable, but slightly different procedure to be able to use and test these sounds in real-time. We pre-tested the new stimuli to evaluate whether they still had the desired properties. In the main experiment, we tested whether or not the incongruent sounds were found surprising, and we assessed the effects of the (in)congruent sounds on the evaluation of the product expression.

4.2 Experiment 1: expression of product sound and product appearance

Experiment 1 was set up to test whether we were able to manipulate the perceived expression of product sounds and to test whether sounds that were evaluated as more congruent in expression with the appearance of the product were also evaluated as a better fit for the product. Therefore, participants evaluated the visual expressions of the four selected products, the expression of the manipulated sounds, and they determined whether or not the manipulated sounds matched the products.

Method

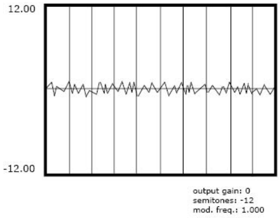
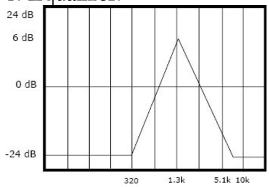
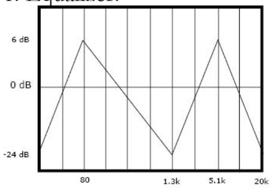
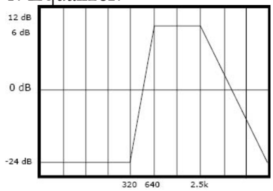
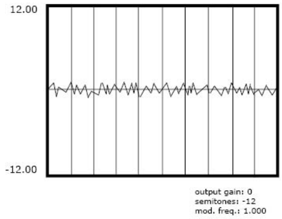
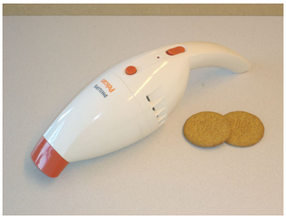
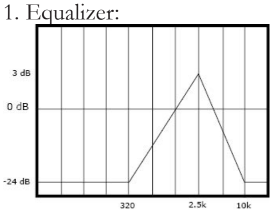
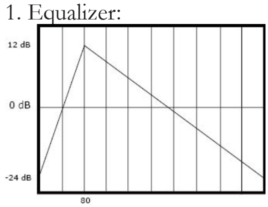
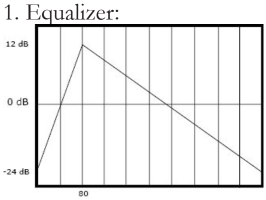
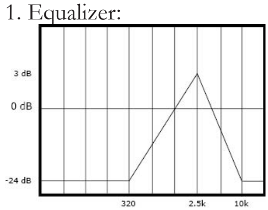
Participants

Forty participants (17 males and 23 females, aged 21-47, mean 24.8) participated in this experiment. All but six participants were students from the Department of Industrial Design Engineering at Delft University of Technology.

Stimuli

For the evaluation of the visual expression of the products, color photographs (10x15 cm) were used. As a size reference, the juicers were photographed together with an orange and the dust busters together with two

Table 4.1 Products used as stimuli, key expressions, and sound manipulations

Product (expression)	Manipulation F-sound	Manipulation NF-sound
 AFK (cheap, ordinary, flimsy)	1. Vibrato:  2. Volume: -3.49 (67%)	1. Equalizer:  2. Pitch shift: semitones: -2 3. Volume: -6.54 (47.1%)
 Clatronic (expensive, exclusive, robust)	1. Equalizer:  2. Pitch shift: semitones: -2 preserve duration 3. Volume: 4.58 (169.4%)	1. Equalizer:  2. Vibrato: 
 Pelican (feminine, round, cute)	1. Equalizer:  2. Pitch shift: semitones: -2 cents: -20 pres. duration	1. Equalizer:  2. Pitch shift: semitones: 3 cents: 50.0 pres. duration
 Hoover (masculine, sharp-edged, tough)	1. Equalizer: 	1. Equalizer:  2. Pitch shift: semitones: -6 cents: -20 pres duration

biscuits (Table 4.1).

For each product, 3 different sounds were used. Besides the actual sound (A-sound) of the product, a sound 'fitting' (F-sound) and a sound 'not fitting' (NF-sound) the product's visual expression was created. We started with the actual recorded sounds of the products to make the F-sounds and NF-sounds. We recorded the sounds during product usage using a Sony Minidisc recorder. The recordings for the juicers were made by placing the microphone of the recorder at a distance of approximately 30 cm from the product as someone squeezed an orange. The recordings for the dust busters were made while someone was vacuuming the surface of a table. All recordings were 13-15 s long.

The sounds were digitally manipulated using Sony Sound Forge. We mostly manipulated the sounds by boosting some frequencies in the sound spectrum and attenuating others, as shown by the equalizers in Table 4.1. For each product category, the sounds were manipulated to emphasize or attenuate their specific expressive characteristics. Therefore, the sounds of the juicers were manipulated based on the expressive characteristics of cheap, flimsy as opposed to expensive, robust, whereas the sounds of the dust busters were manipulated based on the expressive characteristics of tough, masculine as opposed to cute, feminine. Table 4.1 shows that the manipulations for the F- and NF-sounds were cross-linked within each product category. For example, we used similar manipulations to create the F-sound for the Pelican dust buster and the NF-sound for the Hoover dust buster. We used a vibrato for some of the sounds of the juicers to increase the irregularity of the sound. This irregularity was expected to make the products sound cheaper and flimsier. We used a pitch shift for some of the sounds, which resulted in higher or lower pitched sounds. We expected higher sounds to sound cuter and more feminine and lower sounds to sound tougher and more masculine. Finally, for some sounds we adjusted the volume, resulting in softer or louder sounds that were expected to affect the perceived robustness of the products.

Each participant was presented with all stimuli for a single product category: each participant first evaluated 6 sounds, then 2 pictures, and finally 2 sets of a combination of one picture with its three sounds. The order in which the stimuli were presented was randomized within the stimulus types. Nineteen participants evaluated the stimuli for the juicers, and 21 participants evaluated the stimuli for the dust busters.

Procedure

Upon entering the room, participants were seated in a chair in front of a table with an IBM laptop. The participants were instructed to listen carefully to the sounds and to answer the questions intuitively. Participants were provided with a wireless headphone (Philips HC 8410) and carried out the task autonomously. The participants could play the sound as many times as they wanted by clicking a button on the screen. The next screen showed the first 7 of a total of 14 nine-point semantic scales. On the following screen, the remaining 7 scales were presented. We selected items that measured aspects of the expressive product characteristics (cute - tough and flimsy - robust) and that were relevant for both visual and auditory stimuli. The 14 scales had endpoints: unobtrusive – obtrusive, powerful – powerless, extrovert – introvert, small – big, quiet – busy, robust – flimsy, ordinary – exclusive, masculine – feminine, not sharp – sharp, expensive – cheap, tough – cute, not stylish – stylish, funny – serious, and round – edgy. The scales were presented in two different orders to different participants. After evaluating all 6 sounds, the two pictures were evaluated with the same procedure.

Finally, combinations of one picture with three sounds belonging to that product were presented. Participants could play the sounds in random order and were allowed to listen to all three sounds as many times as they wanted. Subsequently, participants rated the degree to which the sounds fitted the picture on a nine-point scale with end points 'does not fit at all' – 'fits very well.' This procedure was repeated for the second combination of a picture with three sounds. The complete task took between 20 to 30 minutes.

Results

For each product, repeated measures ANOVAs were carried out on the ratings for how well the sounds fit the pictures (Degree of fit). We examined mean differences between the three sounds for each product in paired comparisons with Bonferroni adjustment for multiple comparisons (Table 4.2).

We found main effects of Type of sound on Degree of fit for the Pelican dust buster and for the AFK and Clatronic juicers. A successful manipulation would mean that the F-sounds score significantly higher on Degree of fit than the NF-sounds. Therefore, we first examined differences between these F- and NF-sounds. From Table 4.2, we see that for the Clatronic juicer and the Pelican dust buster, ratings for the F-sounds were significantly higher than for the NF-sounds. However, for the AFK juicer, ratings for the NF-sound were not significantly lower than those for the F-sound. Because the lowest fit was found for the A-sound of the AFK juicer, we used the A-sound as the NF-sound for this product in all further analyses.

Table 4.2 Mean scores and F-values for Degree of fit

Degree of fit	F-sound	NF-sound	A-sound	F-value
AFK	**6.1**^{a}	5.4^{a,b}	**4.3**^{b}	3.86*
Clatronic	**6.5**^{a}	**3.1**^{b}	6.7^{a}	22.36**
Pelican	**7.2**^{a}	**2.6**^{b}	4.6^{c}	37.47**
Hoover	**5.6**^{a}	**4.3**^{a}	5.8^{a}	1.48

^{a,b,c} Means with different superscripts were significantly different (horizontal comparison, p<.05).
* Significant main effect at the .05 level, ** at the 0.01 level.
Sounds with means in bold were re-created in Experiment 2.

Responses on the 14 semantic scales were used to construct evaluative factors. Separate Principal Component Analyses were carried out on the data from Experiments 1 and 2. The original analyses on the data from Experiment 1 led to three factors, whereas the analyses on the data from Experiment 2 led to only two factors. The latter factors were highly similar to two of the factors that we found in Experiment 1. Therefore, we decided to construct two scales based on the items with high loadings on these two factors from both analyses. The consistency of these scales (Cronbach's α) proved to be sufficient. The two factors reflect the two dimensions we used to select the stimuli: Quality (5 items with positive end points powerful, robust, exclusive, expensive, and stylish; Cronbach's $\alpha = 0.80$), and Cuteness (6 items with positive end points small, quiet, feminine, not sharp, cute, and round; $\alpha = 0.79$). The means for the 4 products on these scales (for 1 picture and 3 sounds per product) are given in Table 4.3.

The expressions of the appearances of the 4 products can be evaluated by comparing the means in the 2nd column of Table 4.3 vertically. These picture data confirm our expectations that the Clatronic juicer appears superior in quality over the AFK juicer and that the Pelican dust buster looks cuter than the Hoover dust buster. A difference in expression that we had not anticipated was that the AFK juicer looks cuter than the Clatronic juicer (paired two-tailed t-test, $36 < df < 40$, all $p<0.001$).

For each product, the sound data were subjected to separate repeated measures ANOVAs for Quality and Cuteness with Type of sound (3 levels) as the explanatory variable. We examined mean differences between the three sounds in pairwise comparisons with Bonferroni adjustment for multiple comparisons. Horizontal comparisons between means for the 3 sounds in Table 4.3 showed main effects of Type of sound on Cuteness and Quality in all but one case: we found no main effect on Quality for the Pelican dust buster.

Table 4.3. Mean scores on Quality and Cuteness for visual and auditory stimuli

	Visual	Auditory			
	Picture	F-sound	NF-sound	A-sound	F-value†
Quality					
AFK	3.3^{y}	**3.5**^{a}	3.7^{a}	**4.5**^{b}	10.38**
Clatronic	6.7^{z}	**5.8**^{a}	**3.7**^{b}	4.8^{b}	16.55**
Pelican	4.8	**4.5**	**4.7**	5.7	n.s.
Hoover	5.2	**5.2**^{a}	**3.9**^{b}	5.0^{a}	6.45**
Cuteness					
AFK	6.4^{z}	**4.6**^{a}	5.4^{b}	**4.3**^{a}	12.89**
Clatronic	4.6^{y}	**5.9**^{a}	**4.7**^{b}	5.5^{a}	7.14**
Pelican	7.0^{z}	**5.0**^{a}	**4.0**^{b}	5.2^{a}	9.41**
Hoover	3.7^{y}	**4.3**^{b}	**5.0**^{a}	4.1^{a,b}	3.9*

^{y,z}Means for pictures of different products with different superscripts were significantly different (vertical comparison, p<.001).
^{a,b} Means for sounds belonging to the same product with different superscripts were significantly different (horizontal comparison, p<.05).
* Significant main effect at the .05 level, ** at the 0.01 level.
† The degrees of freedom for the F-test are 2 for the denominator and vary between 15 and 19 for the numerator.
Sounds with means in bold were re-created for the second experiment.

In accordance with our manipulations, the sounds for both juicers differed on Quality and the sounds for both dust busters differed on Cuteness. For the AFK juicer, the sound that was rated as the least fitting of the product (the A-sound) scored higher on Quality than the F-sound, and for the juicer Clatronic, the F-sound scored higher on this variable than the NF-sound. For the Pelican dust buster, the F-sound scored higher on Cuteness than the NF-sound; and, as expected, for the Hoover dust buster, the results were the opposite. However, we also found differences between the sounds that we had not anticipated: the F-sound for the Clatronic juicer scored higher on Cuteness than the NF-sound, and the F-sound for the Hoover dust buster scored higher on Quality than the NF-sound.

Discussion

The results show that we were successful in selecting pairs of products that differed in visual expression on the predicted variables, Cuteness and Quality. We found one difference that we had not anticipated: the appearance of the AFK juicer scored higher on Cuteness than the appearance of the Clatronic juicer. This can be explained by the difference in the height to circumference ratio between these products: The Clatronic juicer is taller while the AFK juicer is stockier.

The data also show that we were successful in creating sounds that were perceived and evaluated as having different expressions. The sounds that were selected for the second experiment are indicated in bold in Tables 4.2 and 4.3. For all but one product, we selected the manipulated F- and NF-sounds. For the AFK juicer, we selected the A-sound instead of the manipulated NF-sound, because it was evaluated as less fitting for the product than the NF-sound.

With these pairs of sounds, the mean rating for the best fitting sound was generally closer to the mean for the picture on the target variable (Quality or Cuteness) than the least fitting sound. For the Clatronic juicer, the F-sound as well as the picture showed high ratings on Quality, and for the AFK juicer, the Quality rating was lower for the F-sound and thus better matches the picture than the A-sound. For the Pelican dust buster, the Cuteness rating was higher for the F-sound and thus better matches the picture than the NF-sound, whereas for the Hoover dust buster, opposite results were found for Cuteness. A comparison of Tables 4.2 and 4.3 thus shows that in general sounds and appearances with similar expressions are evaluated as having a higher degree of fit.

4.3 Experiment 2: effect of expression of product sound on overall product expression

Similar to Zampini et al. (2003), in Experiment 2, the sounds of the products were manipulated in real time to simulate a real use environment. To avoid influences that may result from the participants touching the products, the experimenter used each product as the participants watched and listened. In Experiment 1, participants evaluated recordings of manipulated sounds. To manipulate sounds while each product was being used, we had to use an alternative set-up with comparable, but slightly different, sound-manipulations. Therefore, we first pre-tested the sounds manipulated in real time. In the main study, we presented participants with combinations of sounds and products in real-time to test the effects of the expression of the sounds on the complete product expression. The same 4 products that were used in Experiment 1 were used in Experiment 2. In both the pre-test and the main experiment, two sounds were presented to participants for each product (juicer and dust buster). In addition to the photographs that were used as visual stimuli in Experiment 1, we also presented participants with the actual products in this experiment.

Pre-test

Method

Participants

A total of 20 participants (10 males and 10 females, aged 19-26, mean 23.5) evaluated the stimuli. All participants were students from the Department of Industrial Design Engineering at Delft University of Technology.

Stimuli

For all 4 products, one F-sound and one NF-sound was used. The real-time manipulations were made as much as possible to resemble the sounds created for the first experiment. Using Max/MSP (Cycling '74), eight presets of real-time sound manipulations were made that could be easily accessed during the trials. These pre-sets mimicked the sound manipulations developed for Experiment 1. During the trials, a wireless microphone (AKG PT50), placed at approximately 30 cm from the product, picked up the sound of the product. This signal was sent to a receiver (AKG SR50) and then to a laptop where it was manipulated according to the appropriate preset in Max/MSP. The manipulated sound was sent to wireless headphones (Philips HC8410). Each participant was presented with all stimuli for both product categories following a procedure similar to the one used in Experiment 1.

Procedure

Upon entering the room, participants were asked to sit at a table. The complete set-up of the experiment was hidden behind a screen.

For the evaluation of sounds, the experimenter explained that the participants had to listen carefully while she performed tasks behind the screen. The experimenter then selected the appropriate preset on the laptop and performed the first task. For the juicer product category, the experimenter squeezed half an orange. For the dust buster product category, the experimenter vacuumed a table surface of approximately 30x30 cm2 filled with cookie crumbs. After each task, the participants filled out a questionnaire containing the same 14 semantic scales that were used in Experiment 1. All 8 sounds were evaluated with this procedure.

For the evaluation of visual appearances, a product was placed on a table approximately 1 m away from the participant for approximately 15 s. The participant was encouraged to look at the product (but was not allowed to touch it). The product was then taken away. and the participant evaluated this product on the same 14 scales. All 4 products were evaluated in this way.

For the evaluation of product-sound combinations, the actual product was shown to the participant for approximately 10 s. Then a color photograph of the product was put on the table in front of the participant. The experimenter selected the appropriate preset and performed the task for the product behind the screen. The photograph was then removed and the participant evaluated how well the sound fits the product presented on a nine-point scale with end points 'does not fit at all' – 'fits very well.' Next, the actual product was presented again. After approximately 10 s, the photograph again replaced the product, and the experimenter repeated the task with the other preset in Max/MSP for that product. The picture was then removed and the participant evaluated the Degree of fit of the sound. In this way, eight product-sound combinations were evaluated.

Results and discussion

To examine differences on Degree of fit between F- and NF-sounds, we performed repeated measures ANOVAs per product. We found an effect of Type of sound on the Degree of fit variable only for the Clatronic juicer. The F-sound (5.8) created for this product was evaluated as significantly better in fitting the product than the NF-sound (4.0) ($F(1,19) = 8.6$, $p < 0.01$).

The same evaluative items as those in Experiment 1 were used to calculate ratings for Quality ($\alpha = 0.76$) and Cuteness ($\alpha = 0.80$). The means for the visual appearances confirmed our expectations and the results of Experiment 1 (2nd column in Table 4.4, two-tailed t-test, $df = 38$). We subjected the ratings for sounds to repeated measures ANOVAs per product. We found effects on the Cuteness variable for two products (3rd and 4th column in Table 4.4). The F-sound for the Clatronic juicer scored significantly higher on Cuteness than the NF-sound for this product ($F(1,19) = 16.1$, $p < 0.001$).

Furthermore, the F-sound for the Pelican dust buster also scored significantly higher on this variable than the NF-sound for this product ($F(1,19) = 11.5$, $p < 0.01$). No effects were found on the Quality variable.

Table 4.4 Mean scores on Quality and Cuteness for visual and auditory stimuli in pre-test and for combined stimuli in main study

	Pre-test			Main study	
	Visual	**Auditory**		**Visual + auditory**	
	Product	F-sound	NF-sound	Product + F-sound	Product + NF-sound
Quality					
AFK	4.1^{x}	4.2	4.7	4.0	4.3
Clatronic	5.8^{y}	4.3	4.0	5.8	5.7
Pelican	5.6	4.7	4.9	5.1	5.5
Hoover	6.2	4.6	4.4	5.3	5.7
Cuteness					
AFK	6.4^{y}	3.9	3.5	4.7	4.8
Clatronic	5.2^{x}	5.0^{a}	3.9^{b}	5.0^{a}	4.3^{b}
Pelican	6.8^{y}	5.6^{a}	4.8^{b}	5.8	5.9
Hoover	3.5^{x}	4.8	4.6	4.5	4.5

^{x,y} Means for visual stimuli of different products with different superscripts were significantly different (vertical comparison, $p<.001$).
^{a,b} Means for auditory/combined stimuli belonging to the same product with different superscripts were significantly different (horizontal comparison, $p<.01$).

The data from the pre-test show that we were able to replicate only two of the six differences between F- and NF-sounds found on Quality and Cuteness in Experiment 1. Comparing Tables 4.3 and 4.4 shows that even in these two cases, although the difference between the F- and NF-sounds was in the same direction, the mean responses shifted by 0.6 to 0.9. As a result, means for the F-sounds for the Clatronic juicer and the Pelican dust buster became even closer to the means for the visual appearances on the Cuteness variable. In the main study, we assessed the effects of the differences in Cuteness for the sounds of the Clatronic juicer and the Pelican dust buster on complete product expression.

The real-time manipulations used in this pre-test were made to resemble the manipulations used in Experiment 1 as much as possible and were made by manipulating the same variables (boosting or attenuating certain frequencies, pitch shifts, adjusting vibrato and volume). However, the sounds were evaluated differently. The two different software packages that we used to manipulate the sounds (Sony Sound Forge and Max/MSP) have considerably different interfaces and options. Therefore, in some cases, we had to use a somewhat different approach to achieve a similar effect on the sound. For example, in Sound Forge, adding a vibrato to a sound was a standard option, whereas in Max/MSP we had to create a vibrato by using a low-frequency oscillator to continuously modulate the frequency of a tone. Although both software packages suited our purposes during the different stages of our sound design process, it seems that using two different sound editing tools caused hardly noticeable but nevertheless significant differences in our sound manipulations. We will further discuss the use of sound editing software in the general discussion.

Main study

We expected that the differences we found in the expression of the manipulated sounds would be reflected in the expression of the products when presented with these different sounds. Thus, we expected the Clatronic juicer and the Pelican dust buster to score higher on Cuteness when presented with the F-sound than with the NF-sound. We also asked participants to indicate the extent to which they were surprised by the sounds of the stimuli. We expected that the NF-sound for the Clatronic juicer (that scored significantly lower on Degree of fit than the F-sound for this product), would elicit higher ratings on surprise. Finally, to gain further insight into what sound properties influenced people's evaluation of the expression of sounds, this study determined to what extent the perceived sounds differed from what people expected to hear upon visual inspection of the products. We also included the two products for which no effects of sounds were found in the pre-study to check whether any other unexpected changes in expression occurred for these products.

Method

Participants and stimuli

A total of 106 participants (66 males and 40 females, aged 18-29, mean 23.6) participated in the main study. All participants were students from the Department of Industrial Design Engineering at Delft University of Technology. Participants were paid for their participation.

Participants were presented with real-time combinations of products and sounds. We used the 8 product-sound combinations that were used in the pre-test. The set-up for creating the real-time manipulated sounds was similar to the one used in the pre-test.

Each participant evaluated two products, one from each product category. The order in which the products were presented was randomized. Each product-sound combination was evaluated by 25-27 participants.

Procedure

The procedure followed was similar to the one used in the pre-test, except that the experimenter performed the tasks in a kitchen at a distance of approximately 3 m in full sight of the participants. After each task, the participants filled out a questionnaire. The complete session took 15-20 min.

The questionnaire consisted of three parts. All responses were given on 9-point scales. In the first part of the questionnaire, three questions about surprise were asked: 'The (product) sounded exactly as I thought,' 'I am surprised about how the (product) sounds,' and 'I am amazed about how the (product) sounds' with end points 'do not agree at all' and 'agree completely.' In the second part of the questionnaire, we asked about the incongruity between the expected and the actual perception of sound: 'When the (product) was used, it sounded … than I expected' on scales with end points 'more variable – more stable,' 'higher – lower,' 'sharper – more muffled,' 'fuller – emptier,' 'less rough – rougher,' 'less irritating – more irritating,' and 'louder – quieter.' These scales were selected based on perceptual judgements mentioned in the sound identification literature (see e.g., Ballas, 1993; Lederman, 1979) and on their relevance for our sound manipulations (see Table 4.1). Finally, participants evaluated the products on the same 14 semantic scales as used in the previous tests to determine scores on the scales for Quality and Cuteness.

Results and discussion

Evaluation of expression of product-sound combinations

After calculating the ratings for Quality ($\alpha = 0.80$) and Cuteness ($\alpha = 0.79$), we analyzed effects of Type of sound on these variables for each product separately in 8 ANOVAs. We found only one main effect of Type of sound: on the dependent variable Cuteness for the Clatronic juicer ($F(1,50) = 7.24$, $p < 0.01$). As expected for the Clatronic, scores on Cuteness were significantly higher when the product was presented in combination with the F-sound than when it was presented with the NF-sound (5th and 6th column in Table 4.4). We did not find the expected effect on Cuteness for the Pelican dust buster ($F(1,51) = 0.13$, $p > 0.20$). This implies that only one of the two effects expected on the basis of the results from the pre-test was found in the main experiment.

Surprise

The three questions that were used to measure surprise were combined into one variable (3 items, Cronbachs $\alpha = 0.92$). ANOVAs with Type of sound (F-sound and NF-sound) as the explanatory variable and Surprise as the dependent variable were carried out on the data for each product separately. For the Clatronic juicer, we found an effect of Type of sound on Surprise ($F(1,51) = 9.31$, $p < 0.01$). As expected, the mean score for the NF-sound (5.5) on Surprise was significantly higher than for the F-sound (3.7).

Incongruity between expectation and actual perception of sound

The reported deviations between what participants expected to hear based on their visual perception and what they actually heard can be used as measures of visual-auditory incongruity. Therefore, we tested whether mean responses on all 7 incongruity scales differed significantly from the center of the scale (=5) (two-tailed t-tests, df = 25-26, Table 4.5). In general, both the F- and NF-sounds for the juicers sounded rougher, more irritating, and louder than expected. This suggests that all juicer sounds were somewhat incongruent. For the dust busters, significant incongruities occurred only incidentally.

Table 4.5 Deviations in sound characteristics between expectation and actual experience

	Juicer				Dust buster			
	AFK		Clatronic		Pelican		Hoover	
	F	NF	F	NF	F	NF	F	NF
more variable – more stable	**3.7***	4.7*	4.7	**3.8**	**6.2**	5.6	5.5	5.7
higher – lower	5.1	5.3	**5.8***	4.7*	4.6	4.3	4.7	4.4
sharper – more muffled	4.3	**3.9**	5.5*	**3.6***	5.1	4.8	4.5	4.4
Fuller - emptier	4.7	4.3	4.9	4.9	5.1	5.2	4.7	5.2
less rough - rougher	**6.0**	**6.3**	**6.4**	**6.3**	**4.3**	4.9	5.3	4.8
less irritating – more irritating	**6.4**	**6.3**	5.4	**6.3**	4.7	5.2	5.5*	**4.2***
louder - quieter	**3.7**	**3.1**	**4.2**	**4.0**	4.9	4.8	**4.0**	4.6

Means in bold were significantly different from scale center at the .05 level.
* Significant difference between F-sound and NF-sound ($p<.05$).

The reported deviations can also provide insight into participants' expectations about product sounds. Therefore, we tested whether deviations from expectations differed significantly between F- and NF-sounds. For the AFK juicer, the F-sound sounded significantly more variable than the NF-sound. For the Clatronic juicer, the NF-sound sounded significantly higher and sharper than the F-sound. For the Hoover dust buster, the NF-sound sounded significantly less irritating than the F-sound (see Table 4.5).

The difference in sound variability that we found for the AFK juicer is probably related to the different ratings on Quality found in Experiment 1. Similarly, the difference in irritability that we found for the Hoover dust buster is probably related to the different ratings on Cuteness found in Experiment 1 for this product. However, these differences in expression were not replicated in the pre-test of Experiment 2. In the case of the Clatronic juicer, the difference in highness and sharpness is probably related to difference found on the Cuteness dimension in both Experiment 1 and the pre-test of Experiment 2. Although we expected higher sounds to sound cuter, in this case it seems that the higher sounds were perceived as sharper and therefore as less cute. Apparently, although some sound manipulations were perceived in the main study of Experiment 2, these differences did not always lead to differences in perceived expression as measured on the Cuteness and Quality scales.

4.4 General discussion

This study investigated the effect of incongruent sounds on surprise and the effects of the expressions of sounds on the overall product expression. In addition, we tried to gain further insight into how certain sound properties can influence people's evaluation of the expression of sounds. At the same time, these experiments form a case-study that can provide insight into the steps a designer is likely to take in order to design a desired product sound. We first discuss the different effects of our sound manipulations on product expression and the elicitation of surprise and, subsequently, we elaborate on the process of designing a product sound.

Effects of sounds

In this study we assessed the effects of sound manipulations on the product expression of Cuteness and Quality and on the feelings of surprise. Our study shows that predicting the effect of sounds that differ in expression on the complete product expression is difficult. In one case, a difference in the expression of sound was reflected in the expression of the complete product: when the Clatronic juicer was presented with a 'cuter' sound, this juicer was evaluated as 'cuter.' For the Pelican dust buster, however, this effect was not found.

Note that we have used a limited set of products in this experiment with relatively complex sounds. We chose to use electronic products, because users report that sound is relatively important during usage for such products (Schifferstein, 2006). However, this may reflect the importance of sounds for the product's functional use and may not necessarily reflect the role of sound in the product's expression. For other product categories and for simpler sounds, the sound might influence the expression of the product to a larger extent. However, more research is necessary to investigate the different roles sounds can play in the overall expression of products.

As for the element of surprise, in one instance, we found that a sound evaluated as less fitting with the product evoked stronger feelings of surprise than a sound that fits the product. Apparently, people have expectations on how a product will sound. If designers have sufficient insight into these expectations, they can cater to them and either avoid or create surprise reactions.

The complexity of the sounds generated by the products in our experiments may have been of influence on the feelings of surprise. The sounds tested were based on the interaction among multiple parts made of various materials. Although people are in many cases capable of determining the size, the material, or the texture of an object when they hear its sound (Klatzky, Pai, & Krotkov, 2000; Kunkler-Peck & Turvey, 2000; Lederman, 1979), forming an expectation of how complex products will sound during usage may be too complicated, especially since most interacting parts cannot be seen. This may lead to fuzzy, uncertain expectations about how the product will sound, making it less plausible that a surprise will occur. People are possibly better capable of forming expectations of sounds if these are produced by simpler (interactions of) objects. For example, in the design and evaluation of haptic controllers, O'Modhrain and Essl (2004) obtained surprise reactions by manipulating the sounds of direct interactions with simple objects, such as touching pebbles in a box and grains in a bag.

Designing product sound

The results of the experiments show considerable differences. In Experiment 1, we found six differences in the expressions of NF- and F-sounds (Table 4.3). In the pre-test of Experiment 2, only 2 of these were replicated (Table 4.4). Nevertheless, our analysis of how perceived sounds differed from what people expected to hear in the main study of Experiment 2 showed that for three products, the F- and NF-sounds differed on one or two of the sound properties that were evaluated (Table 4.5). However, only for one product did this difference result in a difference in product expression.

Apparently, our sound manipulations for Experiment 2 were not as accurate or strong than those for Experiment 1. The different software packages that we used may have been responsible for these differences in manipulations. To manipulate sounds, a range of software packages can be used that differ in complexity, options, and applicability (see Bernardini, Cirotteau, Ekanayaka, & Glorioso, 2004). Product designers can effectively use such software packages in the early stages of designing a sound, because in most cases sounds are easily manipulated using these tools. However, selecting the proper application to perform the task at hand may not be as easy. Different software packages use various theoretical frameworks for thinking about sound and hearing, which leads to different types of manipulation options. Although the types of manipulations that reflect accepted theory in psychoacoustics are often standardized (Gaver, 1997), exchanging files between different software packages (or even between different versions of the same package) or using files on different computer platforms is often not possible (Bernardini & Rocchesso, 2002). Analogously, the results of our experiments show that translating a desired sound manipulation to another application can cause unexpected side effects. It will most likely be even more difficult to perform similar translation steps in design practice, where sounds often need to be built up from the interaction of multiple parts of a product and are therefore difficult to predict and control. For comparison, one might think of the translation step that designers are confronted with when they design a visual effect in a 3D modeling software package like Solidworks or Maya: an effect on a virtual 3D model will never look completely the same on the final physical product.

Özcan, van Egmond, and Huijs (2006) argue that to design product sounds both time and cost effectively, the desired characteristics of the sounds should be defined early in the design process and developed in an iterative process together with other aspects of the product, such as the appearance of the product and the selection of its sound producing parts. A strong benefit of this approach is that the sound will not just be consequential and a complete surprise for product designers at the end of the process. Instead, developing the sound becomes an integral part of the complete product design. We support such an approach and would like to stress the importance of testing the effects of the different sounds that are created. Our study indicates that during unavoidable translation steps in the design of a product sound, consequential subtle differences in sounds can alter the desired effect of the sound. Therefore, predicting the effects the sounds will eventually have on the product's expression is difficult. This makes an iterative process of creating sounds, (re)producing components, and testing sounds and products essential.

Conclusion

In accordance with previous studies (e.g., Lageat et al., 2003), the present study found that different sounds are perceived to have different expressions. Theories on sensory synergy suggests that making all sensory messages congruent with the intended, overall experience may lead to more preferred products (Hekkert, 2006; Lindstrom, 2005). If this is indeed the case, designers can certainly benefit from designing congruent sensory messages. However, further research has yet to prove this claim.

We have illustrated how the sound of a product can influence the overall perceived expression of that product. However, our findings were not always consistent, and we are far from answering the question of how the different senses work together when people evaluate products. What our experiments do show is that this issue is of great importance for designers. Different types of sensory information are always present in a product. Knowledge of how people use and combine this information can help designers understand how to capitalize on all the sensorial aspects of the products that they design. Extensive research, using a variety of products with controlled manipulations as stimuli, can eventually be very useful for designers in creating multimodally designed products.

Chapter 5 was largely based on: Ludden, G. D. S. & Schifferstein, H. N. J. (submitted to International Journal of Design) Should Mary smell like biscuit? Scent in product design.

Chapter 5
Visual - olfactory incongruity

5.1 Introduction

Designers can manipulate a product's expression to influence how the product is experienced (van Rompay, Hekkert, Saakes, & Russo, 2005). To obtain the product experience desired, designers can use the product information perceived through all the senses (Lindstrom, 2005; Schifferstein & Desmet, 2008). Therefore, designers can also use odors to enhance the experience of products. An example of such a product is Mary Biscuit. Mary Biscuit is a plastic storage box for biscuits designed by Stefano Giovannoni for Alessi (Figure 5.1). It was first produced in 1995 and has been a successful and famous design product ever since (Fiell & Fiell, 2000). The lid of this storage box looks like a giant biscuit and has a vanilla biscuit scent. This scent, which matches the shape and functionality of the product, makes this biscuit box particularly original and appealing.

Figure 5.1 "Mary Biscuit", design Stefano Giovannoni, 1995, biscuit box. Production: Alessi spa.

To facilitate the implementation of odors in products, producers of plastics are now offering standard plastics with added odorants (van Kesteren & Ludden, 2006). This has, amongst other things, led to the introduction of mp3 players with seven different scents, from chocolate to roses to marijuana (Foster, 2006), and to scented packaging (ScentSationalTechnologies, 2008). Furthermore, odorants can be used to communicate the scent and taste of products prior to purchase. For instance, scratch-and-sniff samples in magazines are commonly used to let consumers try out new fragrances. In 2003 the same technique was successfully used in the Netherlands to introduce a new flavour of jam (vanilla-strawberry) by the brand Hero (Janssen, 2004). Next to samples in magazines, the jar of the jam was also given a scratch-and-sniff sample so that consumers could experience the odor (and thus the flavour) of the jam in the store. Furthermore, odorants have been incorporated in the printing ink of stamps and telephone cards to enhance the experience of the themes of the cards (Falck & Schaffelaars, 1999). For example, an image of coffee on a stamp was combined with a coffee odor.

These examples indicate that designers have more and more technical options to use an odor that matches the other characteristics of their design to enhance the experience they would like to evoke. If designers do not deliberately design the odor of a product, this may lead to a perceived mismatch between, for example, the visual and olfactory expression of a product. As a result, the total product experience may not be the one the designer tries to achieve. In addition, a scent that is not congruent with a product's appearance may evoke a surprise reaction. To support designers' choices, in this paper we try to gather knowledge about how and when adding odors can lead to a more positive evaluation of a product. In particular, we wonder what will happen if designers add odorants to products that normally do not carry an odor.

Laird (1932) studied the effect of four different odors (original scent, narcissus, fruity and sachet type) on women's evaluation of silk hose. He found that all scented hoses scored better than the unscented hoses. Because the natural scent of the hosiery was slightly unpleasant, the effect of odor could be attributed to odor pleasantness. Next to odors in products, ambient scent has also been reported to influence product evaluation. For example, it was claimed that a pair of Nike shoes was liked better in a room with a floral ambient scent than in a non-scented room (Miller, 1991). Spangenberg et al. (1996) studied the effect of the presence of an ambient scent (lavender, ginger, spearmint and orange) on consumers' evaluations of a store and of the offered products (decor items, kitchen items, books, school supplies and outdoor athletic gear). They found that when a scent was present in the store, consumers' evaluations of the store environment and of the merchandise in general were more positive. Furthermore, the quality of specific products was evaluated as higher when a scent was present in the environment. The character of the scent used did not matter as much as the presence or absence of a scent.

Other researchers have argued that the appropriateness of the odor also plays an important role in the evaluation of products. However, research on the appropriateness of odors has lead to mixed results. Ellen and Bone (1998) investigated the effects of scratch-and-sniff samples in magazines and found that, whereas a scent congruent with an advertisement did not improve consumer attitude, a scent that was incongruent actually lowered consumer attitudes. Knasko (1995) studied the effects of congruent and incongruent odors on the viewing time of slides and respondents' mood and health, but found no effect of odor congruency. Bone and Jantrania (1992) let respondents use sunscreen and household cleanser without an odor and with either an appropriate or an inappropriate odor (lemon and coconut) and found that the products were more positively evaluated when presented with an appropriate odor. However, in another study on appropriate and inappropriate odors for food, household and personal care products (Schifferstein & Michaut, 2002) no effects of odor congruency on overall product evaluation were found.

The present study

Research on the effect of odor on product evaluation has in some cases led to contradictory findings. Differences in the stimuli and procedures used may explain some of the differences, but they make it difficult to extrapolate results to different situations and to other product categories. In particular, the effects of adding odorants to products that normally do no have an odor have not been studied extensively.

The present study comprises two experiments. For both experiments, we selected a variety of everyday products and presented these to participants with or without added odors. Experiment 1 tested the effect of expectations for scents on surprise and on the evaluation of products. In this experiment, we made a distiction between products that normally have a scent and products that normally do not have a (discernable) scent. In Experiment 2 we only used products that normally do not carry a scent. In this experiment we presented each product with two different odors to test for the effect of the degree of incongruity on product liking.

5.1 Experiment 1: scents for two types of products

Previous studies have for the larger part tested effects of scent using products that normally always have a scent. Experiment 1 investigated the different effects of incongruent scents on the product experience and evaluation for products with scent (WS) or for products that normally do not have a (discernable) scent (no scent, NS).

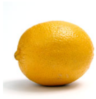
In chapter 3, we tested products for which the tactual experiences deviated from what could be expected on the basis of the visual appearance of the product. For instance, we presented participants with a lamp that looks like it is made out of matt glass (a familiar material for lamp shades), but upon touching the lamp the participant finds out that the shade is flexible (it is made out of silicone rubber). In this study, we found that the participants' familiarity with the product and their certainty of the expectation about the product's tactual characteristics affected the degree of surprise evoked by the product. Analogously, we expect to find differences in the certainty of the expectations about the products' olfactory characteristics between WS and NS products in the present study. Probably, people have a more certain expectation about the odors for WS products than they have for NS products. Therefore, we expect people to be more surprised about the incongruent odors in the WS group, because their initial expectation about the odor is more certain (but disconfirmed). This can also have an effect on overall product evaluation. We expect that incongruent odors for WS products will be appreciated less than incongruent odors for NS products.

Method

Participants

Forty participants (19 female and 21 male, aged 19-27, mean 23) participated in this experiment. All participants were students at the faculty of Industrial Design Engineering of Delft University of Technology.

Table 5.1 Product - odor combinations used in Experiment 1.

Product	Odor	Possible associations
Products that naturally produce a scent (WS)		
 Wooden bowl	 Lemon	Lemons can be placed on the bowl.
 Lemons	 Strawberry	Lemon and strawberry both belong to the product category fruit.
 Plant	 Chocolate	
Products that normally do not have a discernable scent (NS)		
 Boots	 Roses	The color and the print of the boots match the roses.
 Kitchen paper holder	 Coffee	Both product and odor can be present in a kitchen environment
 Decorative dice	 Lavender	

Stimuli

We selected 6 products in two categories as stimuli. The first category (WS, with scent) comprised products that naturally produce a scent: lemons, a wooden bowl and a plant with flowers. For the second category (NS, no scent) we selected products that do not naturally produce a (discernable) scent: plastic boots, a kitchen paper holder and decorative dices for in a car. We added an incongruent scent to all products. The wooden bowl, the lemons, the boots and the kitchen paper holder were sprayed with a liquid odor. A chocolate scent was added to the flowery plant by placing cocoa powder in its container. The decorative dices were filled with dried lavender. Odors were re-applied every day. Table 5.1 shows the products we chose as stimuli and the scents they were presented with. Although we assume the odor to be incongruent, Table 5.1 also indicates possible associations between odor and product that respondents may have formed nevertheless.

Procedure

We created two groups of 3 products. Group A comprised two products in the WS category (lemons and wooden bowl) and one product in the NS category (boots) and group B comprised two products in the NS category (kitchen paper holder and decorative dices) and one product in the WS category (plant with flowers). The two groups of products were placed in separate rooms which were ventilated in between trials. The products were placed on tables and plastic coverings were placed over the products (see Figure 5.2). In this way, when participants entered the room they could see the products (visual information) but could not smell them (olfactory information).

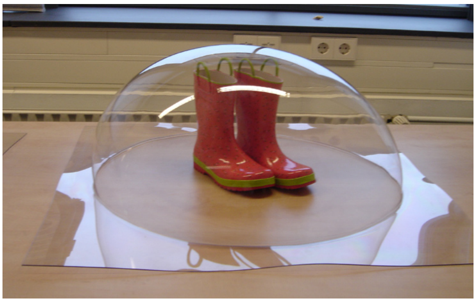


Figure 5.2 Stimulus presentation: products were placed under plastic coverings

Participants evaluated the two groups of products in two different conditions, a 'see'-condition and a 'see and smell'-condition. Half of the participants evaluated group A in the 'see'-condition and group B in the 'see and smell'-condition, the other half evaluated group B in the 'see'-condition and group A in the 'see and smell'-condition. The order in which the products were evaluated was randomised between participants. Participants always evaluated three products in the 'see'-condition first and three products in the 'see and smell'-condition second. Unless indicated otherwise, all responses were recorded on 7-point scales with scale end points 'do not agree at all' and 'agree completely'.

In the 'see'-condition, participants were instructed to look at the product. They were not allowed to remove the plastic covering. The plastic coverings allowed almost full 3D vision of the product. Therefore, using these plastic coverings instead of, for example, photographs of the products, ensured that participants could obtain the same visual information in the two different conditions. After looking at the product ad libitum, participants filled out a questionnaire. Questions about familiarity, certainty and surprise were adapted from our previous study on visual – tactual incongruity (Ludden et al., 2009). Three questions asked about the familiarity of the product: 'This (product) looks familiar', 'I have seen this (product) before' and 'I know things that resemble this (product)'. Two questions inquired about participants' expectations of the product's scent. The first, 'If I would smell this (product), I expect the product to smell…', was answered on five scales with end points 'pleasant – unpleasant', 'sweet – sour', 'fresh – stale', 'heavy – light' and 'synthetical – natural'. For the second, 'I expect this (product) to smell like…', participants chose their answer(s) from a list of 16 options that were chosen for their relevance in relation to the products we used as stimuli (wood, cloth, plastic, leather, grass, roses, plants, pepper, carrot, lemon, strawberry, banana, mint, lavender, chocolate, and coffee). Participants were also given the option to give an alternative answer. Finally, three questions asked about the certainty of the expectation of the product's scent: 'I am certain about how this (product) smells', 'I am curious about how this (product) smells'. The third question about the certainty was directly related to the question about the product's scent: 'I am certain that my answer to the question about the product's scent is correct'. After they filled out the questionnaire for the first product, participants were instructed to look at the second product, and so on. In this way, the three products of one group were evaluated. Subsequently, they evaluated the three other products in the other room in the 'see and smell'-condition.

In the 'see and smell'-condition, participants were instructed to look at the product and, subsequently, to lift the plastic covering using both hands (see Figure 5.3) and to smell the product. Participants were not allowed to touch the product. Subsequently, participants filled out a questionnaire. Three questions asked about the degree of surprise: 'This (product) smells exactly as I expected when I saw it', 'I am surprised about how the (product) smells', and 'I am amazed about how the (product) smells'. Furthermore, participants evaluated their felt surprise on four scales with end points: 'not funny at all – very funny', 'not annoying at all – very annoying', 'not disappointing at al – very disappointing', and 'not pleasant at all – very pleasant'. Two questions assessed the certainty of participants' expectations about the product's scent: 'When I saw the (product), I was certain about how it would smell', and 'When I saw the (product), I was curious about how it would smell'. Two questions asked about the participant's perception of the product's scent. For the first question, participants were instructed to choose the scent of the product from a list of 16 options (the same as used in the 'see'-condition): 'This (product) smells like…'. For the second question, participants evaluated how the scent of the product deviated from their expectation on five scales with end points 'much less pleasant – much more pleasant', 'much less sweet – much more sweet', 'much less fresh – much fresher', 'much less heavy – much heavier' and 'much less synthetical – much more synthetical. Finally, participants expressed their opinion about the product in a few words. After completing their responses for the first product, they evaluated the other two products in the same way.

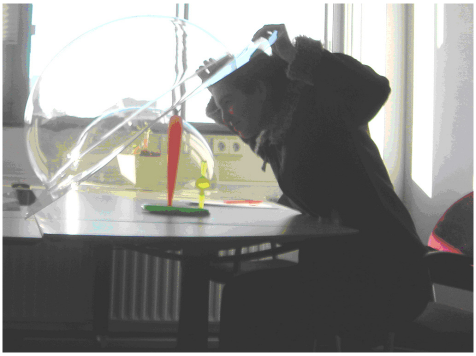


Figure 5.3 Participant in the 'see and smell'-condition smelling a product.

Results

Manipulation check

For each product we compared (expected) odor identification responses in the 'see'-condition to those in the 'see and smell'-condition. For all products, the frequencies of the responses selected differed substantially between the two conditions. In the 'see'-condition, participants most often picked the odor of the product's material as the expected odor ($17 \leq n \leq 20$ for all products, where n = 20 was the maximum). In the 'see and smell'-condition, most participants recognized the added odorants ($11 \leq n \leq 19$), but for 4 products (boots, lemon, plant with flowers and kitchen paper holder) the odor of the material was incorrectly picked quite often ($5 \leq n \leq 11$). Furthermore, some participants identified the rose odorant on the boots as strawberry or lavender, and some identified the lavender odorant on the decorative dices as strawberry or roses.

Table 5.2 Deviation from smell expectation for the 6 products in Experiment 1.

		mean	p
wooden bowl	pleasant	3.9	
	sweet	5.6	0.00
	fresh	6.2	0.00
	heavy	4.0	
	synthetical	5.1	0.00
lemon	pleasant	4.0	
	sweet	6.3	0.00
	fresh	3.0	0.00
	heavy	4.0	
	synthetical	5.2	0.00
plant	pleasant	3.0	0.01
	sweet	4.2	
	fresh	2.5	0.00
	heavy	5.2	0.00
	synthetical	4.2	
boots	pleasant	5.7	0.00
	sweet	5.8	0.00
	fresh	4.9	
	heavy	3.7	
	synthetical	2.6	0.00
kitchen paper holder	pleasant	4.4	
	sweet	3.6	0.05
	fresh	3.6	
	heavy	4.8	0.04
	synthetical	2.3	0.00
dice	pleasant	3.1	0.04
	sweet	6.0	0.00
	fresh	4.5	
	heavy	5.7	0.00
	synthetical	4.6	

As a second manipulation check, two-tailed t-tests were carried out on the five scales in the 'see and smell'-condition that measured deviations from expectation. We checked if mean responses deviated significantly from the centre of the scale (= 4). Table 5.2 shows that for each product we found significant differences ($p < 0.05$) for at least three scales. In conclusion, the analysis of these questions shows that we succeeded in introducing incongruent odors for our stimuli.

Differences between WS and NS products

Cronbach's α values for the scales measuring Familiarity (α = 0.71) and Surprise (α = 0.91) indicated that these scales were consistent. However, the consistency of the scales measuring Certainty was lower than expected: α = 0.57 for the 'see'-condition and α = 0.18 for the 'see and smell'- condition. Therefore, we removed the item 'When I saw the (product), I was curious about how it would smell' from the Certainty scale in the 'see'-condition (Cronbach's α for the resulting scale was 0.65) and analysed this item separately as 'Curiosity'. Furthermore, we analysed the two items in the 'see and smell'-condition separately and we refer to them as 'Certainty' and 'Curiosity'.

To investigate differences in mean responses on these questions between the different types of products, they were analysed as dependent variables in ANOVA s with Type of product (two levels, WS and NS) as factor (Table 5.3). For the 'see'-condition, we found a main effect of Type of product on Curiosity. Scores for both product types were low, but participants were more curious about the odor for the WS products. For the 'see and smell'-condition we found main effects of Type of product on Surprise and on Certainty. People are more surprised when they perceive a different odor for WS products, than when they perceive an odor for NS products. Furthermore, participants indicated that they were more certain about how WS products would smell than they were about how NS products would smell.

Table 5.3 Mean scores and F-values for Experiment 1 (7-point scale)

		NS	WS	F-value
'see'-condition				
	Familiarity	4.5	4.9	1.2
	Certainty	4.8	5.0	0.4
	Curiosity	2.4	3.3	5.5*
'see and smell'-condition				
	Certainty	3.8	5.2	10.3**
	Curiosity	4.5	4.6	0.1
	Surprise	5.6	6.2	5.4*
	Evaluation	4.9	4.5	1.9

NS = products that normally do not have a (discernable) smell,
WS = products that naturally produce a smell.
* significant main effect at the .05 level, ** at the 0.01 level

Overall evaluation of products

The four questions that asked about the evaluation of the surprise reaction formed a scale Evaluation ($\alpha = 0.84$). An ANOVA with Type of product (two levels, WS and NS) as factor showed no main effect of Type of product (Table 5.3). Mean scores on Evaluation are between 4.0 and 5.6 for all products, indicating that people generally evaluated the surprising odors moderately positive.

To gain more insight into participants' evaluation of the surprising odors, we analysed participants' additional comments on the products. We will present some interesting remarks here. The incongruent odors for the boots and the kitchen paper were liked, because their odor could be related to the product (n = 5 for both products, e.g.: "I like the odor; the odor of coffee fits the kitchen" or "The roses on the boots match their odor"). In contrast, participants mentioned that they could not relate the odor of the decorative dices to the product and, therefore, they did not like this odor for this product (n = 6, e.g.: "The lavender scent doesn't match the product at all; they should smell stale instead of fresh"). Furthermore, participants often evaluated the incongruent scents for products in the WS group as unnatural (n = 10 in total, e.g.: "I would rather smell lemons that smell like lemons. That feels more natural" or " I would prefer a wood scent for this product; this is unnatural").

Discussion

This study focused on the differences between adding incongruent odors to products that normally carry versus products that normally do not carry a particular smell. As the added smells were mostly correctly identified, they were probably all perceived as incongruent. Overall, the mean scores for Surprise were above 5.5 on a 7-point scale indicating that, as expected, the products were generally found surprising.

In the study we found several differences between the two types of products. First of all, after only seeing the products, participants reported that they were more curious about how the products in the WS group would smell than how the NS products would smell. Possibly, people did not expect the products in the NS group to have a smell and were, therefore, not that curious about how they would smell. In contrast, after seeing and smelling the products, the participants did not report that they had been more curious when they saw the WS products, but they indicated that they had been more certain about how the WS products would smell and they indicated that they were surprised more by how the products smelled. This suggests that the participants made different inferences before and after smelling the scents of the products. The surprise experienced after smelling the scents was attributed to a higher degree of certainty about how the product was expected to smell, because participants knew how the product would naturally smell. However, before smelling the product during the experiment, the knowledge about the product's natural smell did not increase certainty scores, but probably made participants more suspicious and curious. These outcomes may be interpreted in several different ways. First of all, it is possible that after smelling the products and experiencing surprise, participants incorrectly attributed the intensity of their surprise to the certainty of the expectation, while they should have attributed it to increased curiosity after just seeing the products. Alternatively, the procedure in the 'see' condition may have been experienced as very limiting by the participants and may, therefore, have led to other feelings (of curiosity) that did not occur in the 'see and feel' condition. It is interesting to note that in our other studies on surprises elicited by sensory incongruities (Ludden et al., 2009), responses on scales assessing certainty and curiosity were generally negatively related, whereas in the present study they seem to be unrelated. Future research could clarify whether this finding is specific for surprises elicited by visual-olfactory incongruities. Perhaps participants realized that it is relatively easy to manipulate a product's smell and were therefore wondering about how the experimenters had manipulated the smell.

Finally, we did not find an effect of Type of product on Evaluation. However, participants' spontaneous remarks about the products suggest that using incongruent odors for products that normally do not have a (discernable) odor can lead to a more positive evaluation of the product, especially if the odor matches with the theme or usage context of the product. On the other hand, using incongruent odors for products that normally have a familiar odor mainly elicits negative remarks.

5.3 Experiment 2: effects of degree of incongruity of scents on product evaluation

Product designers mostly design products without explicitly designing their odors. However, the results from Experiment 1 suggest that adding an incongruent odor to a product that usually does not have a discernable odor could lead to a more positive evaluation of that product. However, information on when and how to apply odors in products is scarce. Participants' opinions in Experiment 1 suggested that odors are more positively evaluated if the odor can be related to the product. The odors that participants could somehow relate to the product (odor of roses for boots and odor of coffee for kitchen paper holder) most often received positive comments. On the other hand, the odors that could not in any way be related to the product (e.g., lavender for decorative dices) were more often negatively evaluated. In other words, the more incongruent an odor is, the smaller the positive effect on product evaluation will be. Experiment 2 was set up to provide support for this relationship between degree of incongruity of scents and product evaluation.

Odors are perceived to be more or less incongruent depending on the associations that a perceiver of the odor can make between the odor and the product. Associations can be made through different product attributes such as the material of the product (which is typically responsible for a product's odor), but also through shape, color or product theme, use and use environment.

To gain more insight into how people evaluate the degree of incongruity of an odor and how this affects product evaluation, we presented products either without an added odorant or with one of two different odorants that differed in their association to the product and thus in their expected degree of incongruity. To minimize (side-)effects of odor pleasantness on product evaluation, we tried to select odorants that were equally pleasant. In a pre-study we determined the pleasantness of the odorants and the perceived degree of incongruity of the product-odor combinations. The main study tested the effects of the degree of incongruity on overall product appreciation.

Scented products form a rather new product category and, as a consequence, the additional odor may add to the complexity of the product. Therefore, we also measured the newness and complexity of the product-odor combinations. According to Michaut (2004), the perceived newness and complexity have a positive or negative effect on product liking respectively. Incongruity and surprise are important elements of her newness construct, whereas uncertainty and confusion are elements of her complexity construct.

Pre-study

We tested if the two selected scents for each product were perceived as approximately similar in pleasantness. In addition, we tested if the two scents were perceived to vary in their degree of incongruity with the product. Furthermore, to gain more insight into why scents were perceived as more or less incongruent, we asked participants to identify the scents and to explain why they thought a scent either fitted or did not fit a product.

Method

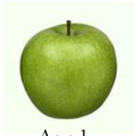
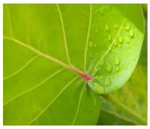
Participants

Twenty participants (8 female and 12 male, aged 19-27, mean 21) participated in the pre-study. They were students of the Faculty of Industrial Design Engineering of Delft University of Technology.

Stimuli

We selected 6 products, each from a different product category: a fruit bowl, a pair of sneakers, a toothbrush, a watering pot, an alarm clock and a baby toy. These products were selected because they did not have a (discernable) odor. We made three groups of two products and selected odorants with different types of associations for each group (Table 5.4). The fruit bowl and the sneakers were presented with odorants that were associated with the material of the product (strong association) or with odorants that could in some cases be connected to the use of the product (weak association). The toothbrush and the watering pot were presented with odorants that were directly and consistently associated with the use of the product (strong association), or with odorants that could be associated with the color or theme of the product (weak association). Finally, the alarm clock and the baby toy were presented with odorants that could be associated with the color or theme of the product (weak association) or with odorants that could be associated with the use environment of the product (weak association). We expected the odorants with weak associations to the products to be more incongruent than those with strong associations. In this way, we varied the degree of perceived incongruity of the odorants with the products both within and between products. We used two similar products that were each sprayed with a different liquid odorant and stored in separate plastic containers to prevent the odorants from spreading during the experiment. Odors were re-applied every day.

Table 5.4 Odor - product combinations used in Experiment 2.

Product	Odor 1	Odor 2
	Naturally produced odor	Odor possibly associated with use
 Fruit bowl	 Wood	 Apple
 Sneakers	 Sneakers	 Outdoor
	Odor always associated with use	Odor associated with color/theme
 Toothbrush	 Mint	 Honey
 Watering pot	 Green leafs	 Red fruit
	Odor associated with color/theme	Odor possibly associated with use
 Alarm clock	 Banana	 Lavender
 Baby toy	 Flowers	 Baby powder

Degree of incongruity between odors and products is expected to increase from left to right (Odor 1 to Odor 2, within products) and to vary from top to bottom (between products).

Procedure

Participants were presented with each of the 12 product-scent combinations. They were instructed to look at the product and to smell it. Subsequently, they filled out a questionnaire about the pleasantness of the scent ('This product smells pleasant', on a 9-point scale with end points 'do not agree at all' and 'agree completely') and the degree of fit of the scent ('How well do you think the scent fits the product?', on a 9-point scale with end points 'does not fit at all' and 'fits excellently'). Participants were also asked to identify the odor by choosing from a list of 20 options (chocolate, grass, lemon, candy, apple, baby powder, wood, bamboo, red fruit, rubber, sneakers, outdoor, flowers, plants, leather, banana, mint, lavender, honey, and mud). They were also given the option to provide an alternative answer. Finally, participants were asked to express why they thought the odor fitted or did not fit with the product. The order in which the products were evaluated was randomized. The room for the experiment was ventilated in between trials.

Results and discussion

For each product, separate repeated measures ANOVAs were carried out on the ratings for Pleasantness and Degree of fit with Odor as explanatory variable. Table 5.5 shows the mean ratings for the products with the two odorants. A successful manipulation would mean that odors were perceived as equally pleasant, and that the degree of fit varied.

We found main effects of Odor on Pleasantness for the sneakers and for the alarm clock. For the sneakers, the outdoor scent was perceived as significantly more pleasant than the sneaker scent. For the alarm clock, the lavender scent was perceived as significantly less pleasant than the banana scent. In addition, both scents had means that were below the scale midpoint, suggesting they were both not pleasant.

For Degree of fit, we found main effects of Odor for 4 of the 6 products (Table 5.5). As expected, odorants that are produced naturally or that are associated consistently with a product rate high on degree of fit. Furthermore, it does not seem to make a difference whether there is a possible association with use or with the product's theme or color. As a consequence, for the baby toy and the alarm clock we did not succeed in creating product-odor combinations that varied in incongruity.

Responses to the questions concerning odor identification and the comments on why odors were perceived to either fit or not fit the product can partly explain why some product-odor combinations yielded better outcomes than others. The outdoor odorant for the sneaker was often (n = 8) identified as a flower odor. It is not so surprising that a flower odor was evaluated as more pleasant than a sneaker odor, which was often (n = 13) correctly identified. As concerns the alarm clock, participants did recognize the association between the banana odor and the color of the alarm clock, but they indicated that they did not like a banana smell in the bedroom environment. Therefore, the banana scent was perceived as not fitting the alarm clock.

Table 5.5 Mean ratings and F-values per product for Pleasantness and Degree of fit (9 – point scale)

		Odor 1	Odor 2	F-value
Pleasantness				
	wooden bowl	5.5	5.3	0.1
	sneakers	3.9^a	5.7^b	13.1**
	toothbrush	6.0	5.1	3.3
	Watering pot	5.7	5.3	0.7
	alarm clock	4.8^a	3.5^b	7.7*
	baby toy	5.0	4.7	0.6
Degree of fit				
	wooden bowl	6.3^a	4.5^b	9.9**
	sneakers	5.8^a	3.7^b	21.7**
	toothbrush	7.2^a	3.8^b	42.5**
	watering pot	6.5^a	4.5^b	9.8**
	alarm clock	4.1	4.1	0.0
	baby toy	5.0	4.7	0.2

^{a,b} means with different superscripts were significantly different ($p < .05$)

* significant main effect at the .05 level, ** at the 0.01 level

Main study

The results of the pre-study show that in several cases (toothbrush, watering pot and fruit bowl) we were successful in creating sets of product-odor combinations for which the odorants were perceived as equally pleasant but varied in perceived degree of fit. The odorants for the sneakers were not perceived as equally pleasant although they did vary in perceived degree of fit. Therefore, results for the sneakers have to be interpreted with caution. Because the odorants presented with the alarm clock and the baby toy did not differ on degree of fit, the combinations for these products are not suitable to test effects of degree of fit. Nevertheless, we included them in the main study to compare evaluations for products with an odor to products without an odor.

Because the products used in this experiment normally do not have a discernable odor, we expect that products presented with an odorant rate higher on newness than products presented without an odorant. Following Michaut's (2004) predictions, a higher rating on newness would have a positive effect on product liking. Furthermore, we expect that odorants that are more incongruent with the product lead to increased perceived complexity, which would negatively influence the overall product liking. Therefore, we expect products presented with an odorant that is more congruent with the product to rate higher on overall product liking than products presented with either a more incongruent odorant or without an odorant.

Method

Participants

Sixty participants (23 female and 37 male, aged 18-26, mean 21) participated in the main study. They were students of the Faculty of Industrial Design Engineering of Delft University of Technology.

Stimuli

The same six product categories were used in the main study as in the prestudy (see Table 5.4). We added an unscented control product to each set of product-odor combinations.

Procedure

Each participant evaluated 6 products in total: one variant from each set of product-odor combinations. Participants always evaluated 2 products without an odorant, and 4 products with an odorant. The order in which the products were evaluated was randomised and differed between participants. The experimenter placed one product on a table in front of the participant. Participants were instructed not to touch the products, but to look at them from a small distance. In this way, we tried to ensure that participants would smell the odorant without directly focusing their attention on it (Schifferstein & Michaut, 2002). Subsequently, participants filled out a questionnaire. The first question asked about overall product liking ('Do you like this product?', on a nine-point scale with end points 'I don't like this product at all' and 'I like this product very much'). Next, participants evaluated the product on 11 nine-point semantic scales. ('I think this product is…' with end points 'conspicious–inconspicuous', 'good quality – bad quality', 'feminine – masculine', 'interesting – boring', 'unpleasant – pleasant', 'stimulating – relaxing', 'funny – serious', 'cheap – expensive', 'agreeable–disagreeable', 'tough – cute', 'quiet – vivid'). These items were selected based on their relevance for product quality and product expression. Furthermore, participants answered the questions about newness and complexity adapted from Michaut (2004): 'Please indicate how the following statements fit the product' on six nine-point scales. For newness the end points were 'This product is something I have seen/heard before – This product is different', 'This is a typical product – This is not a typical product' and 'I am not surprised by this product – I am surprised by this product'. For complexity the end points were 'This product is easy to figure out – This product is puzzling', 'This product is easy to describe – This product is difficult to describe' and 'I know what this product can do for me – I am unsure what this product can do for me'. Furthermore, participants were asked to indicate if the product evoked memories or associations with people, things or events, with 3 options: not at all, reminds me of one other person/thing/event, reminds me of two or more other persons/things/events. In the case of a confirmative response, participants were asked to describe the memory or association that first came to mind. Finally, they were asked to describe their opinion of the product in a few words.

Results

Principal Component Analysis was carried out on the responses on the 11 semantic scales to construct evaluative factors. This led to three factors for which the internal consistency (Cronbach's α) proved to be sufficient. One factor reflected the Quality of the product (5 items, with positive end points good quality, interesting, pleasant, expensive, and agreeable, $\alpha = 0.80$) The other two factors reflected the product expressions Vividness (4 items with positive end points conspicuous, stimulating, funny, vivid, $\alpha = 0.75$) and Masculinity (2 items, with positive end points masculine and tough, $\alpha = 0.74$). Cronbach's α was also sufficient for the scales measuring Newness ($\alpha = 0.71$) and Complexity ($\alpha = 0.71$).

For each product, separate ANOVAs were carried out with Quality, Masculinity, Vividness, Overall liking, Newness and Complexity as dependent variables and Odor (3 levels) as explanatory variable (see Table 5.6). In these analyses, we found a main effect of Odor on Overall liking for the alarm clock and for the plant watering pot. Pairwise comparisons with Bonferroni correction showed no significant differences between the three means for the watering pot. For the alarm clock, the product without an odorant rated higher on overall liking than the alarm clock with the banana scent. We also found a main effect of Odor for the Quality scale of the alarm clock. Again, Quality was rated higher for the unscented clock than for the banana-scented clock. This effect can probably be attributed to the incongruity of the odor with the use environment of the product, because respondents in the pre-study indicated that the smell of banana does not fit a bedroom environment. No other significant effects were found.

Table 5.6 Mean scores and F-values per product (9 – point scales)

		no odor	Odor 1	Odor 2	F-value
Overall liking					
	fruit bowl	6.2	6.0	6.1	0.1
	sneaker	4.3	4.0	4.5	0.3
	toothbrush	5.7	5.2	5.8	0.5
	watering pot	6.4	5.1	6.4	3.4*
	alarm clock	6.3^{a}	4.4^{b}	5.7^{ab}	4.2*
	baby toy	4.9	5.1	4.7	0.4
Quality					
	fruit bowl	5.8	5.7	6.0	0.3
	sneaker	4.2	4.5	4.3	0.2
	toothbrush	5.9	5.6	5.9	0.3
	watering pot	5.7	5.5	5.8	0.6
	alarm clock	5.6^{a}	4.3^{b}	5.0^{ab}	3.8*
	baby toy	5.4	5.0	4.9	0.7
Newness					
	fruit bowl	3.3	4.0	4.4	2.4
	sneaker	1.8	1.6	2.2	1.7
	toothbrush	3.6	3.5	4.1	0.6
	watering pot	3.9	4.4	4.0	0.6
	alarm clock	5.7	4.7	5.3	1.3
	baby toy	3.7	3.7	3.0	1.3
Complexity					
	fruit bowl	2.3	2.7	2.9	1.2
	sneaker	2.2	2.5	2.6	0.6
	toothbrush	2.6	2.5	2.0	1.1
	watering pot	2.9	2.9	3.1	0.1
	alarm clock	4.4	3.5	3.7	1.2
	baby toy	3.1	3.1	2.7	0.5

^{a,b} means with different superscripts were significantly different ($p < .05$)
* significant main effect at the .05 level

To investigate the relationship between the degree of incongruity (evaluated as Degree of fit in the pre-study) and Complexity and Overall liking (evaluated in the main study) of the product-odor combinations, we calculated the correlation coefficient between the means for these variables. Contrary to our expectations, a lower perceived degree of fit of an odorant did not lead to a higher perceived complexity of the product (Pearson's $r = 0.22$, $p = 0.50$). Furthermore, a higher perceived degree of fit of an odorant did not lead to higher ratings on overall liking ($r = 0.05$, $p = 0.87$)

Finally, we analyzed participants' comments on their associations with and opinions about the products. We found fewer but similar remarks about the products' odors as in Experiment 1. Again, some remarks ($n = 5$ in total) concerned whether the scent matched the product in theme or color. Also, remarks were made about scents that were perceived as too strong ($n = 8$). What was interesting is that upon perceiving an odor, participants appeared to be concerned that the product was not new anymore, but had been used before ($n = 4$). For example, a participant remarked that someone must have made lemonade in the watering pot that smelled of red fruit.

5.4 General discussion

We reported two experiments that investigated the effect of scents on product evaluation. Although the results from Experiment 1 tentatively suggested that incongruent odors in products might be evaluated positively, especially for products that normally do not carry a scent of their own, in Experiment 2 in most cases, odors did not influence participants' liking of the product. In addition, participants did not perceive products presented with odorants as newer than products without odorants, and an increasing degree of incongruity did not increase the perceived complexity of the product.

The present data adds to a number of studies that were unable to predict the exact impact of odor quality characteristics on product perception and liking (e.g., Knasko, 1995; Schifferstein & Michaut, 2002). For instance, Schifferstein and Michaut (2002) did not find any effects of odor congruency on the liking of products from multiple product categories. Although it might be argued that scent may have been a relatively unimportant attribute for the products used in the present study (Schifferstein, 2006), this was certainly not the case for Schifferstein and Michaut, who included food products. In addition, in a review of olfaction research relevant to retail environments, Bone and Ellen (1999) concluded that research on the effects of congruity of odors found only weak effects of congruity on product evaluation. Schifferstein and Michaut (2002) suggested that specifically asking about the products' scents might have influenced their results. Therefore, we did not specifically ask about the scents in the main study of Experiment 2. Nevertheless, we did not find the expected effect on product liking.

In Experiment 1 we specifically asked participants to evaluate the scents of the products. As a consequence, the number of participants that mentioned the products' odor in their comments about the product was much larger in Experiment 1 (8-12 out of 20) than in the main study of Experiment 2 (1 or 2 out of 20). This suggests that participants attributed more importance to scent when they were asked about it. However, this may not reflect the actual impact of scent on the overall product experience under real-life conditions. What is interesting here from a scientific perspective is why the predicted effects of odors are so hard to obtain in empirical studies. What is missing in our theoretical framework that causes these unexpected findings? Possibly, the dependent measures should be less explicit and should be restricted to observations of behavior or to indirect questioning (Köster, 2003). Or perhaps the actual impact of scents in products can only be studied in a more realistic setting where people can actually explore and use the products for some time?

Scent in product design

The present outcomes might suggest that scent hardly contributes to product liking. Analogously, in a study on the effect of congruent and incongruent sounds on product expression (Ludden & Schifferstein, 2007), we found that although different sounds were perceived as having different expressions, in most cases the expression of the sounds did not have an effect on the overall product expression. Furthermore, in a study in which the pleasantness of the appearance, feel, sound and smell of several product variants was manipulated (Schifferstein, Otten, Thoolen, & Hekkert, 2008) a significant effect on overall pleasantness was only found for product color. Therefore, it seems that both for product scent and product sound it is hard to predict effects on the overall expression and liking of products.

Although we did not find the expected effects in our study, designers should nevertheless not ignore the potential effects of odors. Research has shown evidence of cross-modal integration of olfaction and vision. For example, Gottfried and Dolan (2003) showed that the detection of odors was larger when an odor was presented together with a congruent picture than when an odor was presented with an incongruent picture. Furthermore, scents even seem to be able to steer people's movements: Castiello et al. (2006) presented objects with either a scent belonging to a larger or to a smaller object. The scents were found to interfere with people's grasping movements. In using products, conflicts between visual and olfactory information could have a negative effect on the usability of products. Our results also indicate that using odors on products can cause negative side effects. For example, using an incongruent scent may cause consumers to believe that the product has been used before. Perhaps, they will be worried that the product is not clean. We have to ask ourselves if people will be prepared to eat cookies that come from a 'smelly' storage box. Possibly, the scent of the Mary Biscuit enhances the experience of eating cookies only because the vanilla smell is highly congruent with most cookies that are stored in the box.

Even though we could not demonstrate the effects of odor (in)congruity in the present study, it would be unwise and premature to conclude that the scent of products is unimportant. Therefore, the advice to designers should probably be to design smells that can be related to the product. When applied in the right way, odors in products will probably be evaluated positively and can contribute to the overall product experience. However, predicting the effects the odors will eventually have on the product's expression and evaluation is difficult. This makes an iterative process of applying and testing odors during the design process essential.

(Chapter 6 was largely based on Ludden, G. D. S., Schifferstein, H. N. J. & Hekkert, P. (submitted) Surprise and emotion: experiencing visual - tactual incongruities in products. And on Ludden, G. D. S., Hekkert, P. & Schifferstein, H. N. J. (2006) Surprise & emotion. Paper presented at the 5th International Conference on Design and Emotion, 27-29 September, Goteborg, Sweden.)

Chapter 6
Beyond surprise

6.1 Introduction

During everyday activities, people almost continuously use products. And while doing so, they experience a variety of emotions (Desmet, 2008; Richins, 1997). Someone may, for example, experience anger because his or her computer is not functioning properly. Or someone may experience joy while riding a new bicycle. To some extent, designers can influence the emotions that people experience while they are using products. In this paper, we focus on how designers may deliberately create surprising products to attract attention to their products or to let users experience something new.

One of the strategies designers use to create surprising products is by incorporating visual- tactual incongruities (Ludden, Schifferstein, & Hekkert, 2008). Upon seeing such an object, an expectation will be formed about how the product will feel, based on the visual impression of the product, previous experiences with that product, or experiences with similar products. Eventually, upon touching the product, the expectation is disconfirmed, resulting in a surprise reaction. An example of such a product is a vase that looks like a familiar crystal vase, but that is made out of plastic and, therefore, feels much lighter than people would expect. Previous studies have demonstrated that products with visual – tactual incongruities indeed surprise people (Ludden, Schifferstein, & Hekkert, 2009).

Degree of incongruity

Presumably, designers who create surprising products by incorporating visual – tactual incongruities in their designs aim to create pleasant surprises. However, the degree of incongruity that people perceive may influence their overall evaluation of the product. Berlyne (1971) suggested that the relationship between incongruity and pleasantness follows an inverted U-curve: a moderate degree of incongruity will be perceived as more pleasant than no incongruity, while a larger degree of incongruity will be perceived as less pleasant than moderate incongruity. Other researchers have found support for Berlyne's theory (e.g., Hopkins, Zelazo, Jacobson, & Kagan, 1976).

However, the stimuli used in their research were primarily simple visual patterns such as polygons. Researchers studying stimuli that were more meaningful to people (as are consumer products) and that varied in the degree of familiarity or prototypicality, found that these two variables explained most variation in aesthetic preference. Whitfield (1983), for example, showed that furniture that was more representative (prototypical) for its category (e.g., chair or table) was preferred over furniture that was less representative. Furthermore, in a study on cubist paintings, Hekkert & van Wieringen (1990) demonstrated a linear relationship between beauty and prototypicality for representational (and, therefore, meaningful) works. In addition, Hekkert (1995) found that the preferred proportions of objects with a rectangular shape were mainly determined by their familiar proportions and not by some universal, aesthetic mathematical rule, such as the Golden section.

For consumer products, congruity contributes positively to prototypicality. After all, product attributes are perceived as congruent when they confirm the perceiver's expectations, which is more often the case with prototypical products. This suggests that consumers will prefer products that provide congruent information. When someone perceives a visual – tactual incongruity and is surprised about this, he or she will probably evaluate the unexpected tactual characteristics as unpleasant. Feeling something that is different from what was expected may startle someone, making the tactual aesthetic experience less pleasant. Therefore, a larger degree of visual – tactual incongruity in a product may have a negative effect on product appreciation.

Nonetheless, a previous study on products with visual – tactual incongruities (Ludden et al., 2009) suggested that these products were in most cases evaluated positively. Our results suggested that a surprise reaction was mostly followed by a positive emotion such as amusement or interest. In some instances, however, the surprise reaction was followed by a negative emotion such as confusion. Therefore, we hypothesize that the overall evaluation of products with visual – tactual incongruities is determined by a negative aesthetic reaction to the disconfirmed expectations and either a positive or a negative effect of the emotional reaction following the surprise (see also Hekkert & Leder, 2008). Whether a positive or a negative emotion follows the surprise reaction will ultimately determine the overall evaluation of the product. Experiencing a positive emotion may overcome the negative effect of perceiving an unexpected tactual characteristic, whereas a negative emotion will only enhance this effect. The next section will discuss in more detail how surprise is related to other emotions.

Emotions following surprise

In a previous study, we found tentative evidence that surprise in products can be seen as the first stage in a process evoking different emotions. An analysis of facial expressions of surprise showed that in 19% of the cases in which a facial expression of surprise was observed, the facial expression revealed two stages. The first stage comprised one of the subcomponents of a surprise expression (widened eyes, opened mouth or raised eyebrows) and the second stage consisted of either an expression of joy or amusement (raised mouth corners: smiling) or of puzzlement or interest (lowered eyebrows: frowning) (Ludden et al., 2009).

According to appraisal theory, emotions are the result of an individual's evaluation and interpretation (appraisal) of events in the environment (Roseman & Evdokas, 2004; Scherer, 1987; Smith & Ellsworth, 1985). Lazarus and Smith (1988) see true appraisal as the assessment of the implications of events for an individual's goal commitments. Most appraisal models suggest that combinations (sequences) of several different appraisal types eventually cause an emotion. In addition, if multiple appraisals are made in succession, multiple emotions may be experienced consecutively. Several researchers (Meyer, Reisenzein, & Schutzwohl, 1997; Scherer, 1987) have argued that in a sequence of appraisals that starts with an appraisal of an event as unexpected, surprise is elicited, after which the surprising event is further evaluated and a 'second' emotion is elicited. Silvia (2005) suggests that interest is related to surprise through such a sequence of appraisals, in which an appraisal of novelty is followed by an appraisal of coping potential.

Furthermore, Vanhamme and Snelders found that surprise can be followed by satisfaction (2001), and people have reported that their surprise reactions were followed by amusement, fascination, disappointment, indignation, and irritation (Ludden, Schifferstein, & Hekkert, 2006). Some, but not all of the possible appraisal patterns for these emotions have been described (see Ludden, Hekkert, & Schifferstein, 2006).

Long-term effect of surprise

Because the phenomenon of surprise relies on the disconfirmation of expectations that were formed based on previous experience, we expect that a surprise is only felt when someone experiences a product for the first time. When a product with a visual – tactual incongruity is encountered for the first time, its visual appearance may be misleading. However, after touching the product, the perceiver of the product will update his or her knowledge. The 'previous experience' of the perceiver has now changed. The second time someone encounters the same product, his or her expectations about the product will probably match the actual (tactual) experience and, therefore, he or she will not be surprised again upon touching the product. Participants in previous experiments indeed sometimes mentioned that a surprise was a one-time experience and that surprising products would become boring on the long-term (Ludden, Schifferstein et al., 2006). To our knowledge, the effects of surprise on people's emotional reactions on the long-term have not been studied before.

Experiencing a surprising product is arousing, it captures attention to the product, leading to increased product recall and recognition, and to increased word-of-mouth (Derbaix & Vanhamme, 2003). Furthermore, it requires a more effortful, conscious, and deliberate analysis of the unexpected event (Meyer, Niepel, Rudolph, & Schutzwohl, 1991; Meyer, Reisenzein, & Schutzwohl, 1997; Stayman, Alden, & Smith, 1992). Therefore, we expect that products with visual – tactual incongruities are remembered better and that people are more interested in seeing/feeling surprising products again. Although we do not expect people to experience a surprise reaction again when they are presented with the same product for the second time, we do expect a difference in emotional reactions towards and evaluation of surprising versus non-surprising products on the long term.

6.2 Experiment: a longitudinal study on the experience of products with visual - tactual incongruities

This study investigated people's reactions to products with visual – tactual incongruities upon repeated presentation. It has three main aims: (1) investigate effects of incongruity size on the evaluation of products, (2) investigate if (and which) other emotions follow surprise, and (3) investigate long-term effects of surprise. To be able to study these issues in relation to product design, we created products with visual – tactual incongruities as stimuli. The visual appearance of all 3 products in a set was kept as similar as possible, while the tactual characteristics of the 3 products differed. The same product was presented to participants at three different points in time.

Method

Participants

A total of 62 participants (36 female and 26 male, aged 18-36, mean 22.6) participated in the first part of this study. 60 participants continued with the second part of the study and 57 participants completed all three parts of the study. Analyses of data obtained in the first part of the study were carried out on the total of 62 participants. Longitudinal analyses were carried out on the 57 participants that completed all three parts of the study. Participants were students at Delft University of Technology and were paid for their participation.

Stimuli

We created 6 product sets, each containing 3 variants of the same product (Table 6.1). The size of visual – tactual incongruity was manipulated within product sets. The visual appearance of all 3 products in a set was kept as similar as possible, while the tactual characteristics of the 3 products differed. The visual appearance of these products elicited an expectation about how the product would feel. The tactual properties of the 3 products in each set were designed either to confirm this expectation (No Incongruity, NI), to be moderately incongruent (MI) with this expectation, or to be largely incongruent (LI) with the expected properties. The product sets either consisted of larger products typically placed on the floor or of smaller products typically placed on a table. Figure 6.1 shows two examples of sets of products and Table 6.1 lists the 6 product sets with detailed descriptions of the three variants per set.

Table 6.1 Stimuli with detailed descriptions and tasks.

	NI	MI	LI	task
 metalcup	feels like metal; inflexible and heavy	feels like hard plastic; inflexible, less heavy	feels like rubber; flexible, less heavy	Walk over to the cup and pick it up. Subsequently, place it back on the table.
 earcup	ear feels like lacquered stoneware: hard	ear feels like rubber on stoneware: rubbery texture	ear feels like cloth on stoneware: soft texture	Walk over to the cup and pick it up. Subsequently, place it back on the table.
 softbox	feels like felt: soft and flexible	feels inflexible, surface feels soft like felt	feels inflexible and surface feels rough	Walk over to the box, pick it up and remove the lid. Subsequently, replace the lid and place the box back on the table
 newspaper stand	inner part feels like cotton: flexible and soft	inner part feels rubbery: less flexible and stickier	inner part feels inflexible and surface feels rough	Walk over to the newspaper stand and remove the magazines from the stand. Place the magazines on the floor.
 tilebench	feels like tiles on concrete: hard	feels softer: yields ~ 0.5 cm	feels flexible, soft, yields ~ 2 cm	Walk over to the bench and sit on the bench. Then stand up.
 concrete bench	feels like massive concrete: very heavy ~ 30 kg	feels less heavy ~ 16 kg	feels light ~ 6 kg	Walk over to the bench and move it approximately 10 cm backwards

Experimental design

Participants were presented with 6 (out of 18) stimuli, one from each set, two NI, two MI and two LI. In this way, 19-21 participants evaluated each stimulus. The order in which participants evaluated the stimuli was randomized. Because one of the aims of this study was to investigate long-term effects of surprise it had a longitudinal set-up. Participants evaluated the products at three different points in time. The second evaluation took place 14 – 21 days after the first and the third evaluation took place 7-14 days after the second.

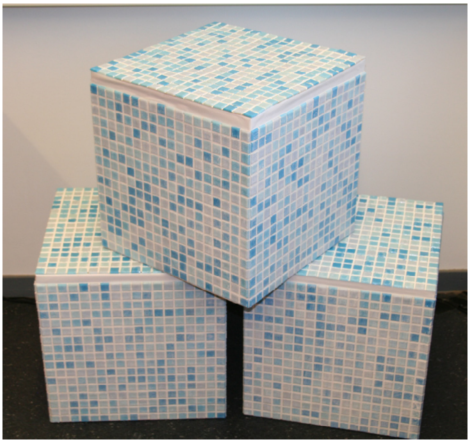


Figure 6.1 Two examples of product sets: soft-boxes and tilebenches.

Procedure for first encounter

The stimuli were placed in a room; the larger products were placed on the floor, the smaller products were placed on a table. All products were covered. A chair was placed in front of one of the stimuli at a distance of approximately 1.5 m. The participant was instructed to sit in the chair and look at the product in front of him/her. Subsequently, the experimenter uncovered the first product and instructed the participant to perform a simple task with the product. The tasks were different for the different products, because different tactual characteristics were manipulated for the different sets of products. Table 6.1 lists the different tasks that were given for the stimuli.

After performing the task, the participant was instructed to sit at a separate table and fill in a questionnaire. The questionnaire consisted of two main parts. Unless indicated otherwise, responses were given on 9-point scales with end points ‘do not agree at all’ and ‘agree completely’. The first part of the questionnaire contained questions related to the size of the incongruity and the pleasantness of the stimuli. Three questions measured Surprise: ‘The (product) felt exactly as I expected (when I saw it)’, ‘I am surprised about how this (product) feels’, and ‘I am amazed about how this (product) feels’. Because we expected that for products with visual – tactual incongruities, perceiving the incongruity would have a negative effect on the aesthetic appreciation of tactual characteristics, this Tactual liking was measured as a separate construct: ‘I like the way this (product) feels’. Three other questions measured Overall liking: ‘I like this (product)’, ‘This (product) is nice’, and ‘I like the way this (product) looks’. Furthermore, four questions measured perceived differences between expected and actual experience (visual – tactual incongruity): ‘The (product) felt … than I thought’ on scales with end points ‘heavier – lighter’, ‘less flexible – more flexible’, ‘less soft – softer’, ‘rougher – smoother’.

In the second part of the questionnaire, participants were asked to evaluate to what extent they felt 8 different emotions ‘After I touched the (product) I was interested / fascinated / amused / disappointed / confused / indignated / satisfied / irritated’ on 8 separate 5-point scales with end points ‘not at all’ and ‘very much’ and midpoint ‘a little’. Finally, to gain further insight into why certain emotions were felt, they were asked to write down why they felt the way they did.

Procedure for second and third encounter

The procedures for the second and third encounters with the stimuli were largely the same as for the first encounter. However, before evaluating the products participants were received in a separate room and were instructed to give a short description of the products they remembered having evaluated. Subsequently, participants were provided with an overview of the stimuli (showing 5x5 cm color photographs) and were asked to indicate which of the products they would like to see and feel again. After performing these tasks, participants were asked to enter the experimental room and were presented again with the same 6 stimuli they evaluated the previous time. Participants were instructed to answer the questions according to their current experience.

Data analysis

All responses on scales were coded 1-9 or 1-5. Internal consistency of the proposed sum scales was evaluated using Cronbach’s α.

We checked the manipulation of our stimuli in two different ways. First, for the 4 scales that measured visual – tactual incongruity, for each product set we tested if responses differed significantly from the center of the scale (two-tailed t-tests) and we used between-subjects analysis of variance (ANOVA), with Bonferroni adjustment for multiple comparisons to examine differences between NI, MI and LI products. We also used ANOVA to test whether NI, MI and LI versions of products differed with respect to the level of Surprise that participants felt.

Because the experience of emotions is specific for individuals, within-subjects analyses are more suitable for research questions considering the experience of emotions (Silvia, 2007). Our data has a multilevel structure: responses on different variables and on three different points in time are nested within people. Therefore, we used multilevel modeling to investigate the relationship between surprise and other emotions (Kreft & de Leeuw, 1998; Silvia, 2007), as well as to examine the effect of time (Bijleveld & van der Kamp, 1998) within subjects. To perform the multilevel analyses the SPSS MIXED procedure was used using restricted maximum likelihood estimation. The coefficients were modeled as random effects (Painter, 2003). Participants' comments on why they felt certain emotions were used to illustrate the results.

To investigate effects of incongruity size on Tactual liking, Overall liking and the experience of emotions we could not use multilevel modeling, because every participant was presented with only one product in each set. Instead, we performed between-subjects analysis of variance and analyzed our data as if each participant had evaluated only one product. To test general effects of incongruity size on Tactual liking, Overall liking and the experience of emotions, we performed these analyses on the aggregated data of products for which our manipulations were successful. However, we will report results for individual sets if they clearly disconfirm the aggregate analysis.

Finally, for the extra two questions participants answered before the second and third presentation of the stimuli regarding the products thy remembered and wanted to see and feel again, frequencies of the products mentioned were counted and subjected to an ANOVA with Type of stimulus (3 levels, NI, MI, LI) as factor.

Results

Manipulation check

Table 6.2 shows mean values for the difference between expected and perceived tactual properties (visual – tactual incongruity). A successful manipulation would mean that for NI versions of products, no incongruities are perceived (m = 5) and that for both MI and LI versions of products incongruities are perceived, with the largest deviations (both in size and in number) for LI versions of products.

Table 6.2 Mean values for difference between expected and perceived tactual properties (visual - tactual incongruity) per product.

	lighter	more flexible	softer	smoother
metalcup NI	4.4	4.9	4.8	5.2
metalcup MI	6.9**	5.3	5	3.6**
metalcup LI	6.9**	8.5**	7.8**	3.6**
earcup NI	4.9	4.8	4.9	5.1
earcup MI	4.3*	5.3	5.6	2.4**
earcup LI	4.8	4.9	6.9**	4.0*
softbox NI	6.4**	6.2*	4.3*	4.8
softbox MI	4.4	2.7**	3.2**	3.9**
softbox LI	5.2	2.0**	1.8**	3.0**
newspaper stand NI	4.8	4.4	4.4	4.5
newspaper stand MI	5	3.9**	2.8**	2.1**
newspaper stand LI	4.7	2.7**	2.5**	2.5**
tilebench NI	5.1	4.2*	3.8**	3.3**
tilebench MI	5	5.7	5.4	4.9
tilebench LI	5.3	7.2**	6.9**	4.3
concretebench NI	1.7**	3.9**	4.8	5.2
concretebench MI	2.7**	4.2*	5	4.3
concretebench LI	5	5	4.8	4.8

two-tailed t-test (df=19-20), significantly different from center of scale (5) *at the 0.05 level, ** at the 0.01 level

Table 6.3 F-values and mean scores per product on Surprise at t=1.

	F-value	NI	MI	LI
metalcup	67.96**	2.2[a]	6.1[b]	8.2[c]
earcup	30.32**	2.4[a]	6.3[b]	7.0[b]
softbox	10.69**	3.1[a]	5.6[b]	6.5[b]
newspaper stand	37.05**	2.5[a]	7.6[b]	6.1[b]
tilebench	11.11**	4.7[a]	5.1[a]	7.4[b]
concretebench	0.40	5.8[a]	5.4[a]	5.2[a]

significant main effect at the .05 level, ** at the 0.01 level
[a,b,c] scores with different superscripts were significantly different (p<.05)

Table 6.2 shows that for the product sets metalcup, earcup and newspaper stand our manipulations work as expected: no incongruities are perceived for NI versions, and incongruities are largest for LI versions. For the product sets softbox, tilebench and concretebench, the manipulations seem less accurate. For these products participants seem to perceive incongruities for the NI versions. In addition, in contrast to our expectations, participants report no incongruities for the MI version of the tilebench and for the LI version of the concretebench.

Table 6.3 shows the results of separate ANOVAs per product with Surprise (3 items, $a = 0.92$) as the dependent variable. Scores for NI, MI and LI products are compared in pairwise comparisons. In terms of surprise, a successful manipulation would mean that scores on Surprise for NI versions of products are low, for MI versions larger and for LI products largest.

We found main effects on Surprise (all $p < 0.01$) for all but one product set: the concretebenches. For 4 product sets (metalcups, earcups, softboxes and tilebenches) the NI version scores lowest on Surprise, the MI version scores higher and the LI version scores highest on Surprise, as expected. However, the differences between means are only significant for the metalcups. Contrary to what was expected, for the product set newspaper stand the MI version tended to have a higher mean score on Surprise than the LI version.

For the larger part, the results of our two manipulation checks are comparable. Results for the metalcups are in both cases entirely as expected. Although the manipulations for the earcups and the softboxes appear to be less strong, we still find considerable differences in the expected directions between the different versions. For the newspaper stands, however, the mean scores on Surprise suggest that the MI version is more surprising than the LI version. Therefore, we will further treat the stimulus that was designed to be the MI version of the newspaper stand as the LI version and vice versa.

For the tilebenches, both manipulation checks show an unexpected result: the NI version is found surprising. Several visual-tactual incongruities were found for the NI version (Table 6.2) and the mean score for Surprise is not significantly lower than that of the MI version (Table 6.3). For the concretebenches more incongruities were found for the NI and MI version than for the LI version (Table 6.2). In addition, all products were found equally surprising (Table 6.3). Therefore, in further analyses of the effects of incongruity size (comparing NI, MI and LI versions of products), we will not include scores for the tilebenches and the concretebenches. All subsequent analyses will be done at the aggregate level, aggregated over the remaining 4 product sets.

Effect of degree of incongruity on product evaluation

To test for the effects of degree of incongruity on the aesthetic appreciation of tactual characteristics and on overall product evaluation, we used the data obtained in the first evaluation of products ($t = 1$) and included Tactual liking and Overall liking (3 items, $a = 0.89$) as dependent variables in an ANOVA with Type of stimulus as factor. We found a significant main effect of Type of stimulus on Tactual liking ($F(2,245) = 18.2$, $p < 0.001$). As expected, pairwise comparisons show that mean ratings were lower for the MI and LI versions of products than for the NI versions of products (see Figure 6.2). However, there was no difference in mean scores between MI and LI products. We found no main effect of Type of stimulus on Overall liking at $t = 1$.

The same analyses at $t = 2$ and $t = 3$ showed a similar pattern for the appreciation of tactual characteristics: mean scores on Tactual liking were lower for MI and LI versions of products. Mean scores on Overall liking were also similar to those at $t = 1$. However, we now found a main effect of Type of stimulus on Overall liking at $t = 2$ ($F(2,237) = 3.67$, $p < 0.05$). Pairwise comparisons showed that ratings were lowest for the MI versions of products (see Figure 6.2).

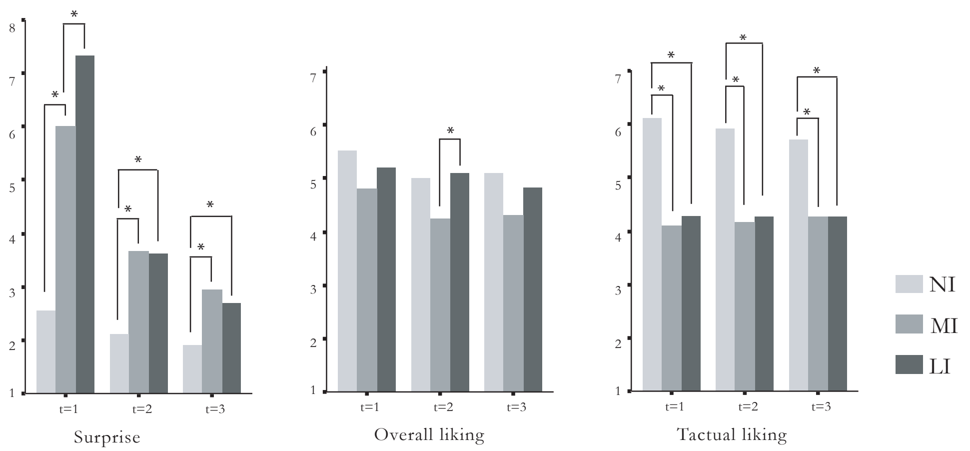


Figure 6.2 Ratings on Surprise, Overall liking and Tactual liking at three points in time for NI, MI and LI versions of products. * Significant difference in pairwise comparisons, $p < 0.05$

Long term effects of surprise

To investigate if surprising products are remembered better, we calculated how often participants mentioned products in the three different types before their second/ third evaluation of the products started. These numbers were subjected to between -subjects ANOVAs with Type of stimulus as explanatory variable. We expected that LI and MI versions of products would be mentioned more often than NI versions. However, for both $t = 2$ and $t = 3$, we found no main effect of Type of stimulus ($F(2,237) < 1.0$, $p > 0.20$). Means for all three types were between 0.7 and 1.0 suggesting that overall, products were remembered well. The same analysis per product showed the expected main effect for the product set earcup at $t = 3$ only ($F(2,53) = 3.6$, $p < 0.05$). However, paired comparisons showed no differences between the three types of products.

The frequencies with which participants mentioned products that they wanted to see/feel again can be regarded as a measure of interest. Again, we expected that LI and MI versions of products would be mentioned more often than NI versions, but we found no main effect of Type of stimulus ($F(2,237) < 1.0$, $p > 0.20$). Means for all three types were between 0.2 and 0.3 suggesting that in general, participants were not often interested in seeing and feeling the products again. The same analysis per product showed the expected main effect for the product set earcup both at $t = 2$ and $t = 3$ ($F(2,57/53) > 3.6$, $p < 0.05$). For this product set, the LI version was mentioned more often than the NI version at both $t = 2$ and $t = 3$. Furthermore, at $t = 2$ the MI version was also mentioned more often than the NI version. We also found a main effect of Type of stimulus for the product set newspaper stand at $t = 2$ ($F(2,57) = 7.0$, $p < 0.01$). Paired comparisons showed an unexpected difference between the three types of products: the NI version of this product was mentioned more often than the LI version. Hence, we did not find a consistent increase in interest for the surprising products.

To show the general effect of time on the experience of surprise, Figure 6.2 presents mean Surprise ratings for the three different types of products at the three different time points. These ratings show that scores for surprise drop at the second evaluation of products and further decrease at the third evaluation of products. Although at $t = 2$ and at $t = 3$ Surprise ratings have dropped substantially, MI and LI products still have significantly higher ratings for Surprise than NI products. However, the difference in Surprise ratings between MI and LI products that was found at $t = 1$ was no longer found at $t = 2$ and $t = 3$.

These ratings only show between-subjects' means. To test the within-person effect of Time on Surprise, we included the different responses participants gave at the three different time-points (i.e., which are nested within people) in multilevel analyses. As expected, we found a significant negative effect ($t(56) = -15.33$, $p < 0.05$) of Time on Surprise.

Emotions following surprise

To test our assumption that surprise is often followed by another emotion, we investigated the relationship between Surprise and the eight emotion scales at $t = 1$. By using multilevel modeling, for each emotion we can test the prediction that when someone experiences surprise, he or she is more likely to also experience that emotion. To do so, a single participant's surprise ratings are related to his or her emotion ratings over all products this participant was presented with. In multilevel modeling, the relationship thus obtained is called a 'slope'. Subsequently, slopes are averaged over people to obtain a relationship between surprise and other emotions. The analyses showed significant positive relationships ($3.79 < t(61) < 10.44$, all $p < 0.001$) between Surprise and interest, fascination, amusement, confusion, indignation and irritation. Furthermore, we found a negative relationship between Surprise and satisfaction ($t(61) = -2.33$, $p < 0.05$). No significant relationship was found between Surprise and disappointment. Hence, these outcomes suggest that surprise is often followed by interest, fascination, amusement, confusion, indignation and irritation, but it is less likely to be followed by satisfaction.

The effect of degree of incongruity on the experience of emotions was investigated in a between-subjects analysis: we included the 8 emotion scales as dependent variables in 8 separate ANOVAs and examined differences between NI, MI and LI versions of products in pairwise comparisons (Figure 6.3, $t = 1$). We found main effects ($F(2,245) > 4.3$, all $p < 0.05$) of Type of stimulus on all emotions. For interest, fascination, amusement and confusion, mean scores for NI versions of products were significantly lower ($p < 0.05$) than mean scores for MI versions and mean scores for MI versions were significantly lower than mean scores for LI versions. The same pattern in means was found for the emotions indignation and irritation, although here differences between MI and LI versions of products were not significant. These results reflect the positive relationships between Surprise and these emotions found in the multilevel analysis.

For disappointment, the mean ratings for MI versions of products were higher than those for NI and LI versions. Furthermore, for satisfaction, mean ratings for MI versions were lower than those for NI and LI versions. Although these differences did not always reach significance, they may reflect the pattern in means we found for Overall liking.

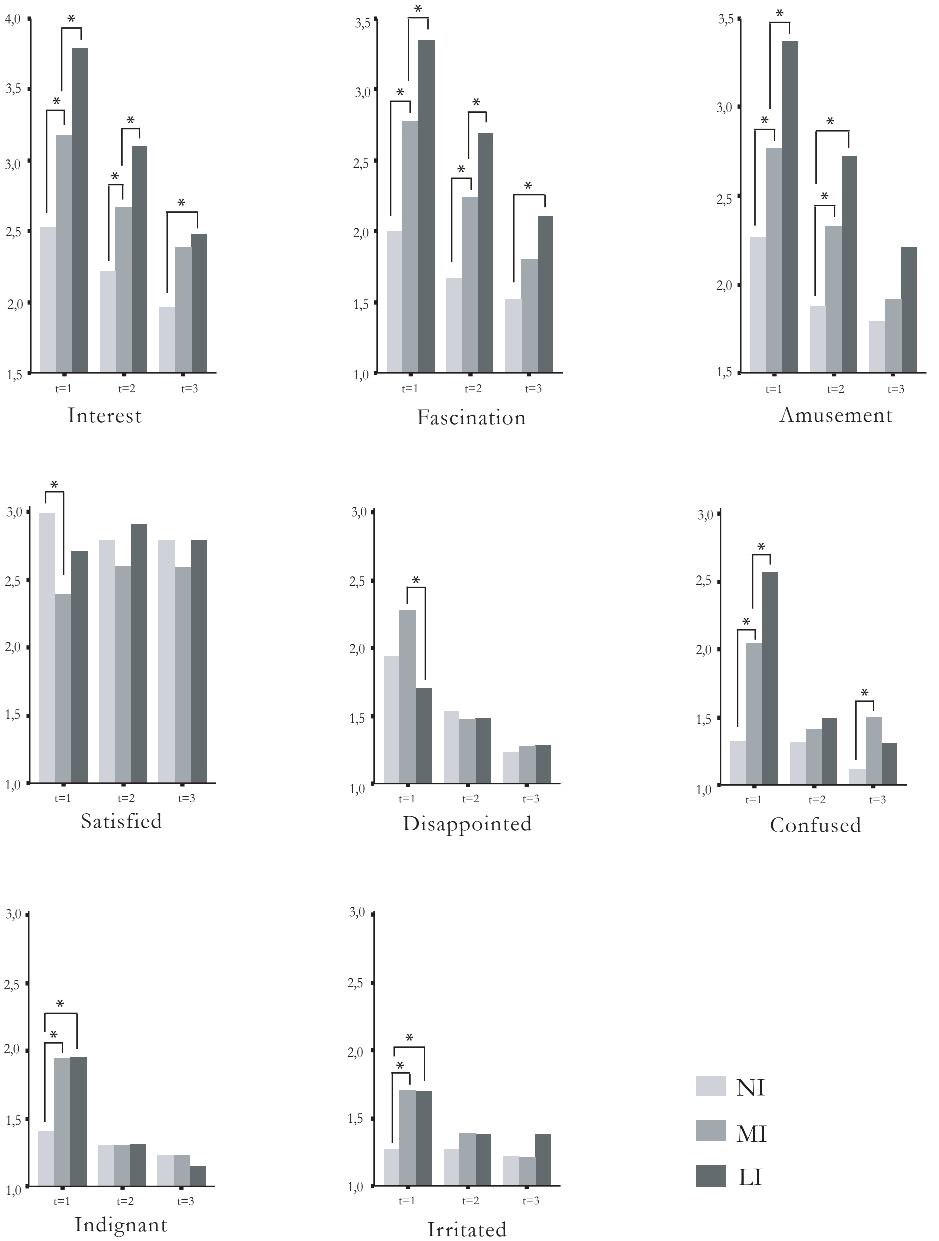


Figure 6.3 Experience of eight emotions at three different points in time for NI, MI and LI versions of products. * Significant difference in pairwise comparisons, $p < 0.05$

To test the within-person effect of Time on emotions, we included the different responses participants gave at the three different time-points (i.e., which are nested within people) in multilevel analyses. We found significant negative effects of Time on 7 of the other 8 emotions ($-4.8 < t(56) < -14.9$; all $p < 0.05$). Only for satisfaction, no significant effect of Time was found. Thus, participants' experience of all emotions except satisfaction seems to decrease over time.

Again, we also investigated differences between NI, MI and LI versions of products in between-subjects analyses (see Figure 6.3, $t = 2$ and $t = 3$). These analyses show that at the second evaluation of products, we still find main effects of Type of stimulus on 3 emotions: interest, fascination and amusement. Differences between the different versions of products are similar to differences after the first evaluation, i.e. mean scores for LI versions are highest, scores for MI versions are lower and scores for NI versions are lowest. At the third evaluation, main effects of Type of stimulus are found on only 2 of these 3 emotions: interest and fascination. Differences between LI, MI and NI versions are smaller (and not always significant), but point in the same direction as at the first and second evaluation. We also found a main effect on confusion at $t = 3$; mean ratings for the MI versions were significantly higher than ratings for the NI versions.

Discussion

It seems that our manipulation of products was not in all cases accurate. We encountered some unexpected reactions to our products. This illustrates that designers can experience difficulties in predicting people's expectations about products. However, using four complete product sets, we could still test our predictions.

Effect of degree of incongruity on product evaluation

As expected, we found a negative effect of degree of incongruity on the aesthetic appreciation of unexpected tactual characteristics. MI and LI versions of products scored lower on Tactual liking. However, this effect did not increase with a larger degree of incongruity: mean scores for MI and LI products were similar. Possibly, the scores on Tactual liking for the MI and LI versions of products are mainly determined by the fact that they contain unexpected characteristics and not so much by the degree of incongruity. The relationship between the variables Surprise and Tactual liking (Pearson $r = -0.39$, $p < 0.01$), confirms that feeling something different from what was expected may make the experience less pleasant. Surprise was not correlated with any of the items in the Overall liking scale ($p > 0.10$).

Ratings on Overall liking tended to be lower for MI versions of products than for NI and LI versions of products (Figure 6.2). Although the difference in ratings for MI and LI versions of products was only significant at $t = 2$, this seems to confirm our hypothesis that the negative effect of perceiving unexpected tactual characteristics may be overcome by a positive effect of experiencing positive emotions following the surprise reaction. Ratings on positive emotions were higher for LI versions of products than for MI versions of products. Therefore, the positive effect of experiencing positive emotions on the overall evaluation of products may have been larger for LI versions of products than for MI versions of products, leading to higher ratings on Overall liking.

Emotions following surprise

The positive relationships we found between Surprise and 6 of the 8 emotions we tested support our assumption that surprise can be seen as the first stage in a sequential process of appraisals that is followed by the experience of other emotions. We only found no relationship between surprise and disappointment.

Mean ratings on amusement (at $t = 1$) were particularly high for the metalcup LI (4.3) and the tilebench LI (3.8) (all other means were below 3.5). In their comments on why they felt certain emotions, participants often mentioned the words 'funny' or 'amusement' for these products (4 and 5 times out of 20, respectively, compared to 0 or 1 time for other products). In both products, unexpected flexibility is the surprise-evoking aspect. Flexibility may be seen as a diminishing attribute: it can make an object seem flimsy, of inferior quality. However, Wyer and Collins (1992) state that perceiving a diminishing attribute that is not evaluated as conflicting with an individual's goals can evoke amusement. Therefore, flexibility in products may be seen as amusing, as long as the flexibility does not diminish the functionality of the product. Please note that it would be unwise to conclude here that all products that are more flexible than expected evoke amusement. The complexity of the products used in our study does not permit such conclusions. However, it would be interesting to further study the relation between surprises due to tactual properties and the specific emotions that can follow the surprise.

We expected that for products with visual – tactual incongruities the tactual aesthetic evaluation would be lower than for products without visual – tactual incongruities. Differences in ratings on Tactual liking indeed seem to confirm this. In addition, it could be argued that Tactual liking may be affected by the tactual properties of the objects themselves. For instance, some of the products with visual – tactual incongruities (the LI softbox, and the MI and LI newspaper stand) may have scored relatively low on Tactual liking because they felt rough or hard. Nevertheless, because this study also included products with incongruities for which the tactual properties were probably quite pleasant (e.g., the soft texture of the earcups or the lightness of the metalcups) the role of the intrinsic pleasantness of the tactual properties needs further investigation.

Comparing Figure 6.2 to Figure 6.3, most emotions seem to follow a pattern of means that is quite similar to the one found for Surprise: at t=1 the intensity of the emotions increases from NI to LI products, and this pattern seems to attenuate over time. This suggests that all these emotions in our case are mainly determined by the occurrence of unexpected events. However, for satisfaction, the pattern of mean responses is very different and resembles the pattern found for Overall liking. In addition, the multilevel analysis for t=1 showed a negative relationship between satisfaction and surprise.

According to Vanhamme & Snelders (2001), surprise in combination with negative emotions may have a negative effect on satisfaction. However, our results give reason to believe that surprises evoked by visual – tactual incongruities generally evoked positive emotions. Although mean ratings for all emotions were relatively low (all < 4), mean ratings for negative emotions were somewhat lower than those for positive emotions. According to Oliver (1997), people experience a higher degree of satisfaction when a product performs according to their expectations or performs better than expected. Indeed, their comments suggest that participants' abilities to understand the products ("I am not satisfied because I still do not know how this product was made") or to perform a task in the experiment ("It gave me a feeling of satisfaction that I could move the bench, because I thought that I would not be able to do that") had an effect on their judgements for satisfaction. It may also explain why we found no effect of time on satisfaction: At the second and third encounter of products, participants often expressed that they were satisfied because they had remembered the products' characteristics: ("I remembered that this bench felt much lighter than it looked and that it felt smooth. This made me feel satisfied"). Therefore, the responses for satisfaction seem to be mainly determined by how participants evaluated the performance of the products as such, and to a lesser extent by their momentary reactions to unexpected events.

Long-term effect of surprise

Contrary to what we expected, participants' recollection of NI, MI and LI versions of products was about the same and participants did not express a greater interest to experience the surprising products again. Our results nevertheless suggest that at the long term, surprising products are evaluated positively.

Although the level of surprise that is felt when someone encounters a product with visual – tactual incongruities seems to decrease considerably when this product is encountered for the second time, the level of surprise is even lower when the same product is encountered for the third time. This implies that a product can, to some extent, be surprising not only at the first, but even at the second (and third) encounter. In other words, the experience of surprise is not simply a one-time-only event. However, the intensity of the surprise decreases with the number of encounters. Participants sometimes expressed their surprise about the feeling of surprise they felt when experiencing the products for the second time: "I thought I knew how this product felt now, but it felt different nevertheless". This could imply that when a person adjusts his knowledge after the first encounter with a surprising product, the adjustment is not complete (e.g., Helson, 1964). Or, alternatively, after the first encounter the stored knowledge may have drifted away again, so that the expectation at t = 2 again differs from the actual experience. The differences in ratings on interest, fascination and amusement between the different product variants at t = 2 and t = 3 may be related to this repeated experience of surprise.

Conclusion

Our results suggest that several emotions can accompany the surprise reactions to industrial products. Although the effect of surprise diminishes over time, it persists and can be measured at multiple occasions. In addition, we have shown that surprising products are evaluated as positively as unsurprising products when they evoke a high enough level of positive emotions. The data support our hypothesis that liking for surprising products may be the composite effect of a decreased liking due to unfamiliar characteristics and increased liking due to positive emotions following surprise. The effects that surprise can have on the long - term makes the experience of surprise and the resulting emotions particularly relevant to designers. Because surprising products offer new experiences to users and stimulate further exploration of the product, designers may benefit from designing surprising products. Hopefully, the findings of this study will stimulate other researchers to further pursue the question of how people's emotional reactions to products develop over time.

6.3 Two-stage model of surprise

We propose a model in which surprise is the first stage in a sequence of appraisals that can lead to different emotions (Figure 6.4). The model we propose differs from earlier models, in that it tries to offer a more complete overview of how surprise can eventually result in a set of emotions, rather than describing the link between surprise and one, distinct other emotion. It is important to note that the appraisals in this process are not conscious and controlled but rather subconscious and fast (Silvia, 2005a). Therefore, the different stages in the process may not be experienced as such.

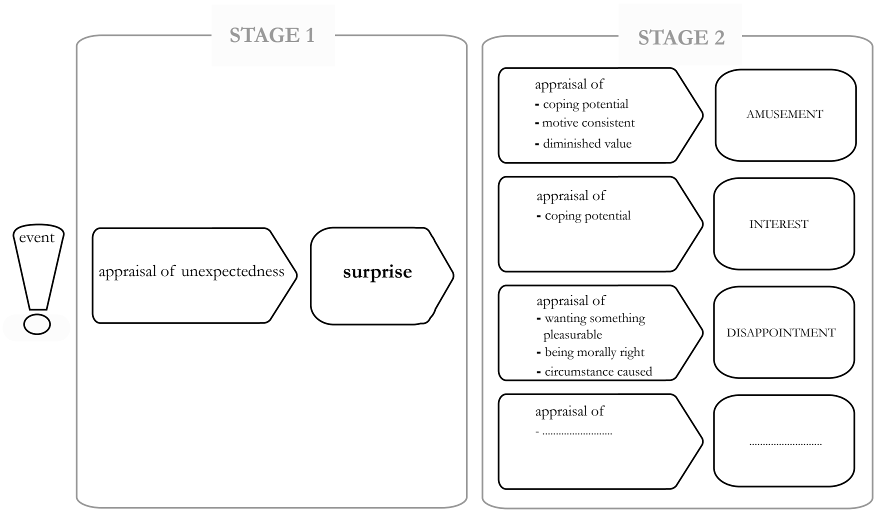


Figure 6.4 Two-stage model of surprise.

Following Roseman et al. (1996), we propose that the process of experiencing surprise starts with the appraisal of an event as unexpected (i.e., as discrepant with someone's anticipatory representation of what was likely to come next, evoked upon perceiving a stimulus (Berlyne, 1971, pp 143)). A different, but related appraisal, novelty, is also associated with surprise. Especially in the case of surprise in product design, the concept of novelty is closely related to unexpectedness. The application of a new material in a product, for example, may be experienced as unexpected and therefore surprising. After all, what is expected (in products) is often familiar and what is novel is surprising (Berlyne, 1971, pp 145). Besides acknowledging the relationship between novelty and surprisingness, Berlyne also explains how one can occur without the other. For instance, we can imagine someone exploring a new model of a mobile phone and discovering that it has largely the same features as an older model. Although in this case the person exploring the phone encounters something that is not novel, she may feel surprised because she was expecting new features. Analogously, Roseman et al. (1996) state that only when novel, unfamiliar, or uncertain stimuli are unexpected, they will produce surprise. The unexpectedness of the event thus causes the surprise reaction.

During a surprise reaction, physiological, behavioral, and verbal/ subjective reactions may occur. In other words, someone can feel surprised, he or she can act in a certain way (for example, explore the surprising event further) and/ or can express his or her feeling of surprise through facial or vocal expressions.

Subsequently, when entering the second phase in our model, the surprising event is further evaluated, using one or more different appraisal types that can lead to various emotions. Which appraisal type is used to evaluate the surprising event further depends on the concerns of the observer (e.g., on the goals he or she wants to achieve), and on the specific surprising event. Unfortunately, most available appraisal models (e.g., Smith and Ellsworth, 1985; Roseman et al., 1996) include only small sets of appraisal types differentiating sets of emotions that do not always include those relevant to product design. A complete overview of which appraisal types following surprise can lead to which emotions is not yet available.

Disappointment, interest and amusement

In this chapter we will discuss the appraisal patterns of three emotions following surprise that seem relevant for product design: disappointment, amusement and interest (see Figure 6.4). All three were mentioned in focus group discussions (Ludden, Schifferstein & Hekkert, 2006) as examples of emotions that followed surprise. Disappointment and amusement belong to the set of product emotions identified by Desmet (2002). In addition, creating interesting products is an everlasting wish of designers. Therefore, we discuss the appraisal patterns for these three emotions and we will illustrate how one particular surprising product (the crystal vase in Figure 2.5, see page 25) can evoke all these three emotions. This vase is surprising because it looks like it is made out of crystal but is actually made out of plastic and, therefore, feels much lighter than expected. Perceiving the lighter weight of the vase is the unexpected event that initiates the sequence of appraisals.

For designers, understanding how disappointment can follow surprise is valuable because it is a reaction that is in most cases undesirable. Van Dijk & Zeelenberg (2002) investigated the appraisal patterns of regret and disappointment based on the appraisal dimensions formulated by Roseman et al. (1996). They concluded that disappointment is associated with appraisals of unexpectedness, of wanting something pleasurable (motivational state), of thinking that one was morally right (legitimacy), and of acknowledging that it was caused by circumstances (agency). The appraisal of unexpectedness reflects the first stage in the two-stage model of surprise. Someone who appreciates the high quality of crystal as a material may feel disappointed upon perceiving that the example product in Figure 2.5 is made out of plastic. He or she would prefer perceiving a crystal vase (perceiving a crystal vase would be a pleasant, motivational state) and he or she feels entitled to perceive a crystal vase because the material looks like crystal (legitimacy). Instead, a plastic vase is perceived. If this event is evaluated as caused by circumstances that are not directly under anyone's control, for example, when the vase was encountered in a shop, disappointment may be evoked.

Silvia (2005b) explored the appraisal structure of interest and proposed that its appraisal structure involves two components: an appraisal of novelty-complexity and an appraisal of coping potential. Silvia uses the term novelty-complexity to refer to a family of variables that includes unexpectedness. This seems to be related to the first stage in our model. Coping potential is broadly defined as the evaluation of the extent to which the individual is able to deal with or control an event. Silvia also recognizes the link with surprise, arguing that if an appraisal of coping potential follows an appraisal of novelty, a shift form surprise to interest would be expected. He states that for interest, coping potential probably refers to appraisals of whether people can understand the ambiguous (i.e., novel, complex, unfamiliar, unexpected) event. Being able to understand the ambiguous event is positively related with interest. A principle in product design that reflects the relationship between the appraisal of coping potential and interest is the Most Advanced Yet Acceptable (MAYA) principle (Hekkert et al., 2003). According to this principle, people prefer things that have an optimal combination of typicality (or familiarity) and novelty. People seem to feel able to deal with novel things (appraisal of coping potential) as long as their typicality is preserved. Interest could be evoked by the 'crystal' vase, for example, when it is perceived by someone who is familiar with and wants to understand production processes. Upon perceiving that the vase is made out of plastic, this person may want to understand exactly how it was produced and how the producer was able to make the product look like crystal.

Amusement is typically not covered in appraisal theories (Desmet, 2002; Hemenover and Schimmack, 2003), but it is discussed in theories on humor. Wyer and Collins (1992) define a humor-eliciting stimulus as an event that is perceived to be amusing. They state that the most common general conception of humor assumes that it is stimulated by the sudden awareness of an incongruity. Indeed, in Suls' (1972) two-stage humor model, perceiving incongruity constitutes the first stage and solving this incongruity constitutes the second stage in evoking amusement. However, according to Wyer and Collins, perceiving and solving incongruity are necessary but not sufficient for humor elicitation. They argue that several additional conditions need to be met. First, the new information must not replace the interpretation that appeared to be correct previously. Second, a diminishing attribute must be perceived: something must be evaluated as less valuable or important than it appeared to be. Furthermore, to experience amusement, an event must be evaluated as not conflicting with an individual's goals. For example, upon perceiving the 'crystal' vase, most people will immediately understand the incongruity perceived, i.e. that the vase is made out of plastic and not out of crystal. Some people may evaluate plastic as a 'diminishing attribute' relative to crystal, because plastic is generally less valuable than crystal. If the perception of plastic does not conflict with a concern described before (that of wanting to perceive crystal, because the status of crystal as a material is appreciated) the vase may be perceived as amusing.

Discussion

The proposed two-stage model of surprise was developed based on emotion theory as well as on tentative research findings. The model has not been tested in experimental research and should, therefore, be seen as a working model. It can serve as a starting point for future research on surprise in product design.

The examples describing the experiences of disappointment, interest and amusement show that the same surprising product can evoke these different emotions depending on the appraisal patterns that are used to evaluate the unexpected event. As the examples described illustrate, the concerns, goals or beliefs of the person perceiving the product determine for a large part which appraisal patterns are used to evaluate the surprise further. However, this does not imply that designers have no influence on the emotions products will evoke. If designers understand the processes described above, they may be able to design products addressing typical concerns, and thereby influence the appraisal process.

Other appraisal patterns than the ones discussed in this paper are expected to precede other emotions that can follow surprise. Additionally, it is not unlikely that surprise can eventually result in mixed emotions when appraisal patterns of different emotions concur. For example, experiencing both amusement and interest upon perceiving a surprising product is not hard to imagine.

It is interesting to consider whether it is possible to experience surprise without a further evaluation (and a subsequent resulting emotion). In theory this seems possible. We can imagine a situation in which someone experiences something unexpected, which is not further evaluated because it is not relevant to him or her. However, in real life, someone experiencing an unexpected event will generally try to 'solve the puzzle', to find out what caused the felt surprise. Inevitably, 'solving the puzzle' is then relevant to this person, which will induce a further evaluation.

(Chapter 7 was largely based on Ludden, G. D. S., Kudrowitz, B. M., Schifferstein, H. N. J. & Hekkert, P. (submitted) Surprise & humor in product design. Designing sensory metaphors in multiple modalities.)

Chapter 7

Designing surprises in multiple modalities

7.1 Introduction

Imagine that you are browsing in a design store, where you see a coffee cup that seems to be made out of stainless steel. However, when you pick it up, you are surprised and a smile appears on your face: the cup felt flexible. It turned out that the cup was made out of a rubbery material. Apparently, what happens in these situations is that you create an expectation about what you will perceive through touch (an inflexible, cold material), based on what you perceived through vision (the color and texture of stainless steel). However, the expectation may be disconfirmed and you will be surprised.

Sensory incongruities like these often occur in products and sometimes designers even deliberately design sensory incongruities in order to create more interesting products (Ludden, Schifferstein, and Hekkert 2008b). In some cases a surprise in a product evoked by sensory incongruity can be humorous.

Most theorists in the fields of emotion and humor agree that humor is a phenomenon that relies on incongruity (e.g., Berlyne 1971, 1972; Deckers and Salais 1983; Nerhardt 1976; Roseman, Antoniou, and Jose 1996; Rothbart 1976; Suls 1972; Wyer and Collins 1992). However, not all forms of incongruity lead to humor and / or amusement. Nerhardt (1976) gives some examples of studies where incongruity did not result in laughter/ amusement. For example, he describes an experiment where he asked people to lift a suitcase varying in weight and to judge its heaviness by looking at the suitcase. The results showed that laughter and smiling did not increase as the weight of the suitcase diverged from expectations. In their efforts to explain how and when incongruity leads to humor, researchers have focused on different topics.

First, there has been some debate about the form of the relationship between incongruity and humor. Berlyne (1972) has described this relation as an inverted-U where humor reaches a maximum at a moderate level of incongruity. Deckers and Salais (1983) also report several experiments in which support for the inverted-U relation was found. However, they argue that with incongruity varying within a single dimension (e.g., weight, as in the example above) a positive but negatively accelerated relation between incongruity and humor will be found.

Second, others (see e.g., Veale 2004) have indicated that incongruity alone is not a sufficient condition for amusement. Suls (1972) has proposed that next to perceived incongruity, whether this incongruity is resolved or not is essential for the experience of humor.

Finally, Rothbart (1976) points out that there is a problem with the use of incongruity and its resolution as an explanatory principle for laughter, because unexpected events may not always lead to amusement. Instead, she claims, they can also evoke fear, curiosity, problem solving or concept learning. In accordance with the latter study, our research on products with visual – tactual incongruities (Ludden, Schifferstein, and Hekkert 2009) suggested that the surprises these products evoked in some cases elicited feelings of amusement, interest or pleasure, but in other cases feelings of puzzlement, confusion or disappointment.

In this article, we test these theories of incongruity, surprise and humor in the field of multisensory product design. Understanding why some surprises are amusing whereas others are confusing is valuable for designers. For a product designer, a surprise reaction can be beneficial, because something surprising attracts attention and stimulates word-of-mouth (Derbaix and Vanhamme 2003). Naturally, if the surprise is a pleasant experience for a user of a product, the product designer or developer will gain from the extra attention.

(In)appropriate incongruities

A sensory incongruity involves the comparison of information from two or more sensory modalities. Apart from sensory perceptions, this process usually involves making cognitive associations. For instance, when describing a particular sensory experience people often make metaphorical mappings between different sensory domains (Cazeaux 2002). Lakoff and Johnson (1980) describe the essence of metaphor as understanding one kind of thing (target) in terms of another (source). Analogously, a sensory metaphor occurs when one kind of sensory characteristic is understood in terms of another sensory domain. For example, someone may describe the color of a product (visual) as "a bitter, lemon yellow" (gustatory), or the sound of a product (auditory) as "soft" or "sharp" (tactual). Cazeaux (2002) states that these metaphorical comparisons between sensory characteristics are basic to any organized experience in the same way as a lexicon of primary metaphors is used in language. Primary metaphors are so commonly used that we do no longer recognize them as metaphors. For example, in the sentence "he undermined my line of reasoning", the metaphor "argument is war" is used. Similarly, it is very common to use terms from one sensory domain to explain a perceived characteristic in another sensory domain.

Forceville (2006) discusses the multimodality of metaphors and states that a metaphor is multimodal if target and source are represented exclusively or predominantly in different modes. He proposes an example of a multimodal metaphor "cat is elephant" in an animation film: a cat that makes a trumpeting sound. In this case, the target is triggered visually and the source by means of sounds.

Sensory metaphors in products can be as simple as the examples mentioned above, but more complex associations can be made as well. As an example, there is a cookie jar on the market that makes a cow sound when the user opens the lid. For a first time user, this cow sound may be surprising. The user will try to make sense of this incongruity. In Suls' (1972) terms, the user will try to resolve the incongruity. There is a strong association between cookies and milk, and another strong association between milk and cows. A user who makes these associations may feel that the cow sound is somehow appropriate for the cookie jar. By making the associations, the user understands the incongruity and this may lead to amusement.

We will use the term appropriate incongruity for incongruities that can be mapped back to other product characteristics and, oppositely, we will use the term inappropriate incongruity for incongruities that cannot be mapped (or are very difficult to map) back to other product characteristics. We expect that people appreciate and enjoy an appropriate incongruity, whereas they are confused by and have negative opinions towards an inappropriate incongruity, similar to jokes they either do or do not understand. In Suls' (1972) joke theory, if the receiver of a joke hears the punchline and either cannot make the connection back to the body of the joke or the punchline is obvious, then the joke will not be funny. Similarly, if the user of the product either cannot make the connection between the incongruent element and the product or if the incongruent element is obviously related to the product, the incongruity may not be amusing. Viewing the product as the body of the joke, someone perceiving the product makes assumptions about what to expect from the product through different modalities. Upon interaction, he or she comes across a sudden incongruity (a "physical punchline") and then attempts to connect the incongruity back to other aspects of the product.

The present study

Because people are capable of seeing objects from large distances and vision provides the most detailed information about a product within the shortest time frame (Jones and O'Neil 1985; Schifferstein and Cleiren 2005), it is most likely that people will perceive an object through vision first and base their expectations for other modalities on the information they perceive through vision. Therefore, in previous experiments, we have explored three types of incongruities that are most likely to occur in products: visual - tactual incongruity, visual – auditory incongruity and visual – olfactory incongruity (Chapters 3, 4 and 5). Analogously, a multimodal metaphor that uses the visual information of the product as target is most likely easier to recognize than other forms of mutimodal metaphors.

The results of our previous experiments suggest that creating surprise through visual – tactual incongruity is the most effective and direct strategy for both generating surprise and product appreciation. This type of incongruity can involve incongruent information about the same product characteristic and, therefore, does not always require associative mappings. We can, for example, both see and feel the shape of a product. On the other hand, visual – olfactory and visual – auditory incongruities always involve at least two different product characteristics.

The results of previous experiments further suggest that the nature of the product in which the incongruity is perceived, is important for the evaluation of the surprise. For example, people may be more disturbed by and less appreciative of an incongruity in a tool than in a toy, because tools are expected to serve a particular function. A surprise experience when using a tool may interfere with the user's functional aims and, therefore, decrease the user's appreciation for the product. On the other hand, toys are used in play, where an unexpected event could contribute to the user's enjoyment.

For the present study, we designed 12 products with various types of incongruities to investigate differences in people's reactions to (1) visual – tactual, visual – auditory and visual-olfactory incongruities; (2) appropriate incongruities and inappropriate incongruities; and (3) incongruities found in tools and incongruities found in toys. The first part of this paper discusses the design, selection, and creation of the products. The second part involves an experiment aimed at the evaluation and comparison of the created products. Finally, we discuss our results with reference to joke theory.

7.2 Design of products

To design the 12 products, several steps were taken. To ascertain that the final products were appropriate for our purposes, several test products were made during the design process. These test products were evaluated by designers working at the department of Industrial Design of Delft University of Technology. Below, we describe the design process in short.

Step 1 - Selecting products

Surprise may result from an unexpected product characteristic alone rather than from an incongruity between sensory elements. Therefore, we aimed at selecting products that are familiar and that naturally produce information for all the senses. More specifically, the selected products must naturally produce an expected sound and a scent.

We selected one tool and one toy. Both products are used in a bathroom environment. As a tool, we selected a roll-on deodorant. This product has a familiar feel, the moving parts ensure the production of a sound and because a deodorant comes in many scents, it is possible to change the scent to a reasonable degree without changing the functionality. For the toy, a rubber ducky was chosen. The rubber ducky is expected to have a light hollow rubber feel, a high-pitched squeak sound, and a rubber scent.

Step 2 - Searching for sources

To search for sources to create sensory metaphors, a technique based on mind mapping (Buzan and Buzan 1994) was developed. A mind map is a non-linear means of organizing, presenting, visualizing, and/or generating thoughts. It typically takes the form of a diagram that involves graphical and textual data that branch radially from a central idea or word. Mind maps are commonly used as a free form tool for study, organization, brainstorming and problem solving. While using the general concept of mind mapping, we created "association maps". These association maps allow a designer to visualize the relationship between a product's attributes and seemingly unrelated objects and concepts.

We created association maps for a rubber ducky (Figure 7.1) and for a roll-on deodorant (Figure 7.2). These association maps formed the basis of the sensory metaphors we designed in our products. We started by branching outward from a product and by making associations with the product's attributes. Because we were searching for sensory metaphors, "feels", "scents" and "sounds" were selected as most important attributes. Next to these, we included four attributes that can directly influence the first three attributes: "form", "material", "use motions" and "effects". Furthermore, we included two attributes describing the product itself: "nature" and "name", and three attributes describing the product's relation to other products: "environment", "used with" and "similar to".

Figure 7.1 Association map for a rubber ducky

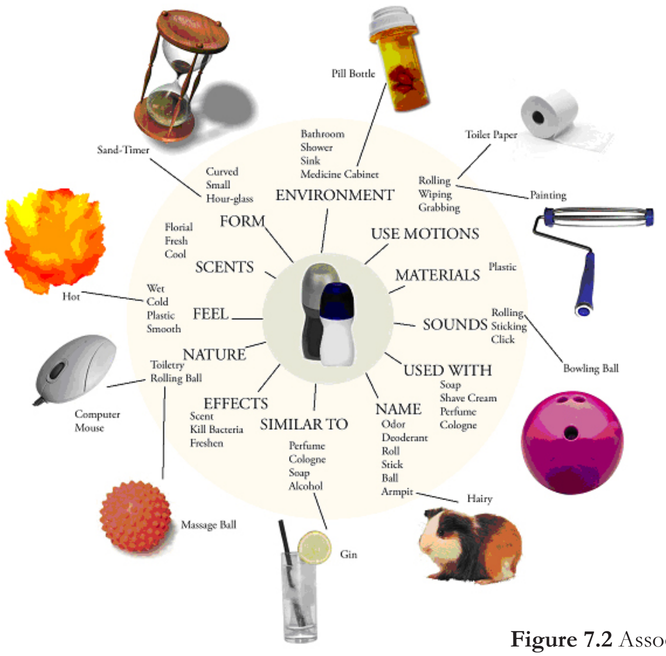


Figure 7.2 Association map for a deodorant

The first branching lists items and concepts directly related to the product. This branching will not contain any possibilities for incongruity. When branching out to additional layers, further associations will be made that are less obviously related to the product. If the designer can incorporate properties of one of these distant associations into the product, the result will be an incongruity that can be related back to the product. This incongruity could then be amusing to the user assuming the incongruity is not too obvious and the user is able to make the connection.

To make inappropriate incongruities, a designer must find sources of associations that are not on the association map (or for which the number of association steps is high enough) so that they cannot be related back to the product (target). This will result in surprise and most likely confusion.

Step 3 - Choosing incongruities

Multiple sources of associations were identified using the maps. Looking at these maps, one can see how some of the connections could lead to surprising (and possibly amusing) product concepts. In the ducky association map, for example, one can see a connection between a rubber ducky and a whoopee cushion. Although this connection is relatively uncommon, both products involve a squeezing use-motion. Similarly, in the deodorant map, one can see a connection between a roll-on deodorant and a massage ball. Again, the two products are not directly related, but they are similar in nature because both products contain a rolling ball. The whoopee cushion and the massage ball can, therefore, serve as possible sources for appropriate incongruities for the rubber ducky and the roll-on deodorant, respectively.

Please note that to create incongruities we specifically did not choose the properties of sources through which they were directly related to the target. For example, the whoopee cushion serves as a source for the rubber ducky because of their resemblance in use-motion, but the use-motion is not used to create a metaphor. To create recognizable metaphors, we chose a salient (Ortony 1993) and, therefore, easily recognizable property of the source. For instance, for the whoopee cushion we chose to implement its sound in the rubber ducky, because it is its most salient property. Using the sound of the whoopee cushion is more likely to result in a recognizable metaphor than, for example, its smell.

To determine the appropriateness or inappropriateness of an incongruity, we selected a number of promising incongruities for each modality from the maps. For these incongruities, we visualized their relation to the product using connection maps similar to the ones presented in Figure 7.3. Connections are denoted as weak (1 line), strong (2 lines) or very strong (3 lines). The strength of each connection was determined in discussion with two designers. Using these maps, we identified which sensory incongruities had strong associations with the product and could thus be easily related back to the product. At the same time, we also identified sensory incongruities that had little to no associations and are thus very difficult to relate back to the product.

Step 4 – Designing the final products

At this stage, we determined the stimulus manipulations needed to incorporate the selected incongruities in the products. We tried to avoid having to use manipulations that would cause changes in functionality of the product because they would, in essence, change the product. An important focus point in the design of the final products was the intensity of the incongruities. The intensity describes the subtlety or non-subtlety of the incongruent element. A very subtle incongruity may go unnoticed and an overly extreme incongruity (i.e., very sharp, very loud, very odorous) may be unpleasant (or surprising) solely for its intensity. Therefore, the intensity of incongruity should be at a moderate level for all types of incongruity.

Other researchers have performed studies trying to equate the intensities of specific product attributes across the senses (e.g., Schifferstein et al. 2008). To perform a similar study prior to the present experiment would require an extremely elaborate study calibrating all attributes to be manipulated. Instead, we tried to control the intensity of the incongruities we designed as much as possible by letting a team of designers analyse the design concepts for level of incongruity prior to testing. Design alterations were made to maintain consistency of incongruity. Finally, six test variants were created for both the rubber ducky and the roll-on deodorant.

To determine which were the best manipulations to use in our experiment, the test products were evaluated by a group of eight designers in a pre-test. They determined if the test products were effective in (1) surprising potential users and (2) providing either an appropriate or inappropriate surprise. Table 7.1 describes the original test products and the final products used in the main study.

In the pre-test, we found that none of the eight participants were able to recognize the scent of baby lotion on the rubber ducky. For this reason we decided that the next best option, banana scent, would be a better choice for an appropriate olfactory incongruity. The designers agreed that all other choices for incongruities in the rubber ducky were effective, but we did make some changes to the ways in which the incongruities were implemented. In creating the farting rubber ducky, for example, we originally attached reeds to the air intake hole. This worked well, but was too visible. Therefore, instead of the reeds, a small whoopee cushion was installed inside the body of the duck. This provided the desired sound in an inconspicuous manner. In the metal clank ducky, small metal disks were attached loosely to the inner body (top and bottom). When the ducky was squeezed, the metal disks would make contact and produce a chime. In the pre-test, we found that the body of the duck somewhat muffled this chime sound and thus a larger opening in the bottom was made to allow the high pitch sound to be audible.

For the deodorants, an off-balanced ball as a roller was too subtle to be recognized and hence we decided to use the second best option for inappropriate tactual incongruity, a very heavy deodorant. For an appropriate tactual incongruity, we first tested a bumpy ball as a roller. However, this bumpy roller was first a visual surprise and second a tactual surprise. Therefore, we decided to pursue a vibrating deodorant as the appropriate tactual incongruity. The original inappropriate scent of almond cookies was mistaken for toilet cleaner and so we decided to use honey scent instead. All other incongruities for the deodorant were deemed effective. In designing the maraca deodorant, several filler materials were tested, including dry rice, small metal beads and chocolate confetti. The dry rice was found to produce the most realistic maraca sound. In designing the bell deodorant, the most pleasant bell sound was made by suspending a single jingle bell in cotton inside the body of the deodorant.

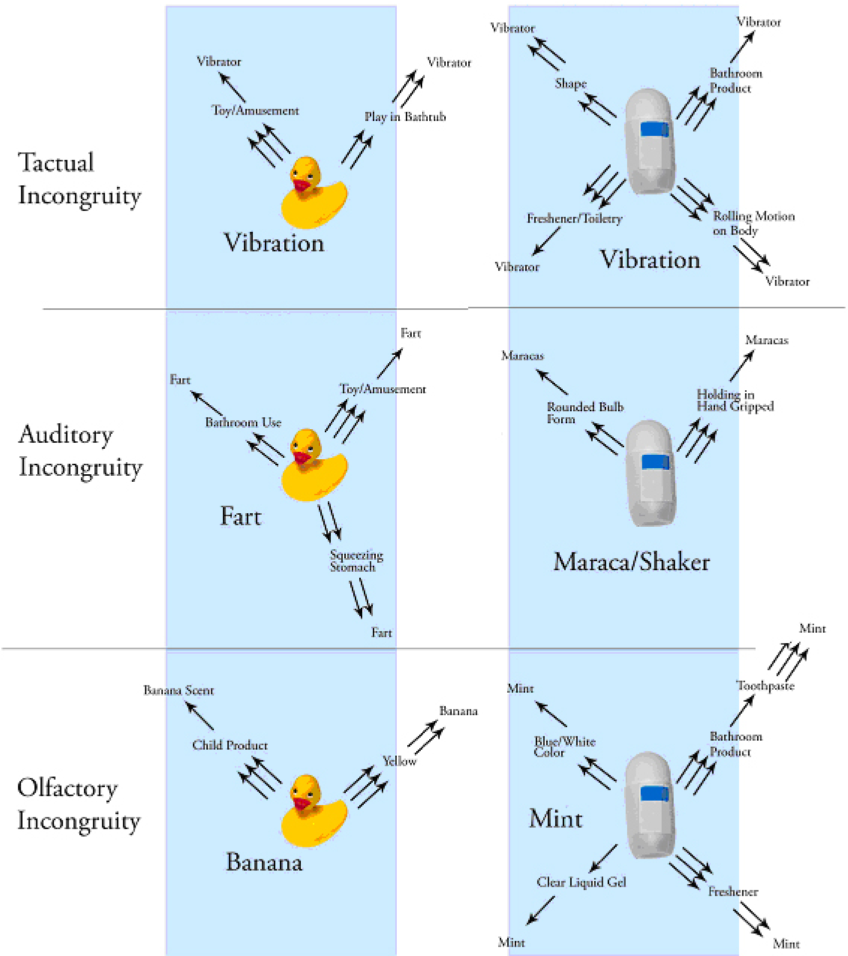


Figure 7.3 Strength of connections of selected appropriate incongruities for ducky and deodorant with the original products.

Table 7.1 Description of test and final products

	Modality	A/ IA*	Test Product	Final Product	Final Manipulation	Effect of manipulation on sensory characteristics
Ducky	Tactual	IA	Hard body	Same	Filled with high-density foam	Ducky feels inflexible when squeezed
	Tactual	A	Vibrating	Same	Reed switch and motor in body, magnet under table	Ducky vibrates when lifted
	Auditory	IA	Metal clank	Same	Metal cymbals are implemented in body	Clank from touching cymbals is heard when ducky is squeezed
	Auditory	A	Farting	Same	Whoopee Cushion is implemented in body	Whoopee Cushion sound is heard when ducky is squeezed
	Olfactory	IA	Wood	Same	Ducky is sprayed with wood fragrance	Ducky smells of wood
	Olfactory	A	Baby lotion	Banana	Ducky is sprayed with banana fragrance	Ducky smells of banana
Deodorant	Tactual	IA	Off-balanced	Heavy	A steel weight is implemented in bottom	Deodorant feels very heavy
	Tactual	A	Massage ball	Vibrating	Reed switch and motor in bottom, magnet placed in the cap	Deodorant applicator vibrates when cap is removed
	Auditory	IA	Bell	Same	A small bell is implemented in bottom	The sound of the bell is heard when the deodorant is moved/ shaken
	Auditory	A	Maraca	Same	Dry rice is implemented in bottom	A maraca sound is heard when the deodorant is moved/ shaken
	Olfactory	IA	Almond	Honey	Deodorant is filled with pure honey	Deodorant smells of honey
	Olfactory	A	Mint	Same	Deodorant is filled with mint fragrance	Deodorant smells of mint

* A/IA stands for appropriate (A) or inappropriate (IA) incongruity

In Figure 7.3 the mappings of the appropriate incongruities are visualized for both the ducky and the deodorant. Thus, the strength of the associations across modalities can be compared. These maps start with the product in the centre and branch outward, similar to the association maps. The maps show the path(s) along which the desired incongruity can be related to the product. All appropriate incongruities have at least one strong connection to the product through an abstract attribute. It might be important to note here that these connections are not necessarily universal and different cultures may make different connections. However, as long as designers are selling or testing their products within their own culture, the intended product users will be able to make the appropriate connections.

7.3 Experiment: effects of (in)appropriateness of incongruities

The products described in Table 7.1 were created as working prototypes. In total, (including a control product without manipulations), there are seven versions of each product that all look the same but sound, feel and smell differently. We added one extra control product to each product set to prevent participants from expecting only surprises when evaluating the products.

The products were evaluated in six focus groups of eight participants each. Using focus groups in the evaluation of products ensured a lively discussion about the products after the evaluation process. In this way, we expected to gain more insight into participants' thoughts and opinions about the different types of products. However, using focus groups also implicated that participants were able to see all of the products and the reactions of other participants during the evaluation process. To minimize the effect this may have had on their judgements, participants were explicitly instructed not to talk to each other before the discussion started.

Participants were students and employees (22 female and 26 male, aged 18-57, mean 25.6) of the faculty of Industrial Design Engineering of Delft University of Technology. The participants of three focus groups were presented with all eight duckies and the participants of the other three focus groups were presented with all eight deodorants. All products were presented without brand labels.

Method

Each focus group sat at a table with eight chairs. There was one product in front of each seat. Each product was placed on a placeholder with a letter code. The questions for each product were similar, but differed slightly (see below).

The participants were asked to review the product in front of them and fill in a questionnaire asking about the level of surprise felt ("This ducky/deodorant is surprising"), deviations from expectation for each sensory modality ("The ducky/deodorant felt/sounded/smelled exactly how I thought it would"), intensity of resulting emotion(s) ("This ducky/deodorant is confusing"; "This ducky/deodorant is amusing"), their overall opinion of the product ("I like this ducky/deodorant"), and of its specific sensory characteristics ("I like the scent/feel/sound of this ducky/deodorant"). This last question differed per type of stimulus: we asked only about the manipulated sensory characteristic. For example, for the products manipulated on sound we asked about the pleasantness of the sound. For one of the control products we asked about sound and for the other one we asked about scent and feel. All questions were on a seven-point scale with end points "disagree strongly" to "agree strongly". The order of the questions differed between products within each questionnaire.

Participants were asked not to take the products apart while examining them. After two minutes during which they filled out the questionnaire, participants placed the product back onto its placeholder, and changed seats to examine the next product. This continued until all participants experienced all eight products. In each focus group products were presented in a different order.
After the group reviewed the set of products, they discussed the entire set. The experimenter led the discussion on the basis of the following questions: "Which product did you like the most?"; "Which product did you like the least?"; "Which product was most surprising?"; "What would be surprising in this type of product?"; "Do you like surprises in products in general? Can you mention examples?". The focus group sessions were videotaped to record (surprise) reactions while the products were examined, as well as reactions and opinions during the discussion.

Data analysis

Separate analyses were carried out for duckies and deodorants throughout the study.

Responses to the questions asking about deviations from sensory expectation were used to check our manipulations. We expected the products with appropriate or inappropriate tactual/auditory/olfactory incongruities to differ from expectations on the corresponding response scales. T-tests were used to test whether product means differed significantly from the centre of the scale (see paragraph Manipulation check).

To study the mutual effects of sensory modality and (in)appropriateness, the questions about overall liking, surprise, amusement and confusion were subjected to ANOVAs with Manipulated sensory modality (3 levels: touch, smell and sound) and (In)appropriateness (2 levels: appropriate and inappropriate) as within-participants factors (see paragraph Interactions between sensory modalities and (in)appropriateness). The data for control products were not included in these ANOVAs. To compare the effects of appropriate and inappropriate incongruities with control conditions, separate ANOVAs were performed with (In)appropprateness (3 levels) as the single within-participants factor (see paragraph Main effects of (in)appropriateness). Differences between appropriate, inappropriate and control products were examined in paired comparisons with Bonferroni adjustment for multiple comparisons.
For each manipulated sensory characteristic (smell, touch, audition) we performed an ANOVA on the liking ratings for that specific sensory characteristic ("I like the scent/feel/sound of this ducky/deodorant") with (In)appropriateness (3 levels: appropriate, inappropriate and control) as within-participants factor (see paragraph Interactions between sensory modalities and (in)appropriateness).

Finally, we analyzed opinions and remarks expressed during the group discussions to illustrate the results from the questionnaires (see paragraph Group discussions).

Results

Results will be discussed in four sections. The first section discusses the manipulation check. The next two sections focus on differences in people's reactions to (1) visual – tactual, visual – auditory and visual – olfactory incongruities; and (2) appropriate incongruities and inappropriate incongruities. The last section discusses people's opinions as expressed in the discussion part of the focus group sessions.

Manipulation check

T-tests were carried out on the questions asking about deviations from expectation in order to test whether mean ratings were significantly lower than the centre of the scale. Generally, Table 7.2 shows that we succeeded in manipulating the desired sensory characteristics (the ratings in bold). However, for some products, the manipulation in one sensory characteristic caused unanticipated experiences in other sensory characteristics. Specifically, manipulations in tactual characteristics sometimes changed the auditory characteristics. We see this for the tactual appropriate and the tactual inappropriate ducky and for the tactual appropriate deodorant. This is not surprising, because changes in tactual characteristics generally imply a change in material characteristics, which can also affect sound properties. Furthermore, the vibrations that were used in the tactual manipulations naturally produced a sound. As our results will later show, these unanticipated changes in sound properties for tactually manipulated products did not directly affect our results.

Table 7.2 Means for deviation from expectation

	feels as expected	sounds as expected	smells as expected
Ducky			
Control	5.8	5.3	5.2
Tactual Appropriate	**2.3***	1.8*	5.2
Tactual Inappropriate	**1.7***	1.8*	5.2
Auditory Appropriate	4.4	**1.9***	5.0
Auditory Inappropriate	4.4	**1.8***	4.9
Olfactory Appropriate	5.5	5.2	**1.8***
Olfactory Inappropriate	5.6	5.8	**2.7***
Deodorant			
Control	5.0	5.7	5.1
Tactual Appropriate	**1.7***	2.0*	4.7
Tactual Inappropriate	**2.0***	5.6	4.7
Auditory Appropriate	4.4	**2.5***	4.9
Auditory Inappropriate	4.0	**2.5***	4.9
Olfactory Appropriate	4.6	5.6	**1.8***
Olfactory Inappropriate	4.9	5.5	**1.5***

Means in bold: deliberately manipulated characteristics
* significantly lower than centre of scale (=4), t-test, $p < 0.05$
N=24 for (in)appropriate products and N=48 for control products

Interactions between sensory modalities and (in)appropriateness

For both the duckies and the deodorants, the ANOVAs with Manipulated sensory modality and (In)appropriateness as factors and surprise, overall liking, amusement and confusion as dependent variables showed interaction effects on overall liking ($F(2,276) = 13.9$ and $F(2,274) = 3.5$, all $p < 0.05$) and amusement ($F(2,276) = 11.8$ and $F(2,274) = 10.6$, all $p < 0.05$), but not for surprise and confusion ($p > 0.20$). Figure 4 shows the interaction effect we found for overall liking. The interaction effect we found for amusement follows a similar pattern (data not shown). In Figure 7.4 we see that differences in mean ratings between products with appropriate and inappropriate incongruities are larger in size for the products that were manipulated in touch and (to a lesser extent) smell, than for the products that were manipulated in sound.

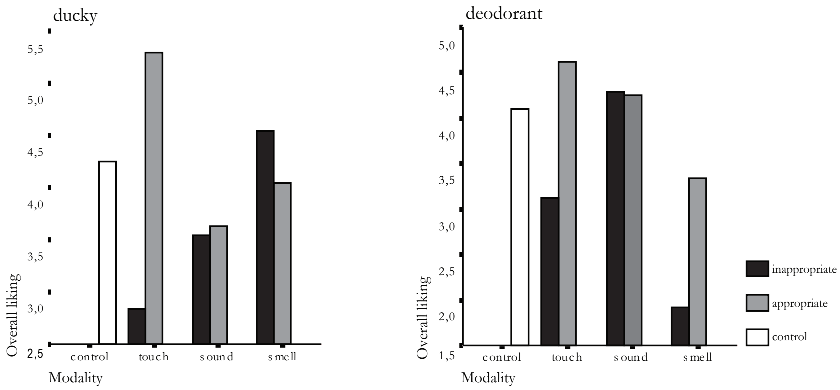


Figure 7.4 Mean ratings on overall liking per Manipulated sensory incongruity and per (In)appropriateness for duckies and deodorants.

We further compared responses to tactual, auditory and olfactory incongruities by looking at ratings on the questions about liking of specific sensory characteristics ("I like the scent/feel/sound of this product") (see Table 7.3). While designing our products, we focused on creating the same average level of pleasantness for all manipulations. For both duckies and deodorants, the control products (the normal product) rated average (3-5) on all three sensory characteristics. However, our analyses showed some interesting deviations for the manipulated stimuli. ANOVAs showed main effects of (In)appropriateness on the perceived liking of the feel of the products ($F(2,69) = 29.5$ and $F(2,69) = 9.1$, both $p < 0.001$). For both product categories, the feel of the tactually inappropriate stimulus was perceived as significantly less pleasant than the feel of both the appropriate and the control stimulus. We found a similar effect of (In)appropriateness on the perceived liking of the scent of deodorants ($F(2,69) = 13.7$, $p < 0.001$). Finally, we also found a main effect of (In)appropriateness on the perceived liking of the sound of duckies ($F(2,69) = 8.5$, $p < 0.001$). Both manipulated sounds for the ducky were evaluated as significantly less pleasant than its original sound.

The mean ratings on overall product liking presented in Figure 7.4 show roughly similar differences between appropriate and inappropriate products as those found for the liking ratings for specific sensory characteristics in Table 7.3. In most cases, ratings on liking for tactual and olfactory inappropriate products are lower than those for appropriate products.

Table 7.3 Means for perceived liking per manipulated sensory characteristic (N = 24)

	like feel	like sound	like smell
Ducky			
Control stimuli	4.9^a	4.5^a	3.5
Appropriate stimuli	4.8^a	2.8^b	4.5
Inappropriate stimuli	2.4^b	2.8^b	3.8
Deodorant			
Control stimuli	4.4^a	3.4	4.1^a
Appropriate stimuli	4.2^a	4.7	3.7^a
Inappropriate stimuli	2.7^b	4.5	1.7^b

^{a,b} Means with different superscripts were significantly different in vertical comparisons, $p < 0.05$.

Main effects of (in)appropriateness

In ANOVAs with (In)appropriateness as factor and the questions about surprise, overall liking, amusement and confusion as dependent variables, we expected to find that both appropriate and inappropriate incongruities were surprising, that appropriate incongruities were more amusing and better liked than inappropriate incongruities and that inappropriate incongruities were more confusing than appropriate incongruities.

Overall, the results for duckies and deodorants were similar and mostly as we expected. We found significant main effects of (In)appropriateness on all four variables (see Table 7.4). As expected, both appropriate and inappropriate versions of products rated higher on surprise than the control versions. However, results for confusion unexpectedly followed a similar pattern: All implemented incongruities were judged to be both surprising and confusing. As expected for overall liking and amusement, in all cases ratings for appropriate versions were higher than those for inappropriate versions of products.

Table 7.4 Mean ratings averaged over sensory conditions and F-values for surprise, confusion, amusement and overall liking per type of product.

	Control N = 48	Inappropriate N = 72	Appropriate N = 72	F-value
Ducky				
Surprise	2.5[a]	4.6[b]	4.4[b]	26.7**
Confusion	2.1[a]	3.6[b]	3.6[b]	16.4**
Amusement	3.9[ab]	3.6[a]	4.4[b]	4.5*
Overall liking	4.3[b]	3.6[a]	4.3[b]	4.2*
Deodorant				
Surprise	2.5[a]	4.4[b]	5.2[c]	35.7**
Confusion	2.3[a]	3.8[b]	4.1[b]	16.7**
Amusement	2.3[a]	3.1[b]	4.5[c]	25.7**
Overall liking	4.1[a]	3.1[b]	4.1[a]	7.5**

[a,b,c] ratings with different superscripts were significantly different ($p<.05$)
* significant main effect at the .05 level, ** at the 0.01 level

Group discussions

We analyzed transcripts from the group discussions to identify similarities in remarks that were made and issues that were raised. Here, we discuss issues that were often mentioned (N > 10 remarks) and/or remarks that further illustrate the results presented above.

Participants were generally concerned about surprises that altered the function of the product (N = 23). Even though one of our products was a toy (the rubber ducky), participants designated play as its function. Therefore, this concern applied to both products: participants mentioned that surprises could be fun in new and unfamiliar products as long as the surprise did not alter or interfere with the functionality of the product.

When describing what they liked about the products or what they would like to encounter in a surprising product many participants (N = 15) mentioned tactual surprises. The other types of sensory incongruity were not mentioned very often (N < 5). A considerable part of the discussion was devoted to participants' personal preferences of smell (N = 21), and, to a lesser extent, sound (N = 7). Liking or disliking a smell was in some cases (N = 4) mentioned in connection with an association of the memory of a scent. Opinions on the pleasantness of smells seemed to vary between participants.

Some participants expressed their concern about the long-term effects of surprise (N = 10). It was often mentioned that surprise is fun, but a one-time-only experience. Also, participants suggested that experiencing surprise over and over again, was bound to become boring. However, several other participants mentioned that they liked a certain product solely because it was surprising (N = 8).

7.4 Discussion

This study had a somewhat explorative character. Although our manipulation check shows that we succeeded in manipulating the desired characteristics in the creation of products, we did not in all cases succeed to completely separate manipulations between the senses. Consequently, some of the results need to be interpreted with caution. Nonetheless, the findings of this show a systematic approach as to how designers can design surprising products that evoke amusement. Our results show that using association maps allows designers to explore less obvious routes to create amusing incongruities.

Differences between product categories

Comparing the results for duckies and deodorants show some interesting differences between the two product categories. We will briefly highlight these differences here.

Results for overall liking and amusement mostly followed a similar pattern. However, the ratings for the control products in Table 7.4 show considerable differences between overall liking and amusement. Whereas the control ducky rates high on both overall liking and amusement, the control deodorant rates high on overall liking but low on amusement. This suggests that for a tool the correlation between overall liking and amusement is less strong than for a toy.

Furthermore, it seems that the olfactory manipulations for deodorants caused stronger effects than those for the duckies (see both Table 7.2 and 7.3). This can be explained by the fact that the scent of a deodorant forms a substantive part of its functionality. Therefore, manipulations on this element are likely to cause stronger effects.
However, overall, the results for duckies and deodorants were largely comparable. It must be noted here that irrespective of its intended functionality, people will in some situations use a product as a toy and, in others, as a tool.

For example, people may play with their pens during meetings while they are not using them to make notes. Therefore, rather than differentiating between toys and tools, in future experiments, it may be more useful to distinguish between the "usage modes" people are in while using the product (Hassenzahl 2008). Hassenzahl proposes two usage modes: a "goal-oriented" mode, where task fulfillment is important and an "activity-oriented" mode, where the focus is on the activity itself. In future studies, this distinction could be used by presenting participants with different tasks for the same product. For example, we could present a pen and ask participants to explore the pen (activity-oriented mode) or to write their name and address with the pen (goal-oriented mode). A pen is a logical product choice in this case, because people use pens both to play and to perform tasks with.

Different types of sensory incongruities

Although we did not find a clear difference in preference between the different types of sensory incongruities in the overall liking ratings of products, both the results from our questionnaire and the discussions with participants suggest that in terms of generating surprise, manipulations involving visual – tactual incongruities are the most successful of the types tested here. Ratings on surprise were highest for products that were manipulated on touch and in the discussions many participants mentioned that they liked and would like to encounter tactual surprises. Furthermore, overall liking ratings in Figure 7.4 show the largest difference between appropriate and inappropriate products for the stimuli that were manipulated on tactual characteristics. Apparently, for tactual incongruities the (in)appropriateness of the incongruity has a larger effect on the pleasantness of the product than for auditory or olfactory incongruities.

As one participant brought to our attention, perhaps we should differentiate between instant surprises and discovery surprises. The surprises that the tactual incongruities in these products evoke can be thought of as "instant surprises" because they do not require much exploration to find. To experience auditory or olfactory incongruities, the user must explore the product further to receive stimulation (i.e., squeezing, bringing near to face, shaking, lifting). Therefore, surprises that the auditory and olfactory incongruities evoke are less direct and can be thought of as "discovery surprises". It is arguable that tactual surprises were mentioned more often in the discussions because they are easier to think of, because visual – tactual incongruities can be perceived in one and the same product attribute. On the other hand, discovery surprises can be more rewarding to the user in the long term, after they have been found.

In three cases with inappropriate incongruities, of tactual and olfactory stimuli, the perceived pleasantness of the stimuli decreased. Possibly, the differences in perceived pleasantness of sensory stimuli are brought about by the inappropriateness of the stimuli. In other words, the inappropriate sensory stimuli can be perceived as less pleasant because they are inappropriate (e.g., Schifferstein and Verlegh 1996). In contrast, we did not find differences in perceived pleasantness between appropriate and inappropriate stimuli for sounds. Probably, this difference is related to the different ways in which sensory stimuli are processed. Whereas scents and tactual perceptions are more directly related to a perceiver's emotional experience, product sounds may be processed in a more cognitive manner (Schifferstein and Desmet 2007).
As for olfactory stimuli, context can play an important role in the perceived pleasantness. Dubois (2000) states that odors cannot be considered as isolated stimuli and that their context always has to be taken into consideration. As an example, some participants mentioned in the discussion that they liked the scent of the olfactory inappropriate deodorant (honey). However, in the context of a deodorant, the sweet smell was perceived as unpleasant. Perhaps any uncommon scent in a deodorant would have been perceived as unfavourable (Herz and Schooler 2002).

Differences between appropriate and inappropriate incongruities

This study also tested if the emotional reactions to appropriate and inappropriate incongruities differ as predicted based on joke theory. Both the products with appropriate incongruities and those with inappropriate incongruities were found surprising. Although based on Suls's (1972) model we expected that inappropriate incongruities would be perceived as more confusing, our results show that both appropriate and inappropriate incongruities were found confusing. Nevertheless, those products with appropriate incongruities were appreciated (liked) more and were perceived as more amusing. Possibly, our results indicate a limitation of Suls's two-stage model. In their review of humor theory, Wyer and Collins (1992) state that Suls's model is primarily applicable to the comprehension of jokes, cartoons, or other stimuli that perceivers believe a priori are supposed to be funny. However, for most products, users do not expect to encounter a humor-eliciting aspect. This may evoke the simultaneous experience of confusion and amusement upon perceiving products with appropriate incongruities.

Alternatively, theory on the sequential processing of emotions (Silvia 2005) might suggest that upon encountering an incongruity, participants experience surprise and confusion. For the inappropriate incongruities, the sequence may end here or, alternatively, participants may experience another emotion that we did not measure in this experiment. For example, it is not unlikely that participants have experienced disappointment in reaction to inappropriate incongruities. For the products with appropriate incongruities our results show that a next step may be taken: the incongruity is resolved (understood) and amusement is experienced.

In future research it would be interesting to test if and how different types of (in)appropriate incongruities can evoke other emotions as well. Again, humor theory could be used to build predictions. We have suggested earlier that in the same way that jokes with an obvious punchline are not funny, a product with an incongruent element that is too easily related back to the product will not be experienced as amusing. Instead, people may experience indignation when they perceive this type of incongruities.

Participants expressed their concern about the long-term effect of surprising (and amusing) products. Nevertheless, in his discussion of the repeated exposure to humor, Suls (1972) states that some forms of humor can be appreciated more than once. He suggests multiple reasons for a repetitive experience of humor. Two of these seem readily applicable to products too. The first is the possibility that the humorous event is associated with the positive emotional response the perceiver had during the first encounter. The other is the possibility that humorous events may become more enjoyable upon repeated exposure, because familiarity with the humorous event may lessen the tension aroused by novel stimuli. In fact, a study where we presented participants with the same surprising products at three different points in time showed that even after the third evaluation people experienced the emotions interest, fascination and confusion (Ludden, Schifferstein, and Hekkert 2008a).

(Paragraph 8.2 was based on Ludden, G. D. S., Schifferstein, H. N. J. & Hekkert, P. (2006) Sensory incongruity: comparing vision to touch, audition and olfaction. Paper presented at the Fifth International Conference on Design and Emotion, 27-29 September, Goteborg, Sweden.)

Chapter 8
General discussion

8.1 Overview of experiments

The studies described in this thesis have shown the possible effects of sensory incongruity on surprise and other emotions, product expression and overall product evaluation. In doing so, they connect to current design practice (see Chapter 2) as well as to the current attention for the senses (see Chapter 1).

Throughout the studies described in this thesis, several types of responses to experiencing sensory incongruity in a product were measured: Presence/absence and intensity of emotional reactions (surprise and other emotions), the evaluation of the expression of the product, and the aesthetic evaluation of the product. Together, these types of responses reflect different elements of the overall product experience (Hekkert, 2006; Desmet & Hekkert, 2007). In some experiments certain aspects of the overall product experience were isolated to investigate the effect of a particular product manipulation. In other studies, we asked about multiple aspects of the experience of products. Figure 8.1 provides a rough indication of the different product attributes that were manipulated and how these were combined with the dependent variables we measured in our experiments.

For all three types of sensory incongruity, we tested if the incongruity resulted in a surprise reaction and we investigated effects of the appropriateness of the incongruity on the emotions amusement and confusion. Additionally, for products with visual – tactual incongruity we investigated effects on other emotions and long-term effects, for products with visual – auditory and visual – olfactory incongruity we investigated how the incongruity influenced the evaluation of the expression of the product, and for products with visual – olfactory and with visual – tactual incongruity we tested how the degree of incongruity affects the overall evaluation of products.

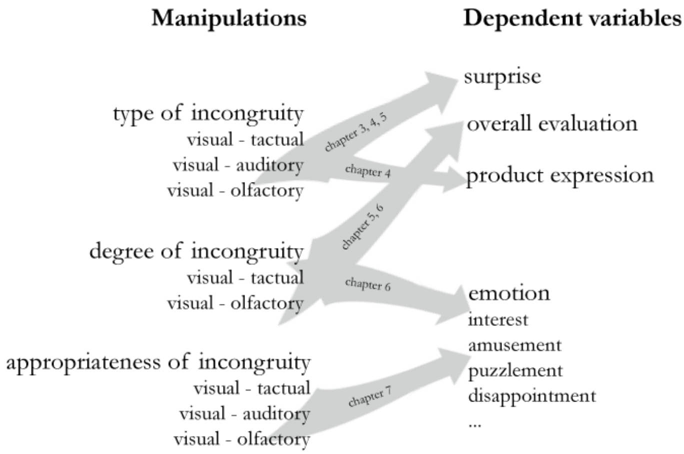


Figure 8.1 Overview of manipulations and dependent variables used

The preceding indicates that many of the possible combinations in Figure 8.1 were addressed. However, some combinations were not included in the experiments described in this thesis. For example, the effects of visual – tactual incongruity on perceived product expression were not tested. Furthermore, for products with visual - auditory incongruity, the effects of degree of incongruity on the overall evaluation of products were not investigated. These combinations of manipulations and dependent variables were not specifically avoided: they could very well lead to interesting results. We can speculate about the effects of other combinations of manipulations and dependent variables than the ones we used in our experiments based on the combined findings of our experiments. For example, chapters 6 and 5 showed that the effects of degree of visual – tactual and visual – olfactory incongruity are hard to measure: Products that were manipulated to produce different degrees of visual – tactual incongruity in chapter 6 appeared to differ in the manipulation check but responses on dependent variables for both groups were largely the same. Furthermore, in chapter 5 we found no effects of degree of visual – olfactory incongruity on the overall product expression and evaluation. Analogously, in chapter 4 we found an effect of visual – auditory incongruity on product expression for one product – sound combination only. Probably, the effects of degree of incongruity for products with visual – auditory incongruities are equally small.

For most of the experiments described in this thesis stimulus material was created by manipulating existing, or creating new products. Creating products with the desired characteristics often proved to be a struggle for two reasons. First, it was often hard to manipulate characteristics perceptible to one of the modalities without altering characteristics perceptible to other modalities. For example, when manipulating tactual characteristics of products, this often interfered with the product's texture, changing the appearance of the product. Furthermore, manipulations in sound sometimes caused vibrations, altering the tactual experience of the product. Second, although it seems easy to anticipate what sensory characteristics people expect of products, this proved to be a very difficult task. The result was that our pre-studies and manipulation checks often indicated that our manipulations were less strong or less accurate than we had expected. Both problems seem to be general problems for this type of research that can only be overcome by involving multiple designers in the stimulus creation process and by extensive pre-testing of stimulus material.

The studies described in this thesis (more specifically those described in chapters 6 and 7) contribute to emotion theory by investigating the relationship between surprise and several other emotions and the long - term effects of surprise. Unfortunately, research on how people (emotionally) respond to products at the long-term is scarce. Hopefully, the findings of our studies will stimulate other researchers to further pursue the question of how people's emotional reactions to products develop over time.

8.2 Comparing types of incongruities

Among the three types of sensory incongruity that we have studied, visual – tactual incongruity takes a special place, because the same product attributes can be perceived through both these senses: people can both see and feel a shape or a texture. Visual – auditory and visual – olfactory incongruities always involve multiple product attributes: people cannot see an odor or a sound. However, when someone sees a small product, he or she may expect it to make a soft sound, and when someone sees a pink object, he or she may expect it to have a sweet smell. Visual – olfactory and visual – auditory incongruities probably occur through cognitive association rather than through direct perception. This difference between visual – tactual incongruity on the one hand and visual – olfactory and visual – auditory incongruity on the other hand probably has consequences for how people experience these incongruities. Comparing the results of the experiments described in chapters 3, 4 and 5, we see that participants were surprised by visual – tactual incongruity, but not by visual – auditory incongruity. The results for visual – olfactory incongruity were mixed. Analogously, the results of the experiment described in chapter 7 (including all three types of sensory incongruity) indicated that in terms of generating surprise, manipulations involving visual – tactual incongruities were the most successful.

The results from our experiments further suggest that the influence of visual – auditory and visual – olfactory incongruity on the evaluation of the expression of the product and on product liking should not be overestimated. This may be partly explained using findings on sensory dominance (Schifferstein, Otten, Thoolen & Hekkert, 2008). For example, our finding that a sound that is incongruent with the appearance of a product only slightly influences the experience of the product suggests that participants paid more attention to the appearance of a product than to the sound. Similarly, the effects of odors on product expression and product liking seem to be negligible compared to the effect of the product's appearance.

One of our participants suggested a distinction between instant surprises and discovery surprises (see Chapter 7). The surprises that the tactual incongruities evoke can be thought of as 'instant surprises' because they do not require much exploration to find. To experience the other types of incongruities, the user must explore the product further to receive auditory or olfactory stimulation (i.e., squeezing, bringing near to face, shaking, lifting). Therefore, surprises that the auditory and olfactory incongruities evoke can be thought of as 'discovery surprises'. In our research on visual – tactual incongruities (Chapter 3) we had already made a distinction between 'Hidden Novelty' and 'Visible Novelty' products and we found that people have different reactions to these two types of surprising products. In HN products the surprises experienced are understood immediately, whereas VN products contain surprises that are only experienced upon further exploration of the product. The latter discovery surprises could be more rewarding to the user when found.

8.3 Implications for product designers

Because for most experiments described in this thesis stimuli with sensory incongruities were created, it bundles a variety of case studies on how to (and how not to) design sensory incongruity. Designers can use these case studies as an inspirational tool in their efforts to design for multiple modalities. First and foremost, designers should always carefully consider whether to design a sensory incongruity or to follow the opposite strategy and design a product that communicates a consistent message to all sensory channels. Furthermore, if possible, they should test the sensory incongruities they design.

The combined findings of the experiments described in this thesis suggest that creating surprises in products can be both beneficial and harmful. It seems that for certain products, depending on how the sensory incongruity influences their functionality, and on the context in which the product is used, creating sensory incongruity can be an effective strategy to design more interesting or amusing products. The experiments described in this thesis have used relatively small and simple products, such as interior products and domestic appliances as stimuli. Most people are familiar with such products and it does not require much effort to use them. This raises the question of how our results can be extrapolated to other product domains. Possibly, people will less appreciate sensory incongruities in products that are more complicated, such as a digital photo camera, because they require all of their attention while using the product. A surprise reaction evoked by a sensory incongruity could in such cases be found disturbing. However, products that people generally use in situations when they are bored (e.g., waiting room benches) and products that people use or encounter in public environments (e.g., table ware in a restaurant), could very well benefit from sensory incongruity.

Creating surprise through visual – tactual incongruity seems to be the most effective strategy. At the same time, visual – auditory and visual – olfactory incongruity are in most cases easier to implement. In some cases, this can be as easy as adding a certain attribute, such as an odorant, to a product. In contrast, designing a tactual incongruity without altering the appearance of a product can be challenging, because several product attributes can be perceived through vision and touch. However, it is worth noting that the easier implementation of visual – auditory and visual – olfactory incongruity could well lead to inappropriate incongruities which are appreciated less (or even detrimental) than appropriate incongruities. The results from the experiment described in Chapter 7 showed that the appropriateness of the incongruity is very important to use surprises in products effectively. Although both appropriate and inappropriate incongruities lead to confusion, products with appropriate incongruities were appreciated more. Probably, participants preferred the appropriate incongruities because they could relate the incongruity back to the product.

Next to the appropriateness of the incongruity, the certainty of the expectation is also important for creating effective surprises. The results from Chapter 4 showed that people were often not surprised about sounds that were incongruent with a product's appearance. Probably, people were not surprised about the incongruous sounds because they did not have a well-defined expectation for the sound of the product. The results of Schifferstein and Cleiren (2005) corroborate this. They presented participants with products via a single sense and asked them to indicate the extent to which they had clear expectations of what they would be likely to perceive concerning the product through their other senses. Overall, people found it easier to imagine (or predict) what a product would look like, or how it would feel, than to predict the sound it would make or how it would smell. Some of these findings were product-specific. As we have shown in Chapter 3, the certainty with which people can make such predictions depends on their familiarity with a particular product or product category. Designers can only succeed in creating surprises if they have sufficient insight into people's expectations for certain product characteristics.

Chapter 6 and 7 discuss how designers can influence the emotional experience of products by creating sensory incongruities and how designers can design for specific emotions. Not only can sensory incongruities evoke a surprise reaction, several other emotions can follow this surprise reaction. Furthermore, the experiment described in Chapter 6 has shown that surprise is not necessarily a one-time only experience. The effects that surprise can have on the long - term makes the experience of surprise and the resulting emotions particularly relevant to designers. Designing for emotion can never be equated with cooking from a cookbook. How people will react to a product partly depends on the product. However, it also depends for a great part on the situation wherein the product is encountered and on the person that encounters the product. However, our findings illustrate how designers can successfully evoke emotions varying from disappointment to amusement and fascination by creating surprising products.

Summary

People continuously experience the world and the objects in it through all their senses. Product designers can influence the way people experience products by paying attention to the multiple sensory aspects of product design: visual, tactual, auditory and olfactory and gustatory aspects all contribute to the ultimate experience of a product. Designing sensory experiences can be aimed at communicating a consistent message to all sensory channels, making this message a stronger one.

The opposite approach, designing a product in a way that incongruent information is provided to different senses, can be used as a means to create surprising products. Someone who perceives a product does not necessarily receive all sensory information at the same time. Therefore, perceiving one sensory aspect of a product first can create an expectation on what will be perceived through other sense modalities. The information perceived at a later stage may disconfirm the expectation formed upon the initial perception, resulting in a surprise reaction.

Designers can deliberately try to evoke a surprise reaction, because it captures attention to the product, leading to increased product recall and recognition, and to increased word-of-mouth. The product user can also benefit from sensory incongruity in a product, because it makes the product potentially more interesting and pleasing to interact with. In addition, experiencing incongruity often involves learning something new about a product or a product aspect, such as the material it is made of.

A study of contemporary product design showed that using visual – tactual incongruities in products is not uncommon. Knowingly or not, a considerable group of designers create visual – tactual incongruities in products, and while doing so, they use different design strategies.

Six of these design strategies are described in chapter 2: 'New material with unknown characteristics', 'New material that looks like familiar material', 'New appearance for known product or material', 'Combination with transparent material', 'Hidden material characteristics', and 'Visual illusion'. These design strategies can result in one of two different types of surprising products that have different mechanisms underlying the surprise reaction: 'Visible Novelty' (VN) and 'Hidden Novelty' (HN). The distinction between these two types is based on the initial sensory expectations the user forms. Products in the VN type do not seem familiar to the perceiver; their novelty is noticed immediately. Because the perceiver cannot form an accurate expectation about how the product will feel based on previous experiences with the same or similar products or materials, this expectation is uncertain. Eventually, upon touching the product, the uncertain expectation may be disconfirmed, resulting in a surprise reaction. In the HN type, the novelty is hidden and the product seems familiar to the perceiver. This results in a high degree of certainty about expectations on how the product will feel. However, upon touching the product, the product feels different from what was expected, resulting in surprise.

In chapter 3, the differences in user responses to VN and HN products are explored and compared to user responses to products without visual – tactual incongruities. In two experiments, different measures of surprise reactions were used: subjective self-reports, observations of exploratory behaviour, facial expressions and vocal expressions. The different types of products with visual – tactual incongruities were found to be distinguishable with respect to their familiarity and the certainty of expectations. To some extent, affective and behavioural reactions to these two types of surprising products were different. Participants seemed to use more exploratory behaviour when confronted with a VN product, and more vocal expressions when interacting with a HN product. This suggests that the familiarity of products and the resulting certainty of expectations influence the way in which people respond to and interact with surprising products.

Among the three types of sensory incongruities that were studied in this thesis, visual – tactual incongruities take a special place, because the same product attributes can be perceived through both these senses: people can both see and feel a shape or a texture. Visual – auditory and visual – olfactory incongruities always involve multiple product attributes: people cannot see an odor or a sound. These types of sensory incongruities probably occur through cognitive association rather than through direct perception. Consequently, the four experiments on visual – auditory and visual - olfactory incongruity yielded less clear results than those on visual – tactual incongruity. People seem less likely to experience surprise upon encountering one of these types of sensory incongruities. Nevertheless, different sounds are perceived to have different expressions and the sound of a product can in some cases influence the overall perceived expression of that product. Incongruent odors in products might be evaluated positively, especially for products that normally do not carry a scent of their own. Our results further suggest that the potential influence of visual – auditory and visual – olfactory incongruity on the evaluation of the expression of the product and on product liking should not be overestimated. However, we are far from answering the question of how the different senses work together when people evaluate products. Therefore, designers should not ignore the potential effects of sounds and odors.

Our studies suggest that out of the three types of incongruities that were studied, visual – tactual incongruities in products are most effective in evoking surprise reactions. In a follow-up study, described in chapter 6, we further investigated products with visual – tactual incongruities. This study had three main aims: (1) investigate effects of incongruity size on the evaluation of products, (2) investigate if other emotions follow surprise (and which), and (3) investigate the long-term effect of surprise. Six sets of 3 products (18 products) were created as stimuli. The visual appearance of these products was similar and elicited an expectation about how the product would feel. The tactual properties of the first product in each set were designed to confirm this expectation (no incongruity). The tactual properties of the second product were designed to be moderately incongruent with this expectation and in the third product the tactual properties were designed to be largely incongruent with the expected properties. These products were evaluated by the same people at three different points in time. The results of this study showed that surprise has a long-term effect on 3 other emotions: interest, fascination and confusion. A model was proposed that presents surprise as the first stage in a sequence of appraisals that can lead to different emotions.

The experiment described in chapter 7 was designed to further investigate how different sensory incongruities can lead to different emotions. In concurrence to joke theory, we argued that people appreciate and enjoy appropriate incongruities that can be related back to the product, whereas they are confused by and have negative opinions towards inappropriate incongruities. Products with (in)appropriate sensory incongruities of three types, visual – tactual, visual – olfactory and visual - auditory incongruities, were evaluated on the level of surprise felt and the intensity of resulting emotions. Both appropriate and inappropriate incongruities were evaluated as surprising and confusing. As expected, appropriate incongruities evoked more amusement and were liked better. Whereas products with visual - tactual incongruities showed large differences in ratings on liking and amusement between appropriate and inappropriate variants, these differences were smaller for products with visual – auditory and visual – olfactory incongruities.

For most experiments described in this thesis, stimuli with sensory incongruities were created. As such, the thesis bundles a variety of case studies on how to (and how not to) design sensory incongruity. These studies show, for example, that especially for sounds and odors, predicting the effects that these stimuli will eventually have on the product's expression is difficult. This makes an iterative process of creating sounds, or adding odors and testing them in a product essential. Designers can use these case studies as a source of inspiration in their efforts to design for multiple modalities.

Creating surprises in products can be both beneficial and harmful. In some cases it can be an effective strategy to design more interesting or amusing products. However, people are less likely to appreciate sensory incongruities in products that are more complex. A surprise reaction evoked by a sensory incongruity could in such cases be found disturbing. Therefore, designers should always carefully consider whether to design a sensory incongruity or to follow the opposite strategy and design a product that communicates a consistent message to all sensory channels.

Samenvatting

Mensen nemen de wereld en de dingen daarin continu met al hun zintuigen waar. Product ontwerpers kunnen de manier waarop mensen producten beleven beïnvloeden door aandacht te besteden aan alle zintuiglijke aspecten van een product: visuele, tactiele, auditieve, olfactorische en gustatorische aspecten van een product dragen allen bij aan de uiteindelijke product beleving. Het ontwerpen van zintuiglijke ervaringen kan gericht zijn op het overdragen van een consistente boodschap via al de zintuigen, op deze manier kan deze boodschap aan kracht winnen.

Een aanpak die hier lijnrecht op staat, een product zo ontwerpen dat via verschillende zintuigen incongruente informatie verkregen wordt, kan gebruikt worden om verrassende producten te ontwerpen. Iemand die een product waarneemt krijgt niet noodzakelijkerwijs alle sensorische informatie tegelijkertijd. Het waarnemen van informatie via het ene zintuig kan verwachtingen creëren over wat door de overige zintuigen waargenomen kan worden. De vervolgens waargenomen informatie kan deze verwachtingen tegenspreken, wat kan leiden tot verrassing.

Ontwerpers kunnen opzettelijk verrassingen ontwerpen omdat een verrassing de aandacht vestigt op een product, dit kan ertoe leiden dat het product beter onthouden en herkent wordt. Bovendien kan een verrassing leiden tot meer mond op mond reclame voor het product. Een gebruiker van een product profiteert ook van een zintuiglijke incongruentie omdat het product door de incongruentie mogelijk interessanter is. Bovendien kan een gebruiker wanneer hij een incongruentie tegenkomt iets nieuws leren over het product of zijn materiaal.

Uit een studie van hedendaagse producten bleek dat het niet ongebruikelijk is visueel - tactiele incongruenties te ontwerpen. Een aanzienlijke groep ontwerpers creëert bewust of onbewust visueel - tactiele incongruenties in producten. Zij gebruiken hiervoor verschillende strategieën. Zes van deze strategieën zijn beschreven in hoofdstuk 2: 'Nieuw materiaal met onbekende eigenschappen', 'Nieuw materiaal dat lijkt op bekend materiaal', 'Nieuw uiterlijk voor bekend product of materiaal', 'Combinatie met transparant materiaal', 'Verstopte materiaal eigenschappen', en 'Optische illusie'. Deze ontwerp strategieën kunnen leiden tot twee verschillende types verrassende producten die kunnen worden onderscheiden op basis van de mechanismes waarop de verrassing tot stand komt: 'Zichtbare Noviteit'(VN) en 'Verborgen Noviteit' (HN). Het verschil tussen de twee types vindt zijn oorsprong in de zintuigelijke verwachtingen die een gebruiker van een product vormt. Producten in het VN type zien er onbekend uit, een waarnemer ziet onmiddelijk een noviteit. Omdat de waarnemer zijn verwachting over hoe het product aan zal voelen niet kan baseren op eerdere ervaringen met dezelfde of vergelijkbare producten of materialen, zal deze verwachting onzeker zijn. Als de waarnemer het product uiteindelijk voelt kan de onzekere verwachting onjuist blijken, wat een verrassing tot gevolg heeft. Bij producten van het HN type is de noviteit verborgen, dit type producten ziet er bekend uit. Dit heeft tot gevolg dat de zekerheid van de verwachting over hoe het product voelt groot is. Echter, wanneer het product aangeraakt wordt voelt het anders dan verwacht, wat verrassing opwekt.

In Hoofdstuk 3 worden de verschillen in reacties van gebruikers op VN en HN producten onderzocht en vergeleken met reacties op producten zonder incongruenties. Verschillende methoden om verrassing te meten werden gebruikt in twee experimenten: subjectieve self – reports, en observaties van exploratief gedrag, gezichtsuitdrukkingen, en vocale uitdrukkingen. De twee types verrassende producten blijken inderdaad te onderscheiden op basis van de bekendheid met het product en de zekerheid van gevormde verwachtingen. Tot op zekere hoogte verschillen de affectieve en gedragsmatige reacties op deze twee types producten. Deelnemers lijken meer exploratief gedrag te gebruiken wanneer zij een VN product waarnemen en meer vocale expressies wanneer zij een HN product gebruiken. Dit suggereert dat de bekendheid van producten, en de daaruit voortvloeiende zekerheid van gevormde verwachtingen, de manier waarop mensen reageren op verrassende producten beïnvloeden.

Tussen de drie types sensorische incongruenties die in dit proefschrift onderzocht worden neemt visueel – tactiele incongruentie een speciale plaats in omdat bij dit type dezelfde producteigenschap waargenomen kan worden door beide zintuigen die een rol spelen bij dit type: mensen kunnen bijvoorbeeld een vorm of een textuur zowel zien als voelen. Visueel – auditieve en visueel – olfactorische incongruenties maken altijd gebruik van meerdere product eigenschappen, immers, mensen kunnen een geluid of een geur niet zien. Hier speelt cognitieve associatie vermoedelijk een grotere rol dan de waarneming op zich. Bij de vier experimenten die visueel – auditieve en visueel – olfactorische incongruentie onderzochten waren de resultaten minder duidelijk dan bij de experimenten die visueel – tactiele incongruentie onderzochten. Het lijkt erop dat verrassing een minder grote rol speelt bij visueel – auditieve en visueel – olfactorische incongruentie. Desalniettemin beoordelen mensen de expressie van verschillende geluiden als verschillend en bovendien kan het geluid van een product in sommige gevallen de totale expressie van een product beïnvloeden. Incongruente geuren in producten zouden een positief effect kunnen hebben, vooral wanneer ze toegepast worden in producten die van zichzelf geen duidelijke geur hebben. Uit onze resultaten blijkt verder dat de mogelijke effecten van visueel – auditieve en visueel – olfactorische incongruenties op de totale expressie van een product en op de waardering voor producten niet overschat moet worden. Daarentegen zijn we nog lang niet zover dat we precies kunnen voorspellen hoe de verschillende zintuigen samenwerken tijdens de evaluatie van producten. Ontwerpers moeten daarom de mogelijke effecten van geluiden en geuren in producten niet veronachtzamen.

Van de drie types incongruenties die onderzocht werden bleken visueel – tactiele incongruenties het meest effectief in het opwekken van verrassingen. In een vervolgstudie die beschreven staat in hoofdstuk 6 hebben we deze producten nader onderzocht. Deze studie had drie hoofddoelen: (1) de effecten van de mate van incongruentie op de evaluatie van producten onderzoeken, (2) onderzoeken of andere emoties (en welke) volgen op verrassing, en (3) het lange termijn effect van verrassing onderzoeken. Zes sets van drie producten (18 producten) werden gemaakt om te dienen als stimuli. Het uiterlijk van deze producten was vergelijkbaar en wekte een verwachting over hoe het product zou aanvoelen. De tactiele eigenschappen van het eerste product in elke set werden zo ontworpen dat ze voldeden aan deze verwachting (geen incongruentie). De tactiele eigenschappen van het tweede product in een set werden zo ontworpen dat ze enigszins incongruent waren met de verwachting en voor het derde product werden de tactiele eigenschappen zo ontworpen dat ze zeer incongruent waren met de verwachte eigenschappen. Deze producten werden op drie momenten geëvalueerd door dezelfde mensen. De resultaten van deze studie laten zien dat verrassing een lange termijn effect heeft op drie andere emoties: interesse, fascinatie en verwarring. Een model is ontwikkeld waarin verrassing de eerste fase vormt in een serie van 'appraisals' (beoordelingen van de situatie) die kan leiden tot verschillende emoties.

Het experiment dat beschreven wordt in hoofdstuk 7 werd opgezet om te onderzoeken hoe verschillende sensorische incongruenties kunnen leiden tot verschillende emoties. Op basis van theorieën over humor beredeneerden we dat mensen toepasselijke incongruenties in producten waarderen en plezierig vinden, terwijl ze niet toepasselijke inconrguenties verwarrend en onprettig vinden. Mensen beoordeelden de mate waarin ze verrast waren en de mate waarin ze andere emoties voelden voor producten met (niet) toepasselijke incongruenties van drie types, visueel – tactiel, visueel – auditief en visueel – olfactorisch. Zowel toepasselijke als niet toepasselijke incongruenties werden beoordeeld als verrassend en verwarrend. Zoals verwacht wekten toepasselijke incongruenties meer plezier op en werden deze geprefereerd. De verschillen in scores op plezier en voorkeur tussen toepasselijke en niet toepasselijke incongruenties waren groot voor de producten waarvan de tactiele eigenschappen gemanipuleerd waren en minder groot voor producten waarvan de auditieve en olfactorische eigenschappen gemanipuleerd waren.

Voor de meeste experimenten die in dit proefschrift beschreven zijn zijn stimuli met sensorische incongruenties gecreëerd. Als zodanig is dit proefschrift een bundeling van case studies die beschrijven hoe sensorische incongruenties ontworpen kunnen worden (en hoe niet). Ze laten bijvoorbeeld zien dat vooral de effecten van geluiden en geuren op de totale expressie van een product moelijk te voorspellen zijn. Daarom is het essentieel om het ontwerpen van geluiden en geuren voor een product aan te pakken als een iteratief proces met verschillende test momenten. Ontwerpers kunnen de case studies in dit proefschrift gebruiken als een bron van inspiratie tijdens het ontwerpen voor meerdere zintuigen.

Het creëren van verrassingen in producten kan zowel voordeel opleveren als schadelijk zijn. Het kan in sommige gevallen een goede strategie zijn om interessantere en plezieriger producten te ontwerpen. Echter, in complexere producten zullen verrassingen waarschijnlijk minder gewaardeerd worden. Een verrassing zou in zo'n product als storend ervaren kunnen worden. Ontwerpers moeten dus altijd goed overwegen of ze sensorische incongruenties willen ontwerpen of er juist voor willen zorgen dat een product een consistente boodschap levert aan alle zintuigen.

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About the author

Geke Ludden was born on June 9, 1978 in Baflo. She completed her VWO at the Willem Lodewijk Gymnasium in Groningen.

Subsequently, Geke started her studies at Delft University of Technology, faculty of Industrial Design Engineering. During her studies, she was a member of several student committees and for one year she was the president of the Student Association *i.d.* Furthermore, she worked at TRICO, bureau for strategic product development during her studies. For her graduation project she was an intern at Sony Ericsson Mobile Communications (SEMC). This project resulted in the design of two concepts of Bluetooth headsets fo the year 2006, one of which was further developed by SEMC into a commercial product. Geke received her Master's degree in 2003.

After graduation, Geke started her PhD project at the department of Industrial Design, faculty of Industrial Design Engineering of Delft University of Technology. Next to her research activities, she supervised and coached research and graduation projects of Master students and she was a faculty representative for the PhDs for one year. Furthermore, she was a member of the organizing committees of two symposia. Geke presented parts of her research at various international conferences.

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