Sensory incongruity: comparing vision to touch, audition and olfaction

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In some cases, the information people obtain from a product through the different senses conflicts, which may lead to a surprise reaction. Experiencing incongruent sensory information in a product (and the resulting surprise reaction) is expected to have an effect on product evaluation. In a series of experiments, we investigated the effects of visual – tactual, visual – auditory and visual – olfactory incongruity on surprise, product expression and product liking. Surprise was evoked by visual – tactual incongruity, but not by visual – auditory or visual – olfactory incongruity. Furthermore, our studies show 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. Creating sensory incongruity can be an effective strategy to design more interesting or amusing products and creating surprise through visual – tactual incongruity seems the most effective strategy.

Keywords: surprise, vision, touch, audition, olfaction, incongruity

Introduction

People experience products through multiple senses. We see, for example, the colour of a product, hear the sound it makes, feel its flexibility and smell its odor. 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. In what way and to what extent information from each sensory modality influences the experience of a product seems to depend on the product that is perceived (Schifferstein, 2006). In some cases the information people retrieve through their different senses may conflict. For example, a small product is not expected to produce a very loud sound. In such cases, information from different senses may be integrated or information from one of the senses may dominate the product experience.

Experimental research on the integration of sensory information and on which modalities are more accurate or dominant in perceiving certain object characteristics is extensive. Some researchers have studied the interrelations (cross-modal interactions) among the modalities in general (Marks, 1978). Others have focussed on the interactions of two specific sensory modalities, e.g., vision and touch (Martino and Marks, 2000), vision and audition (Vroomen and de Gelder, 2000; Shams et al., 2002), vision and olfaction (Blackwell, 1995), and audition and touch (Zampini and Spence, 2004). Next to this, the effects of different sensory information on people's

perception and experience of objects have been studied. For example, Klatzky et al. (2000) studied the effects of sound on the identification of material, Spangenberg et al. (2005) studied the effects of sound and smell in a retail setting, and Lageat et al. (2003) studied the effects of sound on the perception of luxury for cigarette lighters.

Generally, this field of research describes how information from the different modalities influences information from other modalities and the final evaluation of the object that is perceived. In this paper, we discuss a specific situation, the situation where product information perceived through two modalities is incongruent.

Sensory incongruity

When, for example, someone sees a product, he or she forms an expectation about how it will feel, hear and smell based on its visual perception and on previous experiences. 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). Because our research does not involve food products, we will not include the sense of taste in our overview.

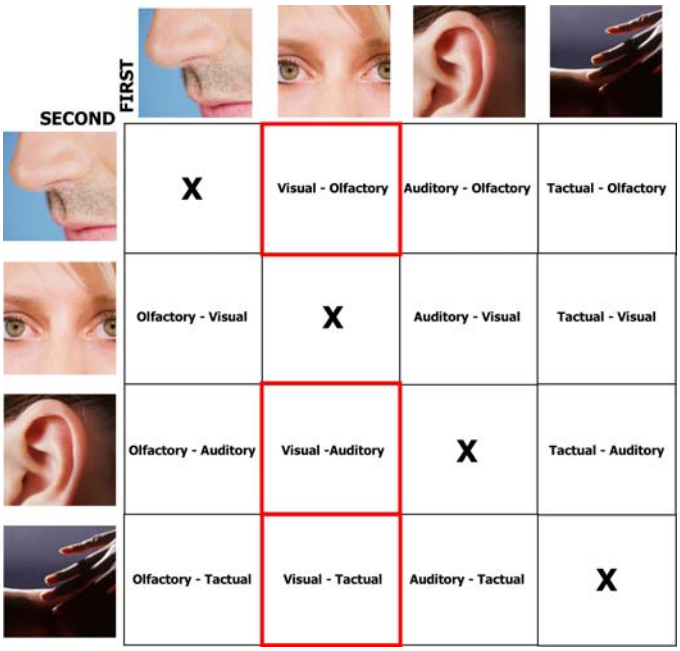

Figure 1. Matrix of sensory incongruity.

Some forms of sensory incongruity in Figure 1 are more likely to occur 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. Therefore, it is more likely that a person will perceive an object through vision, audition or olfaction first. Furthermore, among the three distance senses, vision will provide the most detailed information about a product within the shortest time frame (Jones and O'Neil, 1985; Schifferstein and Cleiren, 2005). Therefore, the forms of sensory incongruity that start with a visual impression seem the most relevant for product design.

Among these, 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.

Experiencing sensory incongruity in a product is expected to have several possible consequences: Conflicting sensory information may in some cases lead to a surprise reaction. This surprise can be followed by a positive emotion (e.g., amusement or interest) or by a negative emotion (e.g., disappointment or irritation). Second, the incongruent sensory information may have an effect on the evaluation of the expression of the product. Third, the pleasantness of the incongruity may affect the aesthetic evaluation of the product. Together, these three types of responses form the overall product experience (Hekkert, 2006).

To gain insight into people’s experience with surprise in products in general and into surprise through sensory incongruity, we organized focus group discussions in which the different types of sensory incongruity were discussed. Furthermore, to investigate specific effects of sensory incongruity, a series of explorative experiments

was carried out using products with visual – tactual, visual – auditory and visual – olfactory incongruity as stimuli. For all experiments, the experimental procedure was similar: We presented participants with products with one type of sensory incongruity under naturalistic conditions. Participants could explore the products through one or both of the relevant senses. For all products, the visual information was likely to be perceived before the other sensory information when both senses were used. Subsequently, participants answered a questionnaire. For all three types of incongruity, we tested if the incongruity resulted in a surprise reaction. Additionally, for products with visual – auditory incongruity, we investigated how this incongruity influenced the evaluation of the expression of the product, and for products with visual – olfactory incongruity, we also investigated the effect of the degree of incongruity on liking.

Experiencing surprise evoked by products

In three focus groups, we asked people to come up with surprising products from their own experience and discuss these. Subsequently, we provided them with examples of products that evoke surprise through sensory incongruity and invited them to comment on these.

Method

A total of 14 participants participated in the study (aged 18-28). Participants were students at the Faculty of Industrial Design Engineering of Delft University of Technology. Each focus group consisted of 4-5 participants.

A week before the focus group was planned, participants were asked to think about products that had surprised them and to bring an example of a product that had surprised them to the focus group meeting.

During the first phase of the discussion, each respondent described his or her experiences with surprising products and showed a surprising product. These examples were discussed by the group. A moderator asked questions to gain further insight into the circumstances under which the surprise was experienced and into the participants' evaluations of and feelings towards the surprising event.

During the second phase, we presented each respondent with three cards containing examples of products with sensory incongruities. Six products were selected from three different product categories: domestic appliances (electric drill and electric

mixer), personal mobile products (mobile phone and watch), and interior products (vase and lamp). For each product, three different sensory incongruities were described on different cards, describing surprising tactile characteristics, a surprising sound, and a surprising odor (see Table 1). The cards were randomly assigned to the participants. For each card, participants filled out a questionnaire with open ended questions. We asked about where and when participants would like to, or would not like to, encounter the product and about products in which participants would like to encounter the described incongruity. Participants had the opportunity to add further remarks. After filling out the questionnaires, participants were asked to discuss the examples on the cards they were presented with. Again, the moderator asked questions to stimulate the discussion.

Table 1.
Products and descriptions of sensory incongruity used on cards.

Product	Visual – tactual incongruity	Visual – auditory incongruity	Visual – olfactory incongruity
 Electric drill	This drill feels lighter than you would expect.	This drill makes a soft, buzzing noise when in use.	This drill smells like a pine tree forest when in use.
 Electric mixer	This mixer does not vibrate when in use.	This mixer makes a rhythmic sound when in use.	This mixer smells like fruit when in use.
 Mobile phone	This mobile phone is not made out of hard plastic but feels flexible and soft.	This mobile phone sounds like an old-fashioned wired phone.	This mobile phone releases an odor for some callers.
 Watch	This watch does not feel cold but has body temperature.	This watch tics in a musical rhythm.	This watch releases a fine fragrance.

 Vase	This vase is very thin and flexible, it will return into its original shape when pressed.	This vase incidentally makes a slurping sound.	This vase smells of flowers.
 Lamp	The switch of this lamp stretches when you pull it to switch it on.	This lamp makes a sound when you switch it on.	This lamp smells like the attic of an old house: dusty and woody.

Results

We analyzed transcripts from the focus groups. A total of 19 surprising products was mentioned in the first phase of the focus groups. The majority of examples (39%) described surprising functionalities of products. For example, several participants mentioned that they were surprised by the functionality of very small products such as small memory cards that can contain 2 GB of data. Six (33%) examples of products with a visual – tactual incongruity were mentioned. These examples described products that were softer, lighter or warmer than expected. For example, several participants mentioned benches that were softer than expected: *"I was at a museum once, where I saw a bench that looked like a rock. I really thought I would be sitting down on a rock but when I did, the rock appeared to be soft. I thought this was funny"*. One example of a product with a visual – olfactory incongruity was mentioned: *"I once received a letter and when I opened it, I perceived an odor that matched the person that sent me the letter"*. Most of the surprises through sensory incongruity were evaluated positively (funny, comfortable, pleasant). None of the examples contained a visual – auditory incongruity.

Analysis of the open-ended questions of the questionnaire provided more insight into participants' opinion on surprise through sensory incongruities. For all types of sensory incongruity, participants were concerned about how the sensory incongruity would influence the functionality of the product. Both positive influences (a lighter or less noisy product is more comfortable) and negative influences (a product that unexpectedly makes a sound can be disturbing) were mentioned. Furthermore, the context in which the incongruity is encountered seemed important for the evaluation of the surprise. For example, participants mentioned that they would like to experience sensory incongruity in a product in a shop or in a public environment: *"I*

would like to encounter such surprises in a shop or in a waiting room, when I am bored anyway". Some participants mentioned that they would not want to own products with sensory incongruities, because they expected the surprise to become boring in the long-term: "*I think all these things will become boring with time, even when they are fun at first, after a couple of times it becomes irritating, so its not fun to have them"*. However, others mentioned that they would like to own such products to be able to show them to other people: *"I think it is fun to have this* (surprisingly soft bench) *in your home because every time someone new comes in and sits on it they experience the same"*.

Discussion

When asked to describe surprises in products from their own experience, less than half of the participants mentioned cases of surprise through sensory incongruity, and most of these concerned surprise through visual – tactual incongruity. Apparently, people do not remember perceiving other types of sensory incongruity. Possibly, visual – auditory and visual – olfactory incongruity are not always perceived consciously. However, this does not necessarily imply that these forms of sensory incongruity do not influence people's evaluation of the product. The experiments described in the following paragraphs investigated if people are surprised by incongruity with vision and how the perceived incongruity influenced their evaluation of the product.

Visual – tactual incongruity

In two experiments, participants' reactions to products (vases, tablecloths and lamps) with visual – tactual incongruities were studied, distinguishing between two groups of products that were hypothesized to evoke two different surprise reactions (Ludden et al., 2006b). Products in the Visible Novelty (VN) group look unfamiliar and, therefore, yield an uncertain expectation. Products in the Hidden Novelty (HN) group look familiar, but appear to be very different when touched. A set of control products without visual – tactual incongruities (No Novelty, NN) was also included. Table 2 shows two examples of products that were used. Several measures for surprise were used: self-reports of the intensity of the surprise, and analysis of exploratory behaviour, vocal expressions, and facial expressions.

Clear differences were found in participants' reactions towards products in the control group versus products with visual – tactual incongruities: People were surprised when they perceived the visual – tactual incongruities. Generally, the surprises were perceived as pleasant. Reactions towards products in the two types of surprising products seemed to differ slightly. Analysis of facial expressions tentatively suggested that products in the VN group were evaluated as more interesting whereas products in the HN group were evaluated as more amusing.

Table 2.
Products selected as stimuli for the visual – tactual experiment.

Product	Nature of incongruity
VN	
 Vase Red and white vase, by Hella Jongerius	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	The shape and decoration of the vase HN is similar to that of a typical crystal vase, but it feels much lighter because it is made out of plastic

Visual – auditory incongruity

In another experiment we manipulated the sounds of dust busters and lemon juicers so that they either fitted or did not fit the expressions of the products' appearances (Ludden and Schifferstein, 2006a). For example, we presented 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) with a soft, high and therefore 'cute' sound or with a rougher, louder and therefore 'not cute' sound. Table 3 presents all stimuli with the expression of their appearance in key-words.

The expressions of the manipulated sounds were first evaluated separately. We then presented participants with products in combination with real-time manipulated sounds presented through headphones and asked them to evaluate the expression of the products. Although the manipulated sounds differed in their perceived

expressions, the expressions of the product-sound combinations were perceived to be largely the same. Furthermore, the products with the non-fitting sounds were not found more surprising than those with the fitting sounds. The results of this study suggest that it is relatively difficult to alter the expression of a product by altering its sound.

Table 3.
Products used as stimuli in the visual – auditory experiment.

Product		Key words for expression
	Lemon juicer AFK	cheap ordinary flimsy
	Lemon juicer Clatronic	expensive exclusive robust
	Dust buster Pelican	feminine round cute
	Dust buster Hoover	masculine sharp-edged tough

Visual olfactory incongruity

A study on visual – olfactory incongruity was set up to provide more insight into the effects of the degree of sensory incongruity on product evaluation (Ludden and Schifferstein, 2006b). In this study, we used six different products (sneakers, fluffy baby toy, children's "Winnie the Pooh" toothbrush, alarm clock, watering pot and wooden fruit bowl). These products were selected because they did not have a discernable odor. Therefore, we expected that perceiving odors in combination with these products would be perceived as incongruent. However, we expected the degree

of perceived incongruity to vary depending on the associations of particular odors with the product. Each product was presented with two different odors, one that was expected to be associated with physical characteristics of the product (color, shape, or material) and one that was expected to be associated with using the product or with the products' use environment. For example, we presented a red watering pot with an odor that we expected to be associated with the red color of the pot (red fruit) and with an odor that we expected to be associated with watering plants (green leaves). The "Winnie the Pooh" toothbrush was presented with an odor that was expected to be associated with the theme of the toothbrush and the shapes of bees and honeycombs on it (honey) and with an odor that was expected to be associated with brushing teeth (mint). The wooden fruit bowl was presented with an odor that was expected to be associated with the material of the product (wood) and with an odor that was expected to be associated with the use of the product (apple). We expected that the degree of incongruity with the visual impression of the product was smaller for odors that could be associated with a physical characteristic of the product than for odors that could be associated with the use of the product.

In a pilot experiment, participants evaluated the pleasantness of both odors and the degree to which the odors fitted the product. We then selected the three products for which the pleasantness of the odors was evaluated as similar and the degrees to which the different odors fitted the product were significantly different (the watering pot, the toothbrush and the wooden fruit bowl described before, see Table 4)

Contrary to our expectations, for the watering pot and the toothbrush, the odors that were expected to be associated with the use of the product were evaluated as fitting the product better than the odors we expected to be associated with the physical characteristics of the product. For the fruit bowl the degree of incongruity was smaller for the wood odor than for the apple odor, as expected.

We presented another group of participants with product – odor combinations or with products without odors. Each participant received one product from each category and reported the liking for the product, the product's expression and the degree of surprise. We found no effects of odors in the responses for any of the variables. Participants were not more surprised about the products with odors and the odors did not influence participants' liking of the product or their evaluation of the expression of the product.

Table 4.
Products selected as stimuli for the visual – olfactory experiment.

Product	Odor associated with physical characteristics	Odor associated with use
Fruit bowl 	 Wood	 Apple
"Winnie the Pooh" toothbrush 	 Honey	 Mint
Watering pot 	 Red fruit	 Green leafs

Discussion

Comparing the results of the three experiments described, we see that participants were surprised by visual – tactual incongruity, but not by visual – auditory or visual – olfactory incongruity. Our experiments were explorative and methodological issues may partly explain this difference. For example, we used products from different categories in the separate experiments and the degree of sensory incongruity varied. However, it could also be argued that the nature of the incongruity is responsible. Notably, in the focus groups, participants spontaneously mentioned the occurrence of surprise through visual – tactual incongruity from their own experience, whereas cases of surprise through visual – auditory and visual – olfactory incongruity were hardly ever mentioned. Possibly, people are more likely to experience surprise through visual – tactual incongruity because this type involves incongruent information about the same product characteristic, whereas for visual – olfactory and visual – auditory incongruity information about at least two product characteristics is compared. People may not feel surprised about these types of sensory incongruity because they do not always expect information about different product characteristics to be congruent.

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 theory on sensory dominance (Schifferstein et al., 2006). 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.

Participants' opinions on the examples of products with sensory incongruities presented in the focus groups, 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. For example, 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. Considering the results from the experiments, it seems most likely that creating surprise through visual – tactual incongruity is an effective strategy. From an analysis of contemporary design in which 101 products with visual – tactual incongruities were analysed, Ludden et al. (2006a) proposed six design strategies that designers could use to create surprise through visual – tactual incongruity.

Based on the results of this study, it is not yet possible to determine the long-term effect of a surprise reaction to a product. This is, however, an important issue to address in future research.

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