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Scenario-based touching: on the influence of top-down processes on tactile and visual appreciation

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Abstract The aim was to propose a testing procedure that allows measuring ecological valid judgments as a tool for selecting e.g. surface materials in the design process. Precise measures are essential for evaluation processes for example in design research and applied studies. Contextual effects in form of top-down processes often lead to biases in measures such as quality or liking judgments. We examined contextual effects of such factors by varying specific instructions, which were based on everyday life scenarios. We also investigated the stability and ecological validity of evaluations with the focus on a multisensory approach involving *vision plus touch*, *touch-only* and *vision-only* conditions. Participants evaluated the materials, for preference in experiment 1, and for perceived material properties (*thermal conductivity, hardness and roughness*) in experiment 2—either with or without specific instructions. Results showed higher consistency in the *vision plus touch* condition than in the unimodal conditions. Moreover, preferences and perceived material properties strongly varied according to the presence and the content of instruction (scenarios). These results demonstrate the strong impact of top-down processes on tactile as well as visual judgments.

Keywords Design evaluation · Haptics · Tactile perception · Visual appreciation · Multisensory perception · Sensotact reference frame

1 Introduction

The process of developing a new product is a highly complex interplay of, inter alia, functional, economic, quality, safety and usability criteria, consumer and market needs as well as company's strategic goals. Systematic engineering and designing processes, including interdisciplinary approaches, are essential for the success of a product (Pahl et al. 2007). Even if the newest technology and the most innovative surface materials were used to develop a prototype, users could disapprove the product in the end. For instance, although they might appreciate the brand new functions of such a product, they could just reject the product by means of the specific, innovative material used. Importantly, such gut feelings of haptically inadequate products are hard to describe and need not evidently be correlated with bad material quality as such. Besides good material quality, the fitting with the task demands and the product's symbolic and functional value seems essential (Creusen and Schoormans 2005).

The human–product interaction is the point where the expertise of various disciplines dealing with design and the development of products comes together. For instance, Hekkert and Schifferstein (2008) noted that understanding the subjective experiences of users is a valuable approach for optimizing e.g. the product usability. Further, the concurrent engineering approach calls for a holistic product view: Holt and Barnes (2010) discussed "design for X" (DFX) techniques in relation to a required holistic approach in product development. Besides the need for a

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more "top-down" weighted approach in DFX as balance to the mostly "bottom-up" approaches, they noted that "there is a need for research to address how preferences in design can be represented and amalgamated" (Holt and Barnes 2010, p. 134). Everything people perceive is processed and interpreted in terms of their previous experiences and external or internal idiosyncratic criteria. Thus, every evaluation or usage of a product takes place in a specific context, either a social context (e.g., Battarbee and Koskinen 2008; Ritterfeld 2002) where "experiences change, evolve, fluctuate, and grow in social interactions […]." (Battarbee and Koskinen 2008, p. 465), an intra-personal context where previous experiences with and knowledge about objects are used to create a meaningful setting for judgments (e.g., Krishna and Morrin 2008), or on an object or physical level, where the combination of two materials, used side by side, can be evaluated in a different way as each of the materials alone (e.g., Kahrimanovic et al. 2009). Figure 1 shows a schematic overview of these three contextual levels.

This study focused on the influence of contextual effects on the preference formation (experiment 1) and the judgment of surface properties like *thermal conductivity, hardness and roughness* (experiment 2). Specifically, we were interested in the development of an ecologically valid testing procedure that can be used as a tool for the pre-selection of material surfaces even on an abstract level in the designing process e.g. before a prototype is manufactured and tested. Due to the fact that people interact with products mostly with all their senses, we tested our participants under three modality conditions: the *vision plus touch* condition, in which the stimuli were explored visually and with touch; the *touch-only* condition, in which the stimuli were explored only with touch and the *vision-only* condition, with purely vision-based judgments. Several studies have shown that evaluations are more accurate when more senses are involved (Alais and Burr 2004; Crilly et al. 2004; Desmet and Hekkert 2007; Gepshtein and Banks 2003; Heufler 2004; Jansson-Boyd and Marlow 2007; Mooy and Robben 2002; Oruç et al. 2003). This has been shown in basic research for stimulus localization (Alais and Burr 2004), slant estimation (Oruç et al. 2003), and distance estimation (Gepshtein and Banks 2003) with better performances in multimodal conditions compared to single modal conditions.

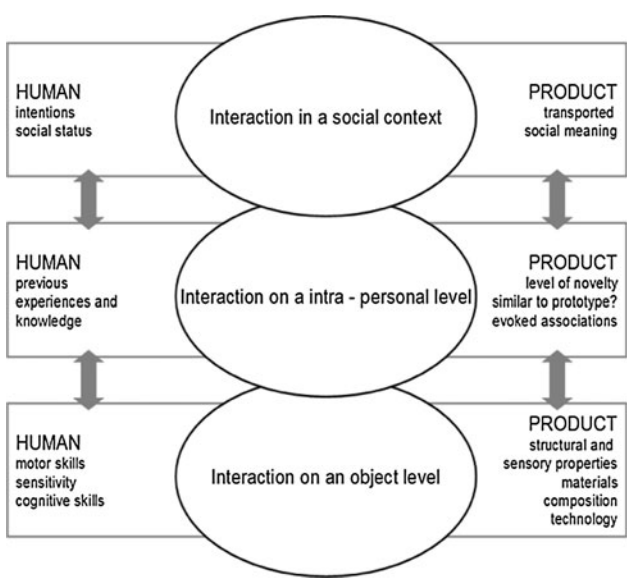

Fig. 1 Schematic overview of context effects occurring at different levels. Parts of the figure were adopted from the model of human—product interaction (Hekkert and Schifferstein 2008)

2 Levels of context effects and their impact on judgments

2.1 Contextual effects on a physical/perceptual level

This schematic level is related to a physical or perceptual context within an object or within the composition of the object. Vision-based perceptual context effects, for example, are found with brightness illusions (e.g., Adelson 1993), luminance contrast or Ebbinghaus–Titchener size contrast illusions (see Fig. 2) where the perception of luminance or size depends on the context.

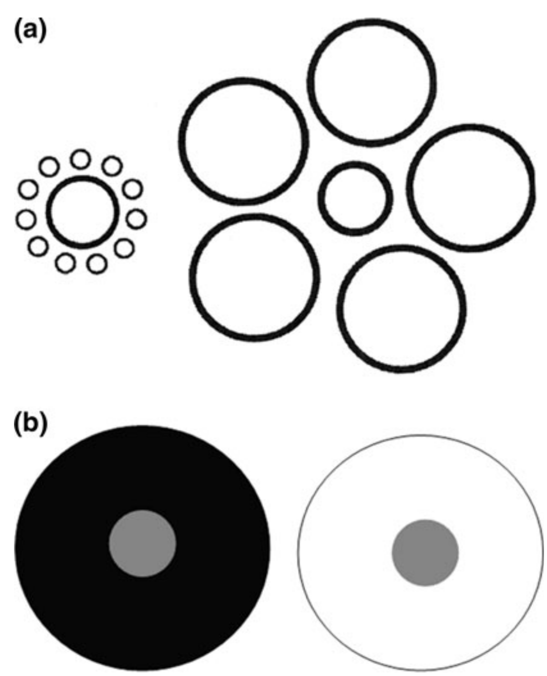

Fig. 2 Examples for vision-based perceptual context effects. **a** Ebbinghaus–Titchender Illusion and **b** an example for luminance illusions

In the haptic domain, context effects were, for instance, found for the perception of roughness. Kahrimanovic et al. (2009) showed that the perceived roughness of a piece of material changes depending on the context (either smoother or rougher context stimuli). Even the container materials (if interpreted as context) seem to influence the judgments for a product (Krishna and Morrin 2008): evaluations (e.g., evaluation of quality and willingness to pay) of products can also be changed using non-diagnostic (information that is not related to the product per se) haptic cues. Krishna and Morrin (2008) showed that non-diagnostic haptic cues (firm versus flimsy cup) influenced quality ratings of the same type of mineral water. But not only a perceptual context is able to change the perceived appearance of a stimulus or product.

2.2 Contextual effects through previous experiences

In a further experiment, Krishna and Morrin (2008) tested the influence of semantic information about haptic properties of cups. The participants' thoughts about the mineral water as well as the touching context (firm versus flimsy cups) were measured. Besides other results, the "firm cup" reduced the proportion of negative thoughts about the target product (mineral water) and influenced the "willingness to pay" for the product in a positive way. Thus, available additional information is compared to stored representations of familiar objects and is used as contextual reference for the judgments.

We were specifically interested in the impact of such previous experiences on preference and surface property judgments and a way of using them as strategy to provide a valid ecological testing procedure. In basic research, unfamiliar stimuli are usually utilized to control the described influence of top-down processes. In the applied field, this approach would be contraproductive as these pre-experiences are of utmost importance. Consumers' cognitive and behavioral repertoire is strongly influenced by previous experience, contextual effects and the specific degree of expertise they have with the material which has to be evaluated. For instance, consumers tend to accept innovative aspects of design only to a specific extent (Hekkert et al. 2003; Loewy 1953) as innovativeness and the perception of oddness of innovative material is correlated with the range of experience with such material (Carbon and Leder 2005; Carbon et al. 2008; Faerber et al. 2010; Jansson-Boyd and Marlow 2007). Similarly, Mooy and Robben (2002) stated that prototypical components of new products might elevate the processing of product-related information based on an activation of pre-existing knowledge. Previous experiences and beholders' knowledge have been shown to be important in the appreciation of artworks (e.g., Belke et al. 2006; Leder et al. 2006; Russell 2003) and design objects (e.g., Carbon and Leder 2005). To sum up, preferences seem to be strongly modulated by expertise and cognitive elaboration.

2.3 Contextual effects through social interactions

The importance of higher-order psychological factors has been demonstrated in simulations of "real-world" processes. Coughlan and Mashman (1999) presented an automobile prototype twice in a period of 3 months with moderated discussions about the prototype resulting in changes in the participants' appreciation. Carbon and Leder (2005) proposed the "Repeated Evaluation Technique" (RET), which simulates the natural consumer evaluation process. Unlike in mere exposure studies (e.g., Kunst-Wilson and Zajonc 1980; Zajonc 1968; Zajonc et al. 1972), participants in the RET explore the stimuli actively as they are forced to evaluate given stimuli on specific dimensions. Hence, this paradigm elicits more and deeper cognitive elaboration. Its use also allows the measurement of dynamic changes in preferences, especially those changes triggered by highly innovative features of consumer products. Ritterfeld (2002) proposed an esthetic impression formation model, which focused on heuristic judgments based on social meaning and the social impression formation approach (e.g., Brewer and Hewstone 2004). Social impression formation models propose a two-way processing: top-down processing, which is category related and based on schemata; and bottom-up processing, which is based on individual information. These two processes represent different kinds of stored information, based on the individual intention and therefore may lead to varying outcomes. Ritterfeld (2002) argued that esthetic judgments are more consistent in the presence of specific and decodable information (e.g., social prototypes) thus when category- and schemata-based processing is available.

The use of real-world scenarios in this study represents specific, decodable (clear interpretable) information about objects and a social context that encouraged more consistent judgments. We propose that clear and specific instructions are as essential to evaluation procedures as controlled stimulus-inherent features are. This account was further extended by the usage of a multisensory framework of testing to analyze the impact of instructions on the evaluation in a more ecological valid way.

3 The relevance of a multisensory approach for evaluation

Even though psychological research in general and research on consumer product design in particular are mainly focused on visual judgments, more and more studies are including further senses, such as the tactile system (e.g., Ludden et al. 2007, 2009) or the auditory system (Mooy and Robben 2002). The advantage of a multisensory evaluation over a purely visual one has been discussed theoretically, (e.g., Crilly et al. 2004; Desmet and Hekkert 2007; Heufler 2004) and shown empirically (e.g., Jansson-Boyd and Marlow 2007; Mooy and Robben 2002). It was shown that tactile impressions are relevant in esthetic evaluations of consumer products and design objects (Desmet and Hekkert 2007; Heufler 2004) and that multisensory evaluation encourages positive attitudes toward a product (Mooy and Robben 2002). Direct experience (products were presented in a "ready-to-use" state and participants were allowed to touch them, to hear the sound, etc.) compared to indirect experience (photographs of products) resulted in more extensive evaluations in the form of increased opportunity and ability to process product-related information (Mooy and Robben 2002). Astonishingly enough, the potential of evaluations based on other modalities than the visual sense is rarely used. Schönhammer's (2001) review of haptic perception showed that tactile, olfactory, gustatory and auditory features are usually accidental components in design objects. It is worth to say that it depends on the presented product whether an additional tactile evaluation is useful or not (Schifferstein 2006).

Basic psychological studies have demonstrated the importance of haptic/tactile experiences. Ernst et al. (2000) compared behavioral data (visual and haptic input) for height judgments with the results of a simulation (maximum likelihood integrator) to measure the dominance of the visual and/or haptic inputs and alternatively the quality of human sensory integration performance. The simulation is based on the minimization of variance in the resulting estimate. It occurred that the behavioral height judgments were similar to the predicted judgments of the maximum likelihood integrator. Ernst et al. (2000) noted that more visual information is captured when the visual input has less variance than the haptic input; the opposite occurs if the haptic input has less variance. The combination of senses leads to a more precise percept than one sense alone. Subsuming, including tactile/haptic tasks in evaluation processes of products might be a more powerful and ecological valid tool for assessing consumer product's qualities.

3.1 The present study

We aimed to use a testing procedure that allows analyzing the reliability of evaluation processes considering a multisensory approach (e.g., Schifferstein and Spence 2008). We also attempted to show the impact of contextual effects on tactile preference judgments and on judgments of perceived material properties, such as *thermal conductivity, hardness and roughness*. Two experiments were conducted in this respect. By using everyday life scenarios (a detailed description will follow in the methods section) compared to a control condition (base condition), a specific context was created. To show the variety of individual contextual references in participants (e.g. "the material reminds me of granny's old couch") when no specific context is created, we employed a "free association phase". We expected more consistent ratings in the scenario conditions compared to the base condition based on a clearer contextual reference.

We used standard tactile reference frames (experiment 1: Sensotact V2; experiment 2: Sensotact V3) that were created in the design sector of the automobile industry to enable standardized measurements of tactile perceptions. Similar standardized reference frames are commonly used in other aspects of product design such as color (e.g., the Pantone Color matching system, which is a standardized color reproduction system) and fabrics (e.g., CHES–FY = comprehensive handle evaluation system of fabrics and yarns created by Du and Yu 2007). The Sensotact V2/V3 reference frames represent tactile dimensions relevant for basic research as well as applied demands. We propose that specific scenarios are needed to ensure adequate imagery (through a clear contextual reference), which is essential for valid and stable responses. In experiment 1, the influence of contextual information (processing of scenarios) on preferences was tested. In experiment 2, the impact of contextual information on judgments of surface properties (*thermal conductivity, hardness, roughness*) was examined. We assumed to receive more precise judgments in the *vision plus touch* condition than in the *touch-only* and the *vision-only* condition. Furthermore, we expected judgments of perceived material properties to change with varying scenario instructions.

4 Empirical work

4.1 Experiment 1: methods

4.1.1 Participants

Ninety-six undergraduate students of psychology (48 women and 48 men; mean age: 22.2 and 24.7 years, respectively) from the University of Vienna participated in the study for course credit. Their tactile sensitivity and visual acuity, measured with standard tests (Semmes–Weinstein monofilaments, two-point discriminator—description see *Materials*), were within the normal range.

4.1.2 Material

The Sensotact V2 tactile reference frame, typically used in the automobile industry, was used. The reference frame includes three top-level tactile dimensions, which are based on different touching strategies: tangential movement (dimensions: fibrous, roughness, braking, slippery and depth), orthogonal movement (dimensions: hardness, nervousness, memory of shape and stickiness) and static movement (dimension: thermal). Each dimension includes five stimuli representing levels of linearly increasing degrees of the regarding dimension: from low to high, for example, for hardness: from very soft (= low) to very hard (= high). The descriptions of the material and the instructions for handling it were adapted from the original Sensotact V2 manual and were translated into German. The instructions and the definitions were presented using a 17-inch PC notebook that was placed on the table to the right of the participants (see Fig. 3).

Everyday life scenarios were created, representing a condition with detailed and specific instructions (scenario conditions 1, 2, 3, 4), thus serving as a specific context to rate the materials. As a control condition (base condition), the materials had to be rated without detailed and specific instruction in a separate block in the beginning of the experiment. The variety of associated representational contents (e.g. "the material reminds me of granny's old couch") of the participants, which they used as context for their judgments, was demonstrated by an additional "free association" phase after the base condition was employed. In contrast, specific scenarios provide a valuable and standardized context for the participants' judgments. The following is an example of a scenario: "Imagine you are visiting an automobile fair. Your aim is to find a new car for yourself. Please think of sitting in one of the cars with your hands on the steering wheel. Please remember the feeling of the steering wheel in your hands while evaluating the stimuli. How should it feel in your opinion?"

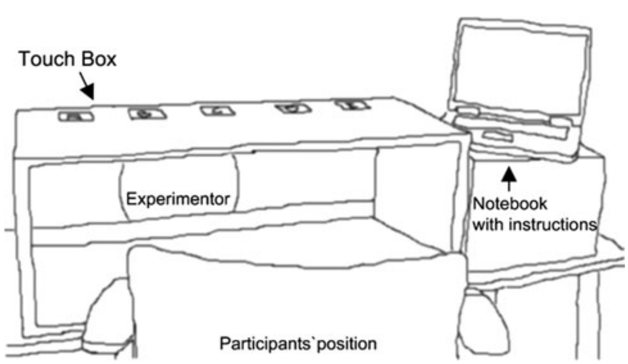

Fig. 3 Sketch of the experimental setup with "touch-box" and PC notebook for presenting the instructions

[German version: "Stellen Sie sich vor, Sie besuchen eine Automesse und haben die Möglichkeit sich hinter die Steuer einiger Prototypen zu setzen und Ihre Hände auf das Lenkrad zu legen. Denken Sie bei der Beurteilung des Materials an das Lenkrad in Ihren Händen—wie sollte es sich Ihrer Meinung nach anfühlen?"].

Three conditions were tested: *vision plus touch, touch only* and *vision only*. For the *touch-only* condition, a "touch-box" with an open front and back and with magnetic strips for fixing the plates was created. The open back allowed the experimenter to monitor the touching process. Letters (A–E, left to right), which corresponded to the positions of the plates inside the box, were written on top of the box. This helped the participants to orient themselves during the tasks. In the *vision plus touch* and the *vision-only* condition, magnetic strips were placed directly on the table. The labeling and distances between the plates were the same as those in the *touch-only* condition.

The Semmes–Weinstein monofilaments and two-point "Disk–Criminator" tests were used to measure tactile sensitivity. The Semmes–Weinstein monofilaments test, developed by Josephine Semmes and Sidney Weinstein in 1960 (see Weinstein 1993), is one of the most commonly used tactile sensitivity measure in the clinical sector (e.g., Bell-Krotoski et al. 1995). The test includes calibrated nylon filaments of varying diameters. Tactile sensitivity thresholds (normal, diminished light touch, diminished protective sensation and loss of protective sensation) for different body parts can be measured. The two-point "Disk–Criminator" test provides precise measurements of the density of nerves based on standardized intervals (1–15 mm) between tips. Participants' visual acuity was measured with the Oculus © low-vision test (distance = 40 cm). This test includes seven short texts of different font sizes and a chart with Snellen "E" and Landolt "C" optotypes. The Edinburgh Handedness Inventory (Oldfield 1971) was additionally used to get objective information about the handedness of our participants. During the evaluation process, we instructed the participants to touch the materials only with their leading hand to standardize the procedure over participants.

4.1.3 Procedure

Participants were tested individually. The experiment consisted of four phases. In phase 1, the participants read the introduction and filled out the Edinburgh Handedness Inventory (Oldfield 1971). Then, the tactile sensitivity of their preferred writing hand was tested using the two tests described earlier. They were subsequently instructed to wash their hands in order to preserve the materials and to reduce disruptive factors of adhesives or other substances on the skin. They were also told to avoid touching anything but the plates so that their ratings would not be influenced by other surfaces. Finally, the participants sat in the correct position in front of the table and the tactile box; their hands were guided by the experimenter.

In phase 2, participants evaluated all 10 (dimensions) × 5 (stimuli per dimension) = in total 50 stimuli (base condition). After exploring the stimuli (per dimension), they were rated on a 7-point Likert scale (1: "I don't favor it", 7: "I favor it a lot"). The dimension sequence was pseudo–randomized between participants. To reduce the cognitive load, the 7-point scale, including its endpoint labels, was placed on the wall in front of the participants. The scale was therefore visible for the entire duration of the experiment. In order to measure the variety of different representations provoked by the stimuli, participants were asked at the end of phase 2 whether they had any specific associations when exposed to the materials (e.g., "What did you think while touching and evaluating this stimulus?"). The experimenter recorded the stated associations referring to each stimulus.

Phase 3 was identical to phase 2, except for the scenarios given before the exploration and ratings of the stimuli. The four scenarios were presented in four separate blocks and consisted of the following: steering wheel, rear window heating switch, exterior mirror switch and radio switch. At the beginning of each block, a scenario with illustrative pictures depicting the regarding scenario was presented on the screen. All 50 stimuli (10 dimensions × 5 stimuli per dimension) were rated under each scenario. The presentation sequence of the four scenario blocks and the presentation sequence of the trials (asking for different dimensions) were counterbalanced between subjects.

In phase 4, participants evaluated each dimension's relevance to each scenario on a 7-point Likert scale (1: not at all relevant, 7: very relevant). The whole procedure lasted about 50–60 min per participant.

4.2 Experiment 1: results

Mean ratings were analyzed. The overall pattern of means (see Fig. 4) showed that the *base* condition differed considerably from the *scenarios* in five (hardness, nervousness, memory of shape, braking, fibrous) of the ten Sensotact dimensions.

To test for cross-modal effects, the data set was split by *modality*. The pattern of means (see Fig. 5) indicated higher consistency across scenarios in the *vision plus touch* than in the *touch-only* and the *vision-only* condition.

Participants' mean preference ratings (= dependent variable) were submitted to a mixed-design analysis of variance (ANOVA) with *modality* (*vision plus touch/touch only/vision only*) as a between-subjects factor and *scenario* (base condition and scenarios 1, 2, 3 and 4) as a within-

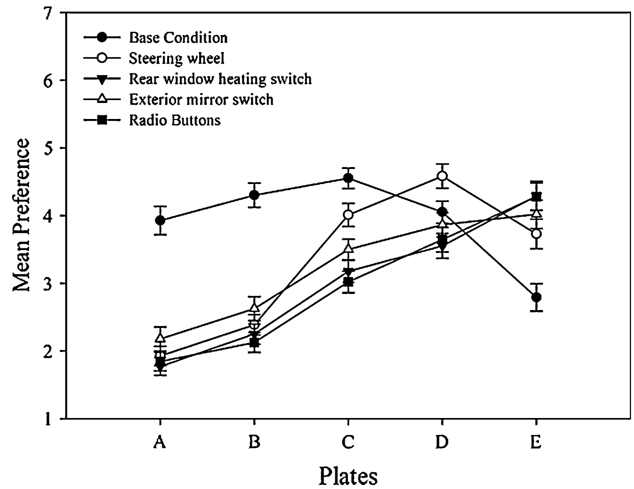

Fig. 4 Mean preference ratings for all plates (*A–E*) for the 'hardness' dimension (all conditions). *Error bars* indicate one standard error of the mean

subject factor. The ANOVA revealed a main effect of *scenario*, $F(4, 474) = 52.43$, $p < .001$, $\eta_p^2 = .31$. There was no main effect of *modality*, $F(2, 477) = 2.20$, $p = .10$, *n.s.* A significant interaction between *scenario* and *modality*; $F(8, 950) = 5.91$, $p < .001$, $\eta_p^2 = .05$, qualified the main effect of *scenario*. Simple main effects indicated that there were significant *modality* differences for the following: the "steering wheel scenario" between *touch only* and *vision only* ($\Delta = .330$, $p = .01$), the "rear window heating switch scenario" between *sight plus touch* and *touch only* ($\Delta = .276$, $p = .03$) as well as *sight only* and *touch only* ($\Delta = .339$, $p = < .001$) and a trend in the "mirror switch scenario" between *touch only* and *sight only* ($\Delta = .218$, $p = .05$, *n.s.*). The analysis further revealed that the contextual manipulation was effective as for all modality conditions, the base condition differed significantly from the scenario conditions. Interestingly, the context effect varied across modalities: we found the same resulting pattern for the *vision plus touch* and the *vision-only* condition, considerable different evaluations between the base condition and the scenarios and no significant differences between the scenarios themselves. In contrast, the pattern of data in the *touch-only* condition was much more inconsistent with significantly different values between the similar switch scenarios (for a comparison see Fig. 3). Consequently, data from the rear window heating switch and mirror switch scenarios were used to check the consistency of participants' ratings. Cronbach's alpha revealed reliable testing for the *vision-only* ($\alpha = .78$) and the *vision-plus touch* ($\alpha = .83$) conditions, whereas condition *touch only* was shown to be unreliable $\alpha = .08$). Additionally calculated ANOVAs between items revealed no significant difference between the two scenarios in the *vision plus touch* condition, $F(1, 159) = < 1$, *n.s.*, whereas

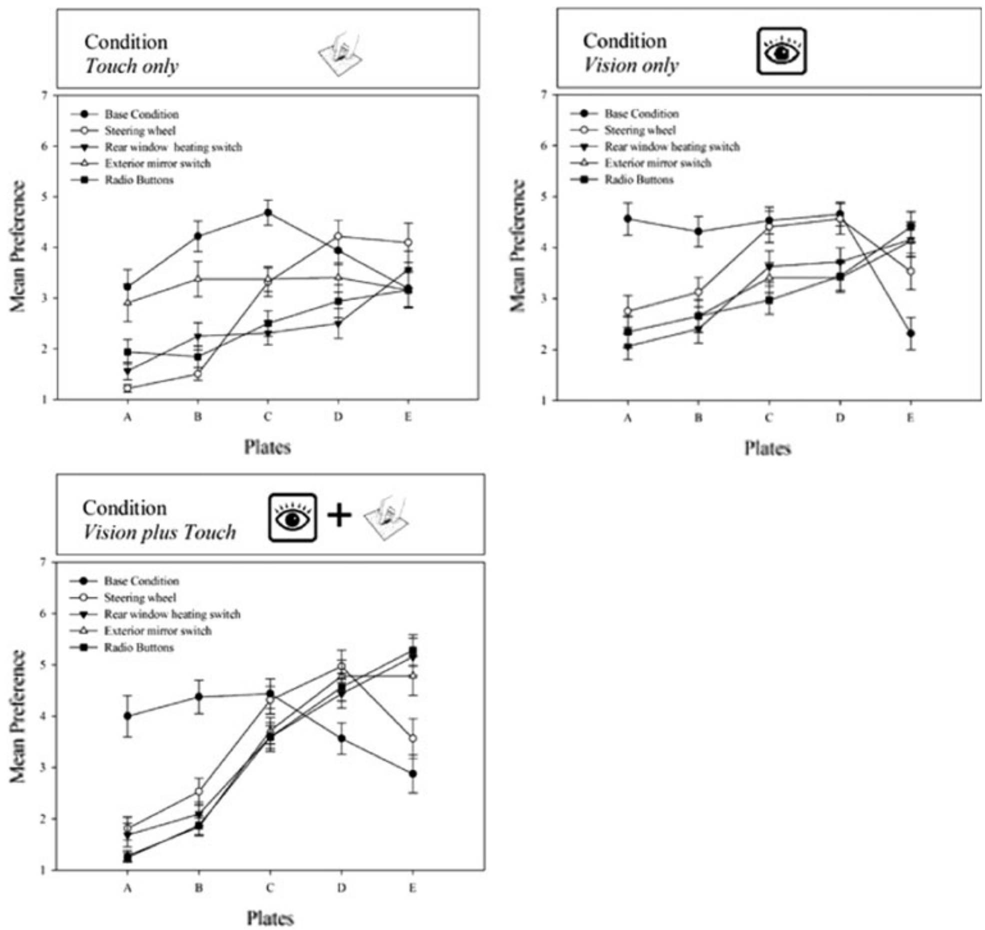

Fig. 5 Mean preference ratings for the hardness dimension split by *modality*. *Error bars* indicate one standard error of the mean

the ratings differed significantly in both unimodal conditions: for *touch only*, $F(1, 159) = 14.20$, $p < .001$, and for *vision only*, $F(1, 159) = 5.31$, $p = .02$.

We also examined participants' associations in the base condition, especially the associations evoked by the materials. Participants' preference judgments might have been based on these associations in the base condition. We recorded and analyzed the participants' associations using a qualitative approach. The associations varied tremendously among the participants. For example, plate A (thermal conductivity dimension) evoked thoughts such as "mirror," "ice," "parquet flooring," "worktop," "the Terminator," "peace of metal" and "tile." The number of reported associations for each dimension is illustrated in Fig. 6. This demonstrated that without specific instructions, people use highly different contextual references associated with the material properties.

4.3 Experiment 2: methods

In experiment 1, the impact of contextual information in the form of scenario-based instructions was shown for preference judgments. In order to test the impact of contextual information on judgments of *physical* properties of surfaces, we conducted a second experiment with the important research question: Is contextual information "powerful" enough to change the experienced thermal conductivity, hardness or roughness of stimuli?

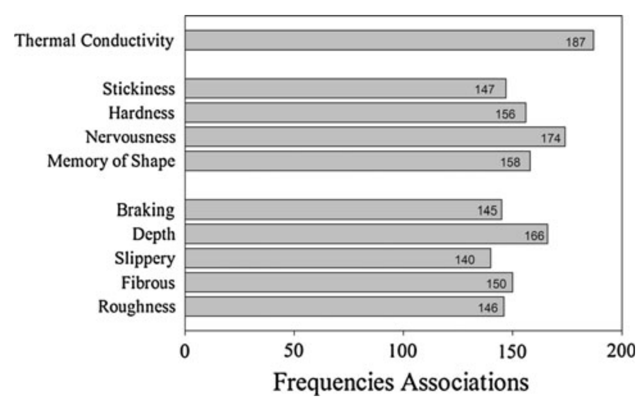

Fig. 6 Total number of different associations for each dimension over all participants

4.3.1 Participants

Sixty students (44 women, 16 men; mean age: 21.0 and 22.2 years, respectively) with normal tactile sensitivity and visual acuity participated for course credit.

4.3.2 Material

Thermal conductivity, hardness and roughness plates from the Sensotact V3 were used based on the relevance ratings for the scenarios gathered in experiment 1. The Sensotact V3 is structured similar to the Sensotact V2 (used in Exp. 1; see details within the method section of Exp. 1). We chose one relevant dimension representational for each touching strategy (static touch: thermal conductivity; orthogonal movement: hardness; tangential movement: roughness). However, for the hardness and roughness dimensions, the V3 has eight instead of the V2 having five plates. To optimize the length of the experiment, we decided to present three instead of four scenarios. This decision was informed by the variation of empirical data obtained in experiment 1. We preserved scenarios 1 and 2 (steering wheel *and* rear window heating switch*)* and added a *third scenario (interior door handle) to extend the range of scenarios.*

4.3.3 Procedure

The procedure, including the four phases, was the same as in experiment 1, but instead of preference ratings, the stimuli were rated according to thermal conductivity, hardness and roughness on 7-point scales (1: low thermal conductivity/hardness/roughness, 7: high thermal conductivity/hardness/roughness). The whole procedure took about 20–30 min per participant.

4.4 Experiment 2: results

The data were analyzed in the same manner as in experiment 1. Figure 7 shows the mean ratings in the base condition and the three scenarios for the dimension hardness split by modality (*vision plus touch*, *touch only* and *vision only*).

A mixed-design MANOVA was calculated with *scenario* as within-subject factor, *modality* as between-subjects factor and thermal conductivity, hardness and roughness ratings as dependent variables (over the stimuli). The multivariate analysis revealed no significant main effect of *scenario,* $F(9, 51) = 1.70$, $p = .10$, *n.s.*, and no significant main effect of *modality*, $F(6, 116) = 1.12$, $p = .35$, *n.s.*, but a significant interaction between *scenario* and *modality*, $F(18, 104) = 1.81$, $p = .03$, $\eta_p^2 = .24$. Subsequent univariate analyses revealed a significant *scenario* effect of hardness, $F(3, 177) = 5.54$, $p < .01$, $\eta_p^2 = .09$, and a significant interaction between *scenario* and *modality* $F(6, 177) = 4.45$, $p < .01$, $\eta_p^2 = .13$. Modality had an influence on the ratings in the base condition, resulting in a systematic underestimation of hardness in the *vision-only* condition compared to the *touch-only* and the *vision plus touch* condition (vision only–touch only: $\Delta = -.57$, $p = .00$; vision only–vision plus touch: $\Delta = -.48$, $p = .01$). Further, the effect of *scenario* only occurred in the vision plus touch and the touch only condition indicating the relevance of a multisensory evaluation especially for the evaluation of surface properties. The factor *scenario* had no impact on the thermal conductivity and roughness ratings. The finding that the evaluations of hardness in the base condition differ significantly from the scenario conditions is coherent with the results of experiment 1.

5 General discussion

Two experiments compared the preferences and assessments of physical properties within a multisensory *vision plus touch* evaluation setting with single sensory evaluation settings of *touch only* and *vision only*. Furthermore, the influence of top-down processes on these evaluations, triggered by different instructions based on everyday life scenarios, was measured.

5.1 Contextual effects

A comparison between a base condition without specific instructions and the scenario conditions with specific instructions showed significant differences, especially in evaluations that involved both vision and touch. Our results demonstrated that the presentation of additional information influenced the evaluations of the materials. For instance, the stimuli were perceived as being harder in the base condition than in the scenario conditions. Thus, the additional information on the contextual usage provided a specific context for the evaluation process. The change in the perception of material property showed that contextual effects were not only due to the presentation of additional materials (Kahrimanovic et al. 2009), but were also due to scenario-based instructions. The findings highlight the strong impact of top-down processes on tactile and visual appreciation and, thus, are in line with Ritterfeld's (2002) argument that specific and decodable information leads to more consistent esthetic judgments. She noted that if social meaning is unavailable, bottom-up processing based on formal structural attributes takes place. The scenario instructions simulate a context that consists of stored and highly familiar schemata. These schemata are used in the

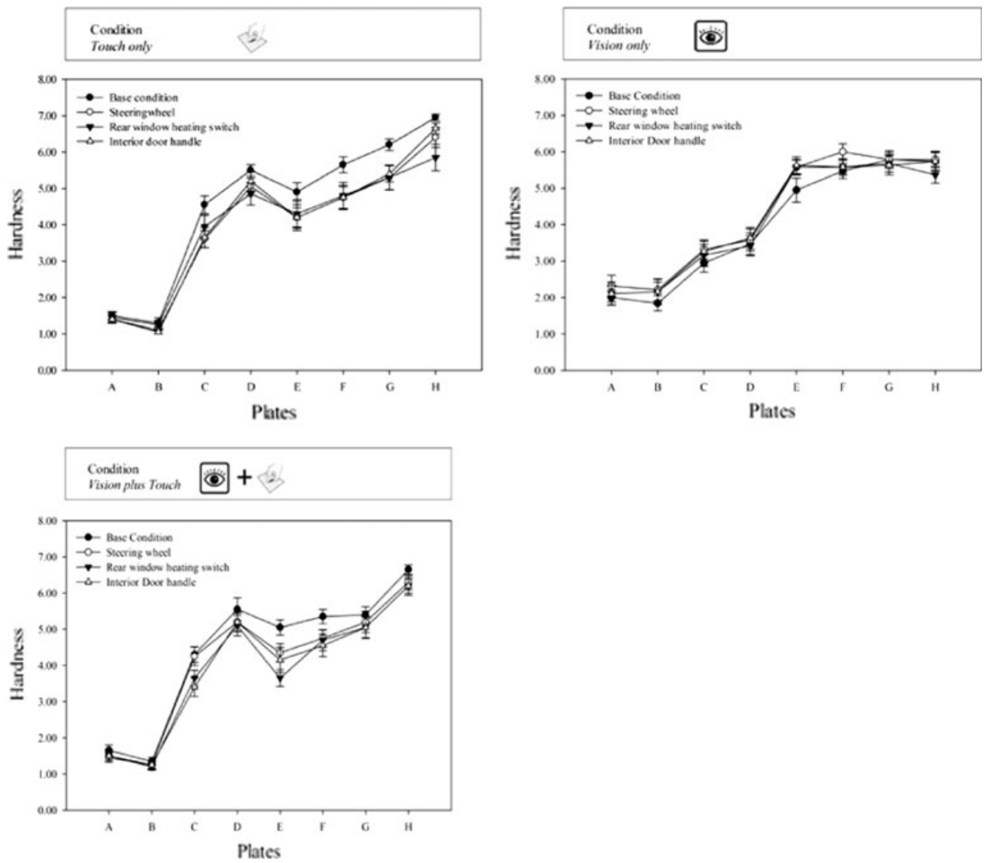

Fig. 7 Mean hardness ratings split by *modality. Error bars* indicate one standard error of the mean

initial evaluation: they activate associations regarding everyday life scenarios for which the participants have experience with. This helps to evaluate the material in a more specific way with the outcome of ecologically more valid assessments. Without instructions (base condition), the evaluation process might begin with an analysis of the formal structural attributes. On later processing stages, these attributes are compared to known material properties. The resulting evaluations are rather unspecific and are not associated with experiences. The participants' associations with the stimuli showed that there were big differences in what people were thinking while touching and/or seeing a stimulus. The evaluation of and preference for a stimulus may change depending on a person's thoughts and associations. It seems obvious that a person will evaluate a surface differently depending on whether he or she is thinking of a car interior, a kitchen table or grandmother's sofa. As revealed by both experiments, even tactile impressions reflecting rather "objective" responses, such as the perception of hardness, can obviously be modified.

5.2 Modality effects considering a multisensory approach

The more reliable findings (indicated by more consistent evaluations of the switch scenarios) in the *vision plus touch* condition illustrate the value of using a multisensory approach in design evaluation (Desmet and Hekkert 2007; Schifferstein 2006; Schönhammer 2001). Clearer patterns in the *vision plus touch* condition indicate a more differentiated evaluation through "more" and diverse sensory input. Furthermore, it can be argued that any multisensory evaluation is per se more precise than an evaluation based on only one sense (cf. Alais and Burr 2004; Gepshtein and Banks 2003; Oruç et al. 2003). We argue that multisensory processing is useful for obtaining stable and clear patterns of data, and that it is necessary for attaining ecologically valid product design evaluations regarding the fact that typical users handle their products in a multisensory way in everyday life usage as well. Pure visual evaluation of surface properties like the hardness is seemingly not as accurate as a multisensory approach as our results in experiment 2 demonstrate.

6 Conclusion

Instructions consisting of scenarios may be helpful because people can easily imagine real-world scenarios. Therefore, scenario-based instructions are a helpful tool for more valid testing procedures. Last but not least, the consequent usage of specific scenarios will help to better predict consumer products' qualities and their market success, the essential variables for applied research (Carbon 2010).

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