Crossmodal Correspondences between Color, Smell, and Texture: Investigating the Sensory Attributes of a Body Lotion

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This research explores the crossmodal correspondences within the field of sensory marketing. In particular, we investigate crossmodal effects between the visual, olfactory, and haptic senses. An extensive literature review reveals a lack of studies in this area but has allowed for a theory-driven approach. An empirical study was performed to explore how different combinations of sensory attributes of a body lotion affect (i) the perception of its color, scent, and texture; and (ii) the evaluation of success measures such as product quality and product liking. A preliminary study was done to determine the sensory attributes of the body lotion to be used in the main study. These attributes are designed to be perceived differently with respect to the manipulated modality but are otherwise similar. The main study employs a 2 × 2 × 2 full-factorial between-subjects design. The empirical findings demonstrate the existence of crossmodal effects. With regard to the assessment of the product, texture of the body lotion emerges as the most important sensory attribute.

1. Introduction

When people talk about the five senses, they usually have the impression that they operate separately from each other (Maric and Jacquot 2013). However, individuals need combinations of different sensory information to better understand their environment (Calvert, Spence and Stein 2004). In most everyday situations, the senses are confronted with various sensory signals (Spence 2011), and events and information from the surrounding area are perceivable via several sensory modalities (Costantini et al. 2018). When evaluating products in particular, whether at the place of purchase or during actual use, consumers make use of all senses (Churchill et al. 2009).

Although the senses hardly act in isolation from each other (Wright 2006), the focus within the marketing literature is mostly on how individual senses influence consumer behavior (Krishna, Elder and Caldara 2010). In this context, Krishna (2012, p. 345) stresses that despite the increased research interest in sensory marketing, there is a need for research on other aspects: "While a lot of work has been done on sensory marketing in the last two decades as we have seen, there is still need for additional research on many aspects of sensory marketing. [...] In terms of links where little research has been conducted so far, we have the interaction of senses." Building on

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this, scholars have expressed the necessity "to better understand how customers' perceptions, emotions, preferences and consumption are affected by sensory and unconscious processes" (Krishna, Cian, and Aydýnoğlu 2017, p. 44).

This research follows Krishna's call and examines the interaction of senses in the context of crossmodal correspondences. Crossmodal correspondences describe the phenomenon in which a sensory characteristic of one sensory modality is associated with that of another modality (Heatherly et al. 2019). The existence of crossmodal interactions has already been observed in various pairs of sensory modalities, with scientific literature focusing primarily on those between auditory and visual stimuli (Spence 2011). In addition, crossmodal correspondence between the visual (color) and olfactory senses has often been documented (Kim 2013; Kaeppler 2018). However, research on the extent to which color influences haptic perception seems to be deficient (Chylinski, Northey and Ngo 2015). Similarly, there is generally little information on crossmodal effects of the olfactory sense on the perception of other sensory modalities (Churchill et al. 2009).

A systematic literature analysis was conducted to gain deeper insight into the state of research on crossmodal correspondences between the visual-olfactory, olfactory-haptic, and visual-haptic senses (section 2). This analysis shows that research involving the study of crossmodal correspondences between these senses is not being carried out in the marketing area and rarely uses consumer goods as a subject of investigation. In the same way, the study of crossmodal interactions between more than two senses has almost been ignored so far.

In an attempt to narrow this research gap, an empirical study was performed, and the sensory attributes of a consumer product were experimentally manipulated. Consistent with the literature, we focused on color, smell, and texture. A partner from the cosmetics industry cooperated with us for the empirical project and produced different samples of a body lotion. The importance of color, smell, and texture for the choice of cosmetics perfectly qualifies a body lotion for our investigation. Section 3 reports on a preliminary study to determine two different intensity levels for each of the three sensory modalities. The main study (section 4) uses a 2 × 2 × 2 full-factorial between-subjects design and the intensities identified as factor levels. The implications, limitations, and further research are presented in section 5, which concludes the paper.

The contributions of this paper are twofold. First, we provide new theoretical and conceptual insights into crossmodal correspondences between the three analyzed senses. To the best of our knowledge, this research is pioneering in examining three-way interactions. Second, the results are relevant from a managerial perspective. They point to the importance of texture and clearly demonstrate that smell and vision also impact or moderate consumer-related success measures. The latter point has largely been ignored by the industry partner so far.

2. Theoretical background

Vision. There is no doubt that visual stimuli represent the majority of information processed by humans and that colors constitute an important facet of visuals. In a marketing context, Elliott (2007) finds that colors might improve the evaluation of products' attractiveness, and Labrecque and Milne (2013) indicate that colors might signal product quality. Although there are many different ways for categorizing colors, we will follow the simple scheme proposed by Bellizzi and Hite (1992) and distinguish between cool and warm colors. Amongst others, calmness is associated with cool colors (e.g., blue, green, purple; Crowley 1993), and excitement is associated with warm colors (e.g., yellow, orange, red; Labrecque and Milne 2012).

Smell. Smell is humans' phylogenetically oldest sense and is highly relevant in everyday life. This sense contributes to taste perception, and certain scents are indicators of aspects such as danger (Doty, 2012). Odor plays a prominent role in social life because of its link to emotions and memories (Herz 2010). This property explains the important influence of scents on consumer behaviors, such as the evaluation of product quality. A generally accepted, well-established classification scheme for smells is missing (Kaeppler and Mueller 2013). Zarzo (2008) proposes distinguishing between pleasant versus unpleasant aromas, whereas Edwards (2019) advocates for a broader view based on a fragrance wheel. He positions 14 different scents in a circular arrangement and differentiates particularly between oriental versus fresh notes and floral versus woody notes. For tractability, this study attempts to use a bipolar characterization and follows Zarzo and Stanton (2009) in using a fresh versus warm dimension. Furthermore, they show that fresh smells are associated with naturalness, while warm smells are associated with sensuality.

Haptic. Touch is very important in sensory marketing because it strengthens the experience that an individual has when interacting with a product (Peck 2010). However, it is the least researched sensory modality so far. Haptic perception matures first among all senses during the prenatal stage of human development and disappears as last of all senses (Krishna 2012). In the case of consumer behavior, tactile information, especially texture, plays a predominant role in product evaluation (Hultén, Broweus and van Dijk 2009; Morales 2010). Classification schemes depend on whether one is considering a liquid or an illiquid surface. For liquids, the amount of viscosity is considered. Some authors differentiate between thick and thin liquids (Lee et al. 2005; Parente, Ares and Manzoni 2010).

Crossmodal correspondences. [1] Rather than concentrating on a single sense, this research focuses on crossmodal correspondences between multiple senses – i.e., on "nonarbitrary associations that appear to exist between different basic physical stimulus attributes, or features, in different sensory modalities" (Spence 2011, p. 972). Such crossmodal correspondences occur because information from different senses is processed simultaneously rather than sequentially (Costantini et al. 2018). Furthermore, research indicates that crossmodal correspondences are characterized by unexpected connections that people make between stimuli or other attributes from different sensory modalities. As an example, Spector and Maurer (2012) find that vanilla aroma is associated with viscous textures. Interestingly, crossmodal correspondences seem to be a universal phenomenon because they are common for most humans (Spence 2011).

Tab. 1a, 1b, and *1c* show the results of an extensive literature review on the interactions between sight (more pre-

	Visual and olfactory senses
Reference	**Most important findings**
Gilbert et al. (1996)	• Study proves robust fragrance-color correspondences. Certain fragrances are associated with specific colors/color names: Bergamot oil ➔ yellow; Cinnamaldehyde (intensive cinnamon fragrance) ➔ red.
Kemp & Gilbert (1997)	• Crossmodal correspondences between fragrance and color exist. Stronger fragrances ➔ darker colors; there is an inverse relationship between the brightness of color and the perceived fragrance intensity.
Schifferstein & Tanudjaja (2004)	• Colors are not randomly matched to fragrances ➔ crossmodal correspondences. Perception of the intensity of fragrance is increased by adding dyes to odor fluids (the suitability of the fragrance-color combination does not matter). In dark product samples, the fragrance was described as more intense. Pleasure is the emotion most likely to be involved in the fragrance-color relationship.
Demattè et al. (2006a)	• Study proves robust crossmodal fragrance-color correspondences. Certain fragrances are associated with certain colors. The reaction of the subjects to fragrance-color pairs, which have a strong association (mint - turquoise, strawberry - pink), was faster and more accurate.
Zellner et al. (2008)	• Masculinity/femininity of an odor plays an important role in crossmodal correspondences. Color selection for "unisex perfumes" is influenced by whether subjects considered the fragrances to be male/female. The attitude towards a fragrance influences the appropriate choice of a color to a fragrance. Favoring a fragrance affects color selection.
Spector & Maurer (2012)	• Significant correspondences between color and fragrance exist. Both the scents that have not been detected and those that have been detected have consistent color associations: lemon fragrance ➔ yellow; peppermint ➔ blue; vanilla ➔ brown; cinnamon ➔ red; bergamot ➔ yellow; almond scent ➔ red.
Stevenson et al. (2012)	• Study proves fragrance-color correspondences. Mowed lawn smell ➔ green; lemon fragrance ➔ yellow.
Kim (2013)	• There are correspondences between the sense of vision and the sense of smell. Certain fragrance families are linked to certain dimensions of color (tone and brightness/saturation). Floral fragrances ➔ warm lighter colors; woody fragrances ➔ cool darker colors; fresh fragrances ➔ cool colors; oriental fragrances ➔ strong colors.
Maric & Jacquot (2013)	• Study documents the existence of crossmodal correspondences between scents and colors: Lavender ➔ violet, pale blue, green; lime ➔ yellow, orange, green, brown; caramel ➔ brown, orange; cucumber ➔ green, orange. For pleasant fragrances, lighter colors (yellow) were chosen; for unpleasant, rather darker and neutral colors were chosen (brown, grey, white).
Kaeppler (2018)	• Study proves correspondences between fragrance and the sense of vision.
Heatherly et al. (2019)	• Study proves crossmodal correspondence between smell, color, & shapes in the case of realistic stimuli (wine labels) and complex odors: yellow label ➔ chardonnay flavorings. Hedonic values act as mediators and play an important role in crossmodal correspondences.

Tab. 1a: Results concerning crossmodal correspondences between visual and olfactory senses reported in the literature

cisely, color), smell, and touch in a consumer behavior context. Köhler (1929) analyzed associations between words and shapes 90 years ago, but research in the area of crossmodal correspondences has been limited and has only recently increased. We identified eleven papers dealing with the visual and olfactory senses (published between 1996 and 2019), seven papers focusing on the olfactory and haptic senses (published between 2006 and 2015), and only three papers concentrating on sight and touch (published between 2013 and 2015). Most of the studies originate from psychology or neurology but do not consider marketing issues. Researchers conducted their empirical studies under highly controlled experimental conditions and used quite abstract stimuli (e.g., color palettes, color wheels, tactile stimulation by robots, swatch, abrasive paper, and wood shapes). Consumer goods were rarely employed as stimuli, and the experimental setting did not allow for the exploration of real product experiences.

In most of the cases, crossmodal effects have been detected. To name a few, (i) intense fragrances are associated with dark colors (Kemp and Gilbert 1997; Schifferstein and Tanudjaja 2004); (ii) subjects perceive fabric patterns with lavender (pleasant) fragrance as gentler than fabric patterns with animal (unpleasant) fragrance (Demattè, Sanabria and Spence 2006a); and (iii) lighter colors are associated with softer and smoother haptic sensations (Slobodenyuk et al. 2015; Ludwig and Simner 2013). Furthermore, a study analyzing three-way interactions between sight, smell, and touch has been missing so far. In addition, the problem is complex because of the huge number of potential combinations between colors, scents, and textures, which has limited systematic research.

Research question. Given the research gap, the current study investigates crossmodal effects between color, smell, and texture in terms of sensory perception in a consumer behavior context. In more detail, we are interested in the impact of different combinations of these sensory properties on the evaluation of a consumer product.

Sensual information is processed in parallel, but vision is usually the leading modality for buyers browsing in a store. In particular, if a product does not catch the visual attention of a customer, it will most likely be ignored. To guarantee a systematic product evaluation process that mirrors actual consumer behavior as closely as possible

	Olfactory and tactile senses
Reference	**Most important findings**
Demattè et al. (2006b)	• Study proves crossmodal correspondences between fragrance and haptics. Smells can influence/change the perception of sense of touch. Pleasant fragrances make a fabric feel softer. Fabric patterns with a lavender scent feel generally gentler than those with an unpleasant fragrance.
Churchill et al. (2009)	• Crossmodal correspondence of fragrance on the perception of the sense of touch exists. The perception of texture attributes can be influenced by different scents. This applies both to the texture attributes of a product and to the surface on which it is applied (i.e., hairs). Properties of liking (total, fragrance, texture, appearance) correlate with texture attributes.
Spector & Maurer (2012)	• There are significant fragrance-texture correspondences (they are not random). Not all correspondences have been learned. Lemon fragrance ➔ soft, smooth, sticky texture; vanilla ➔ soft, smooth, thick, liquid texture; lavender ➔ liquid, sticky, gentle, thin texture; peppermint ➔ smooth, moist, sticky, hard texture.
Stevenson et al. (2012)	• There are consistent crossmodal fragrance texture correspondences. Caramel and durian fruit ➔ soft, smooth texture; strawberry ➔ gentle texture; aftershave ➔ soft, smooth texture; lemon fragrance ➔ soft, smooth texture. Different fragrance characteristics (e.g., intensity, nameability, familiarity) create crossmodal associations with odors.
Kikuchi et al. (2013)	• Fragrances affect tactile perception. Lip balm with lemon fragrance has been rated as gentler and moisturizing. The lipstick with vanilla fragrance, on the other hand, was considered as significantly stickier.
Croy et al. (2014)	• How pleasant a tactile perception is can be changed by olfactory stimuli. Unpleasant scent makes touch feel more unpleasant.
Koijck et al. (2015)	• No crossmodal correspondences between scent and tactile perception of a solid/rough material can be proven. In both experiments, no effect of odors (whether pleasant/unpleasant odors or with low/high trigeminal value) on tactile perception could be detected.

Tab. 1b: Results concerning crossmodal correspondences between olfactory and tactile senses reported in the literature

	Visual and tactile senses
Reference	**Most important findings**
Ludwig & Simner (2013)	• Study confirms crossmodal correspondences between color and haptics: rough ➔ brown, soft ➔ pink. There is a positive correlation between the brightness of the color and the smoothness, softness and rounding of the haptic stimuli. The chroma of a color correlates positively with softness and smoothness.
Chylinski et al. (2015)	• Crossmodal correspondences between sense of sight and sense of touch exist. The correspondences are independent of the product type or whether the color of the product is appropriate/typical. Crossmodal correspondences between color and texture are amplified in the case of a high need for touch condition. The color affects liking and intention to buy significantly. The extent to which the color has an effect on liking and intention to buy depends on perceived texture.
Slobodenyuk et al. (2015)	• Crossmodal correspondences between the properties of a color and haptic sensations exist. Strong correlation between the brightness of a color and the intensity of a haptic sensation: the lighter, softer the texture, the lighter the color. Subjects linked the least intense haptic stimuli to the least pigmented colors.

Tab. 1c: Results concerning crossmodal correspondences between vision and tactile senses reported in the literature

(in terms of purchase decision and regular usage), the setup of the empirical study assumed that a consumer first perceives the color of a product or its packaging. After becoming interested in a product, a consumer approaches it and further explores its smell. Finally, the product is unwrapped and touched. These considerations resulted in the conceptual model presented in *Fig. 1a*, where visual perception is followed by olfactory and haptic perception of the product's attributes (i.e., color, smell, and texture), followed by the consumer's assessment of the product. Based on the crossmodal correspondences reported in the literature, we pose the following research suppositions:

RSa: The exposure to a product's color affects the perception of its smell.

RSb: The exposure to a product's smell affects the perception of its texture.

RSc: The exposure to a product's color affects the perception of its texture.

Given the prematurity of the field, we only pose an exploratory research question:

RQ: How do different combinations of a product's sensory attributes affect the evaluation of consumer-related success measures?

A comprehensive empirical project was carried out to address this research agenda. Section 3 reports on a preliminary study, and the results allow us to specify the effects addressed in RSa, RSb, and RSc more concretely.

3. Preliminary study

3.1. Product category

The research agenda outlined above calls for a consumer product with strong sensory attributes concerning visual, olfactory, and haptic modalities. A partner from the cosmetics industry was also interested in crossmodal correspondences and agreed to cooperate for the empirical

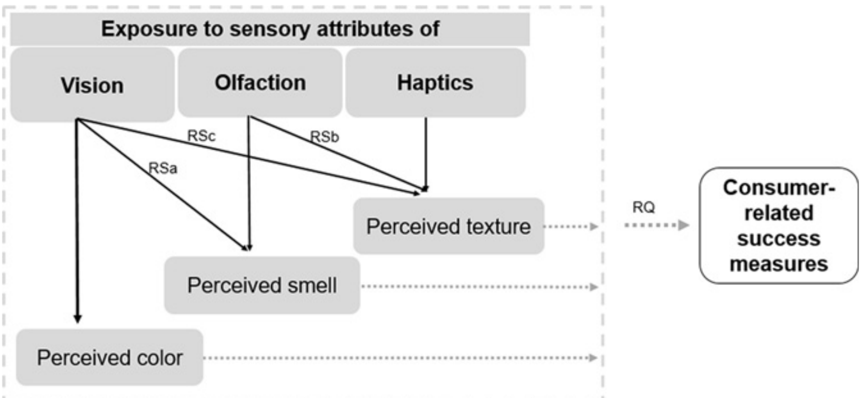


Fig. 1a: Conceptual research model

project. The company contributed to the research and offered to produce samples of a body lotion.

Many real-world cosmetic products are artificially colored. For example, green can be used to signal natural/organic ingredients, or blue can be used for moisturizing properties. For skin care products, fragrance is a central attribute and communicates properties such as gentleness of the emulsion or usage comfort (Jellinek 2003). Theofanides and Kerasidou (2012) find that haptic perception is of the utmost importance for the quality assessment of facial lotions, and Greenaway (2010) and Klatzky (2010) point to the prominent role that texture has when evaluating the liking of skin care products. They specify consistency, ease of spreading, and absorption as noticeable texture attributes. All these properties make cosmetics an appropriate choice for the current study.

3.2. Classification of sensory attributes

There are different classification schemes for each sensory modality in the literature. The applied classification schemes were selected based on a review of canonical literature and were subject to three selection criteria. First, the classification scheme for each sensory attribute should be a clear and well-established binary scheme. The use of more than two characteristics per sensory modality would have resulted in a design that is too complex. Second, the characteristics of each classification scheme should be clearly distinguishable for laymen without sensory expertise (consumers), and third, they should simply and realistically be applicable to the investigated product category (body lotion) without adverse consequences.

As the empirical study was designed in cooperation with a cosmetics manufacturer, real products were used (not artificial stimuli). Therefore, it was not viable to use classification schemes that could possibly induce adverse consequences, such as pleasant versus unpleasant or appropriate versus inappropriate. Understandably, the manufacturer would not want to produce such a body lotion, such as one with an unpleasant smell.

Color attributes, such as hue, color value, or saturation/intensity, may serve as possible indices for the categorization of colors, but the distinction between warm and cool colors is frequently used (Labrecque, Patrick, and Milne 2013) and has also proven practicable in the field of crossmodal correspondences (e.g., Ho et al. 2014). Obviously, besides color, there are other properties that determine the visual appearance of products, such as opacity, turbidity, and sheen. These other visual properties have received only a little scientific attention and would be interesting to consider in the future.

Despite efforts to establish comprehensive standards for the description, measurement, and prediction of odor quality characteristics, there is no comprehensive or generally accepted classification system describing the psychological dimensions of human odor perception (Kaeppler and Müller 2013). However, classification approaches have been proposed (e.g., Zarzo 2008; Zellner et al. 2008). One repeatedly proposed categorization refers to the dimensions of warmness and freshness of odors (Blumenthal 1979; Zarzo and Stanton 2009). The scents that our practice partner employed best fit this classification scheme, and consumers were able to clearly distinguish between fresh and warm smells, so we decided to work with these dimensions.

Regarding tactile texture, scholars have proposed different classification dimensions. Some suggest classifying tactile textures according to their most prominent psychophysical dimensions, such as roughness/smoothness, warmness/coldness, hardness/softness, and friction (moistness/dryness, stickiness/slipperiness) (Okamoto, Nagano, and Yamada 2012). Others, however, distinguish four perceptual dimensions: softness/harshness, thinness/thickness, relief, and hardness (Picard et al. 2003). Nevertheless, the product category investigated in this study has a fluid-coated rather than dry, solid surface texture, and attributes related to the thinness or thickness play a vital role in the perception of such fluid-coated surfaces (Guest et al. 2012). Thus, thinness and thickness emerged as appropriate classification dimensions, which could also be simply manipulated by the manufacturer and clearly distinguished by consumers.

3.3. Determination of stimuli for the main study

The intent of the preliminary study was to determine stimuli for the main study. Two different levels for each of the three senses should be developed for pragmatic reasons – i.e., to keep the design of the main study as simple as possible and based on the outlined classification scheme. These levels should be designed so that they are perceived differently with respect to the manipulated modality (color: cool versus warm; smell: fresh versus warm; texture: different degrees of viscosity) but otherwise similar. The choice of the different intensity levels was guided by results from the literature (particularly concerning classification of colors as cool versus warm and of smell as fresh versus warm) and market experience accumulated by management of the company concerning common practice. In particular, the industry partner provided 12 body lotions:

- Stimuli 1 – 4: Four different levels of color (cool: green, blue; warm: yellow, red), no smell and regular texture
- Stimuli 5 – 8: Four different levels of smell (fresh: apple, lemongrass aroma; warm: vanilla, chocolate), white color and regular texture
- Stimuli 9 – 12: Four different levels of texture (very thin – similar to a body milk, thin – somewhat thinner than regular body lotion, thick – similar to a regular body lotion, very thick – similar to a body butter), white color and no smell

A non-student sample (69 % females) of 32 respondents evaluated the 12 different types of a body lotion (within-

Fig. 2: Sample cosmetic jar for a body lotion (similar design used for both, the preliminary study and the main study)

subjects design) in a laboratory setting. Each body lotion was presented in a neutral jar, and only a three-digit number on the jar identified the type of the stimulus to the investigator (*Fig.* 2). Depending on the stimulus presented, subjects assessed either visual, olfactory, haptic properties of the product. Subsequently, they completed a short questionnaire evaluating sensory properties and product fit (on seven-point rating scales). Open-ended questions were also asked about associations with the body lotion.

Varying the ordering of the samples reduced potential sequencing biases. Research assistants gave special support to each subject to make sure that they followed the detailed instructions on how to test and evaluate the body lotions. These instructions were necessary to prevent overlapping effects from testing different samples. For example, after testing a certain smell, respondents neutralized their olfactory sensibility by sniffing coffee beans, and after evaluating a certain texture, they cleaned their hands with wet wipes and water.

Results concerning color. Respondents clearly classified green and blue as cool, while yellow and red were considered warm colors (see upper panel of *Tab.* 2 for marginal means, standard errors, and RM ANOVA contrast test results). The evaluations of green, yellow, and red concerning pleasantness, color intensity, and product fit did not differ significantly from each other according to pairwise RM ANOVA contrast tests, but blue was perceived as different. Therefore, we selected green and yellow for subsequent analyses.

RM ANOVA: classification of color
The color of the body lotion is a … 1=cool color, 7=warm color

Main effect: $F_{3, 93}$=129.15 p<.01			warm color: red 5.53(1) (.16)(2)	warm color: yellow 6.31(1) (.15)(2)
cool color	blue	1.88(1) (.21)(2)	$F_{1, 31}$=223.94(3) p<.01	$F_{1, 31}$=195.58(3) p<.01
cool color	green	3.06(1) (.21)(2)	$F_{1, 31}$=94.51(3) p<.01	$F_{1, 31}$=137.87(3) p<.01

RM ANOVA: classification of smell
The smell of the body lotion is a … 1=fresh smell, 7=warm smell

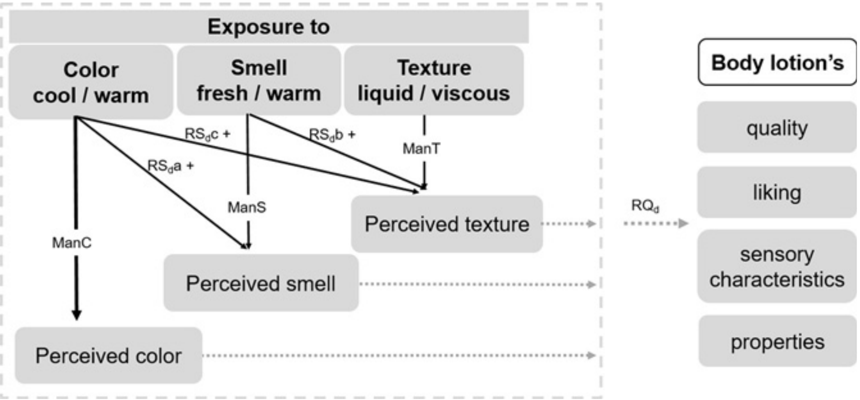
Main effect: $F_{3, 93}$=43.40 p<.01			warm smell: vanilla 5.19(1) (.31)(2)	warm smell: chocolate 5.16(1) (.25)(2)
fresh smell	apple	2.94(1) (.25)(2)	$F_{1, 31}$=26.43(3) p<.01	$F_{1, 31}$=35.02(3) p<.01
fresh smell	lemon grass	1.66(1) (.20)(2)	$F_{1, 31}$=62.48(3) p<.01	$F_{1, 31}$=94.94(3) p<.01

RM ANOVA: classification of texture
The texture of the body lotion is a … 1=thin texture, 7=thick texture

Main effect: $F_{3, 93}$=111.45 p<.01			thick texture: thick 4.31(1) (.25)(2)	thick texture: very thick 6.56(1) (.15)(2)
thin texture	thin	4.47(1) (.29)(2)	$F_{1, 31}$=.19(3) p=.67	$F_{1, 31}$=50.15(3) p<.01
thin texture	very thin	1.53(1) (.14)(2)	$F_{1, 31}$=155.12(3) p<.01	$F_{1, 31}$=644.38(3) p<.01

(1) marginal means (2) (standard errors) (3) contrast test
Cells shaded in grey flag sensory combinations used in the main study

Tab. 2: Evaluating and testing sensory intensities (preliminary study)



ManC: Manipulation check for color; ManS: Manipulation check for smell; ManT: Manipulation check for texture

Fig. 1b: More detailed conceptual research model

Results concerning smell. Again, respondents classified apple and lemongrass aroma as fresh, but vanilla and chocolate were considered as warm smells (see middle panel of *Tab.* 2 for RM ANOVA contrast test results). Pairwise comparisons (RM ANOVA contrast tests) of pleasantness did not find significant differences with one exception: vanilla had a better evaluation than chocolate. Concerning intensity, apple, vanilla, and chocolate smells were assessed similarly, but lemongrass aroma was considered significantly more intense. Concerning product fit, chocolate was the (negative) outlier. No differences were detected with respect to awareness of these smells. Therefore, we decided to distinguish between apple and vanilla smell in the main study.

Results concerning texture. Classification concerning texture resulted in three groups, with thin and thick intensities considered as similar to each other but being different from both the very thin and the very thick stimuli (see lower panel of *Tab. 2* for RM ANOVA contrast test results). Concerning pleasantness, the very thick body lotion was considered significantly worse. Therefore, we selected very thin and thick as intensity levels for texture.

In all cases, the stated associations in response to the open-ended questions confirmed the results of the statistical analyses. This applied especially to the texture attribute, where the very thick body lotion evoked many negative associations. The responses also illustrated vocabulary used to describe attributes and important characteristics of body lotions, such as "greasy," "light," "soft," "gentle," "rich," "smooth," "absorbs quickly," "easy to spread," "moisturizing," "refreshing," "nourishing," "cream for winter," and "everyday cream."

3.4. More detailed conceptual research framework

Based on the literature review and the results from the preliminary study, we confined our research suppositions RSa, RSb, RSc and our research question RQ (see *Fig. 1b*):

RS_da: Exposure to a warm versus cool-colored body lotion (i.e., yellow versus green color) causes its scent to be perceived as warm rather than fresh.

RS_db: Exposure to a warm versus fresh scented body lotion (i.e., vanilla versus apple smell) causes its textures to be perceived as thick rather than thin.

RS_dc: Exposure to a warm versus cool-colored body lotion (i.e., yellow versus green color) causes its texture to be perceived as thick rather than thin.

RQ_d: How do different combinations of a body lotion's sensory attributes affect the evaluation of consumer-related success measures such as product quality, product liking, product sensory characteristics, and properties?

Literature dealing with cosmetic products (Churchill et al. 2009; Parente, Ares, and Manzoni 2010; Wortel and Wiechers 2000) guided the selection of consumer-related success measures.

4. Main study

4.1. Method

The main study employed a 2 × 2 × 2 full-factorial between-subjects design. Participants were randomly assigned to a certain experimental condition, and they tested and evaluated one body lotion in a laboratory setting to control for other extraneous influences (e.g., illumination and temperature of the lab, surface of the table where the product was displayed, disturbances from other respondents). Body lotions were presented in a neutral cosmetic jar with a capacity of 50 ml. Labels only showed a three-digit number for identification purposes (see *Fig.* 2). Each participant received a closed, new jar, blinded to the research objective, and had to follow strict instructions on how to proceed with the evaluations. Research assistants first opened the jar, and the respondent evaluated the color of the body lotion. Subsequently, the respondent was asked to smell and then evaluate the perceived aroma of the body lotion. In accordance with the left part of *Fig. 1b*, assessment of the perceived texture constituted the third step. The subjects dipped the forefinger of the dominant hand into the cosmetic jar and then rubbed the lotion on the back of a hand. Based on this sensory experience, the texture thickness was evaluated. Finally, the body lotion was assessed in terms of consumer-related success measures (right part of *Fig. 1b*) and some demographic information was obtained. After leaving the lab, respondents were debriefed and received a compensation of 7 €.

Subjects with color blindness and odor restriction were not allowed to participate. Furthermore, they were asked not to smoke for one hour before the data collection. On average, respondents needed about 10 minutes to carry out their evaluations. Employing a good proportion of single items (seven-point scales throughout) enabled this rather short duration. For body-lotion-specific variables, we adapted and modified established scales (Churchill et al. 2009; Parente et al. 2010) by relying on the open-ended responses from our preliminary study. *Tab. 3* displays the items employed and corresponding reliability indexes (Cronbach α). Since the results are above the required threshold of .7, composites were formed for softness, applicability, and (favorable) properties.

The sample size was 323 subjects with about 40 subjects per experimental condition. We strived for a quota sample with respect to age and achieved an age range of 28–69 years with an average of 38 years. Given that we analyzed a cosmetic product, the percentage of females in the sample was higher (61 %). Participants were quite familiar with this product category, and 36 % used a body lotion every day.

The content of the questionnaire did not contain sensitive issues that might induce biased response behavior due to social desirability. In addition, the method of administration assured respondents' anonymity. Harman's single factor test found that when all variables are loaded onto this factor, only 29 % of the variance is explained. These measures safeguard against common method variance (see Podsakoff et al., 2003).

4.2. Results for postulated research suppositions

Tab. 4 presents the results of the manipulation checks (ManC, ManS, ManT in *Fig. 1b*) and the analysis of the postulated research suppositions (RS_da, RS_db, RS_dc).

- An ANOVA contrast test supported that manipulation of color was successful because green (M_{green} = 2.88) was perceived as significantly cooler than yellow (M_{yellow} = 4.14).
- A multiple ANOVA investigated ManS and RS_da with perceived warmness of smell as a dependent variable manipulated color and smell as independent variables. The main effect of smell (M^{apple} = 3.53 versus $M^{vanilla}$ = 5.09) was statistically significant, which corroborated that the manipulation of smell was successful – i.e., apple smell was perceived less warm than vanilla smell. Both the main effect of color and the interaction effect were statistically significant. A more detailed

Perceived sensory modalities (single items)
The color of the body lotion is a … 1=cold color, 7=warm color
The smell of the body lotion is a … 1=fresh smell, 7=warm smell
The texture of the body lotion is a … 1=thin texture, 7=thick texture

Quality (single item)
How do you evaluate the quality of this body lotion? (1)

Liking (single item; adapted from Churchill et al., 2009)
How do you assess the body lotion? (2)

Sensory characteristics (adapted from Parente et al., 2010; Wortel and Wiechers, 2000)
Please indicate to which extent do the following characteristics apply/not apply to the body lotion? (3)

Softness: gentle; soft	Cronbach α = .81
Applicability: light; elastic; infiltrates easily; easily spreadable	Cronbach α = .71

(Favorable) properties (adapted from Parente et al., 2010; Greenaway, 2010: Wortel and Wiechers, 2000)
Please indicate to which extent you agree/disagree with the following statements regarding the properties of the body lotion? (4)

Tightening, nurturing, protective, rejuvenating, moisturizing	Cronbach α = .72

Response formats:

(1) 1=very low quality, 7=very high quality
(2) 1=does not like it all, 7=like it very much
(3) 1=does not apply at all, 7=fully applies
(4) 1=strongly disagree, 7=strongly agree

Tab. 3: Scales employed in main study and Cronbach alpha reliabilities (if applicable)

Experimental manipulation			Marginal mean (1)	Standard error	*F*-test(2) *p*-level	Comment
			DV: perceived color warmness			
color		green	2.88	.11	$F_{1, 321}$=66.70 p<.01	ManC – manipulation check for color successful
		yellow	4.14	.11		
			DV: perceived smell warmness			
smell	apple		3.53	.12	$F_{1, 319}$=86.22 p<.01	ManS – manipulation check for smell successful
	vanilla		5.09	.12		
color		green	4.12	.12	$F_{1, 319}$=5.20 p=.02	RS$_d$a supported for apple smell
		yellow	4.50	.12		
smell × color	apple	green	3.16	.17	$F_{1, 319}$=9.70 p<.01	
		yellow	3.90	.17		
	vanilla	green	5.07	.17	$F_{1, 319}$=.01 p=.92	
		yellow	5.10	.17		
			DV: perceived texture thickness			
texture		thin	1.88	.10	$F_{1, 315}$=263.57 p<.01	ManT – manipulation check for texture successful
		thick	4.13	.10		
smell	apple		2.88	.10	$F_{1, 315}$=2.95 p=.09	RS$_d$b weakly supported
	vanilla		3.12	.10		
color		green	2.87	.10	$F_{1, 315}$=3.92 p=.05	RS$_d$c supported
		yellow	3.14	.10		
All two-way and three-way interactions were not significant, cf. *Fig. 3*						

(1) evaluated on a seven-point scale (1 – cool/fresh/thin, …, 7 – warm/warm/thick)

(2) contrast test

Tab. 4: Effects of sensory attributes on perception
Results for RS$_d$a, RS$_d$b, RS$_d$c and manipulation checks (ManC, ManS, ManT)

analysis (contrast tests) found that the smell of the yellow body lotion was perceived as warmer than that of the green body lotion for the apple aroma (M^{apple}_{yellow} = 3.90 versus M^{apple}_{green} = 3.16), but there was no significant difference for vanilla ($M^{vanilla}_{yellow}$ = 5.10 versus $M^{vanilla}_{green}$ = 5.07). Thus, a green color can help to make the smell feel fresher than a yellow color (particularly for a body lotion with an apple smell). This result is in accordance with RS$_d$a.

- Finally, a multiple ANOVA used perceived texture thickness of the body lotion as a dependent variable but manipulated color, smell, and texture as independent variables and investigated ManT, RS$_d$b, and RS$_d$c. We first note that the main effect of texture was significant: perceived thickness for the thin body lotion was lower than for the thick body lotion (^{thin}M = 1.88 versus $^{thick}M$ = 4.13). This corroborated the successful manipulation of texture. Main effects of smell (M^{apple} = 2.88 versus $M^{vanilla}$ = 3.12) and color (M_{green} = 2.87 versus M_{yellow} = 3.14) were statistically significant. All two-way and three-way interactions were not significant (see *Fig. 3*). This allows for direct interpretation of the main effects. Therefore, a warmer smell (i.e., vanilla) and a warmer color (i.e., yellow) result in increased perceived texture thickness. Particularly, with a vanilla smell, texture is perceived as thicker than with an apple smell (only weakly signifi-

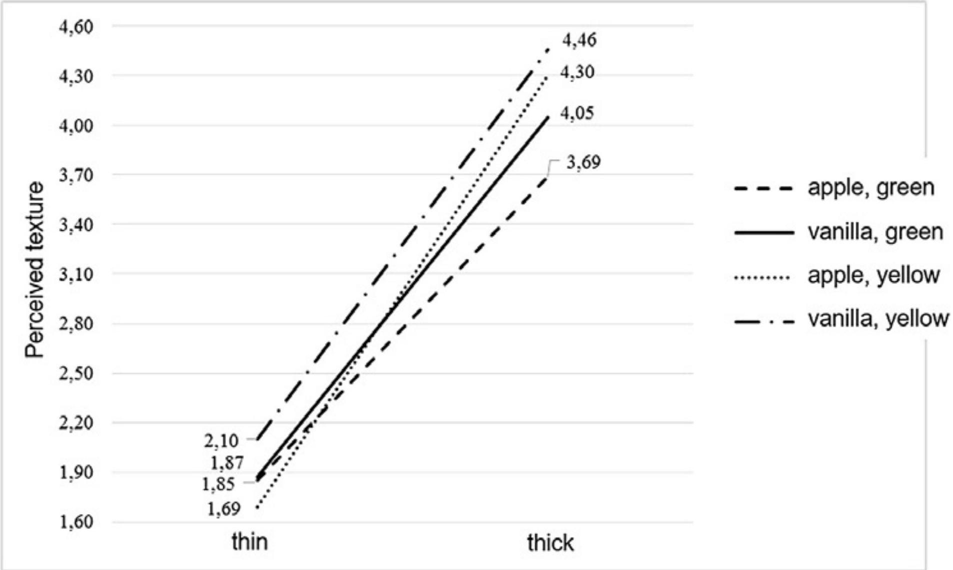


Fig. 3: Analysis of RS_db, RS_dc, two-way and three way interactions on perceived texture thickness

cant), while with yellow color, texture is perceived as thicker than with a green color. These results fully support RS_db and RS_dc. As a matter of fact, we concede that the main effect of texture is stronger than the main effects of smell and color.

As an aside, we note that covariates (e.g., gender, product familiarity, age) were found not to be significant, so they were excluded from analyses.

4.3. Statistical results for exploratory research question

The right column in *Fig. 1b* lists the investigated success measures, which indicate whether sensory attributes not only affect sensory perceptions but carry over to other consumer reactions. *Tab. 3* illustrates in detail how these variables (and composites) have been measured. Given the exploratory nature of the research question, the statistical analysis focuses on total effects of the experimental conditions (and their interactions) on success measures rather than running mediation analyses via sensory perceptions. Sensory perceptions, however, are included as explanatory variables in a series of regression analyses. *Tab. 5* presents the results in a condensed format (estimates for the different dependent variables are shown in columns 2–6 of the upper part of *Tab. 5*). In addition to their difference in content, modest correlations between these dependent variables warrant separate analyses.

We first observe that summary fit statistics are satisfactory for all but one model (that for softness). Main effects of experimentally manipulated product attributes are positive throughout but statistically significant for smell and texture only. In contrast, two-way interactions are consistently negative, but three-way interactions are consistently positive again. Many of these interactions are statistically significant (for presentational convenience, cells showing significant estimates are shaded in grey). Sensory perceptions play a minor role according to the size (relative to the other regressors) of standardized regression parameters and statistical significance. Interestingly, the impact of smell perception on all dependent variables is negative (we will discuss this finding in the next subsection).

Keeping the significant interactions in mind makes the interpretation of the results somewhat tedious, especially when it comes to managerial implications, which would require concrete advice on which sensory properties to choose. For the purpose of reducing the complexity of sensory attributes' effects, the lower part of *Tab.* 5 presents comparisons of marginal means of main effects. [2] Obviously, thick texture is important for evaluating quality and liking positively. In this case, the positive direct and three-way interaction effect and perception of texture outweigh negative two-way interactions. Remarkably, vanilla smell positively impacts applicability, and positive effects dominate negative effects for applicability. As a tentative result, we notice that green outperforms yellow color throughout (although statistically not significant), and the same applies for vanilla over apple smell and thick over thin texture. In addition, these general results do not hold for all success measures to the same extent. Utilizing interactions between sensory attributes might help to achieve certain managerial goals. Of course, these results are preliminary responses to RQ_d, and more research is necessary to make the findings more reliable.

4.4. Conceptual results for exploratory research question

Differential impact of direct and indirect sensory stimuli. Even though we expected interaction effects, their extent is striking. In particular, the differential impact of direct and indirect (via their perceptions) sensory stimuli requires attention. Indirect effects may mix two types of influences, namely bottom-up ("stimulus-driven") influences (which are actually the basis of cross-

Dependent variables	**Quality**		**Liking**		**Softness**		**Applicability**		**Properties**	
Independent variables	Parameter estimate (1)	*p*-level	Parameter estimate (1)	*p*-level	Parameter estimate(1)	*p*-level	Parameter estimate (1)	*p*-level	Parameter estimate (1)	*p*-level
Constant	3.98	<.01	3.86	<.01	5.17	<.01	4.90	<.01	4.16	<.01
Color (2)	.26	.38	.58	.07	.46	.07	.03	.92	.03	.89
Smell (3)	.72	.02	.96	<.01	.80	<.01	.99	<.01	.44	.05
Texture (4)	.72	.02	1.23	<.01	.50	.06	.70	.02	.43	.05
Co × Sm	-.84	.04	-1.16	<.01	-1.03	<.01	-.34	.42	-.20	.51
Co × Te	-.43	.30	-1.17	<.01	-.59	.10	-.37	.37	-.31	.30
Sm × Te	-.68	.09	-1.07	.02	-1.02	<.01	-1.31	<.01	-.67	.02
Co×Sm×Te	.91	.11	1.83	<.01	1.42	<.01	.85	.14	.73	.08
Per. color	.06	.28	.09	.12	.03	.58	.04	.44	.04	.27
Per. smell	-.12	.01	-.14	.01	.01	.82	-.12	.02	-.05	.20
Per. texture	.12	.05	.06	.34	-.01	.92	-.10	.10	.08	.06
	R^2=.10		R^2=.11		R^2=.04		R^2=.08		R^2=.07	
	$F_{10, 312}$=3.36	<.01	$F_{10, 312}$=3.88	<.01	$F_{10, 312}$=1.40	.18	$F_{10, 312}$=2.57	<.01	$F_{10, 312}$=2.18	.02
	Marginal means (5)	*p*-(6) level	Marginal means (5)	*p*-(6) level	Marginal means (5)	*p*-(6) level	Marginal means (5)	*p*-(6) level	Marginal means (5)	*p*-(6) level
green	4.56	.36	4.60	.44	5.68	.97	4.76	.49	4.62	.70
yellow	4.42		4.47		5.69		4.65		4.58	
apple	4.40	.25	4.39	.09	5.62	.36	4.52	.02	4.51	.12
vanilla	4.59		4.69		5.75		4.90		4.70	
thin	4.30	.04	4.25	<.01	5.66	.76	4.67	.70	4.54	.38
thick	4.69		4.82		5.71		4.75		4.66	

(1) Non standardized parameter estimates
(2) Color (0 – green, 1 – yellow) (3) Smell (0 – apple, 1 – vanilla) (4) Texture (0 – thin, 1 – thick)
(5) Marginal means of main effects
(6) *p*-level of an ANOVA *F*-test comparing marginal means: $F_{1, 312}$ (Tabachnick and Fidell 2007, p. 194).
Entries shaded in grey highlight estimates significant for a type I error of .05

Tab. 5: Effects of sensory attributes on consumer related success measures
Results for RQ_d

modal correspondences that we investigate here) and top-down influences (due to asking about perception, which requires a little more mental activity and thus a higher degree of cognition). As Gordon et al. (2019, p. 1) put it: "Perception likely results from the interplay between sensory information and top-down signals." Therefore, it might be possible that the direct effects would actually capture the bottom-up component (especially the effects of our stimuli; i.e., the largely unconscious crossmodal correspondences). In the case of indirect effects, the integration of bottom-up and top-down effects could take place to some extent, which could possibly lead to the correspondingly different results. The stronger integration of top-down effects could thus have triggered different processes and changed reactions. [3]

The attention paid to perception of stimuli (by directly asking respondents about it) could also have played a role here. There is literature claiming that this attention can contribute to directing processes more towards top-down and that the interaction between attention and multisensory integration can also lead to contradictory results (Hartcher-O'Brien, Salvador, and Adam 2017). These two phenomena might explain the consistently identified reverse directions of effects of smell perception versus the main direct effect of smell because olfactorial sensation has the most direct link to emotions and is evaluated unconsciously to a large extent.

Common features of sensory modalities. The design of the experiment defined the sequence with which subjects were exposed to the different sensory stimuli. On a more general level, however, mutual interaction between sensory modalities might take place, and the question arises of whether some underlying mechanism could be at work. [4] Within the research field of crossmodal correspondences, scholars distinguish a number of different ways in which stimuli of different sensory modalities can be matched or associated (Marks 1978). Basically, crossmodal correspondences may occur as low-level or higher-level cognitive correspondences and may be established based on (i) a common (amodal) feature shared by several (or all) of these modalities; (ii) a matching between seemingly unrelated (possibly modal) features in different sensory modalities; (iii) a matching on a more abstract level (e.g., factors such as perceived pleasantness or cognitive meaning); or (iv) similar effects of stimuli on the observer (e.g., on alertness, emotional state, etc.) (Spence 2011). Considering the investigated attributes, both matchings based on (iii) and (iv) could be imaginable. For instance, in the case of (iii), we conducted a manipulation check to assure that all sensory stimuli were perceived as equally pleasant and appropriate, which might enable a matching based on these factors. But in light of the high complexity of the experimental design, no assessment of these options was included. However, the search for underlying mechanisms would represent an exciting undertaking for future studies.

Other than the phenomenon of synesthesia (which is considered as unidirectional; e.g., a number may induce a color, but not vice versa), crossmodal correspondences are considered as bidirectional in nature (Bruno and Pavani 2018). Hence, it might reasonably be assumed that there are also effects of scent and texture on vision and of texture on scent (see *Tab. 1a, 1b,* and *1c*). However, our experimental design was not conceptualized for a complete investigation of all bidirectional correspondences, but rather followed the "real" procedure of using a body lotion (i.e., looking at the product and assessing color, evaluating the perceived smell, and evaluating texture). Thus, it does not allow for respective conclusions. An assessment of all bidirectional correspondences involved would surely have been interesting, but it would have required an even more complex and more unrealistic experimental design, from which we refrained for pragmatic reasons.

5. Implications, limitations, and further research

Theoretical implications. This study explored crossmodal correspondences between different senses. To the best our knowledge, this is the first research analyzing three-way interactions between the visual, olfactory, and haptic senses. In addition, investigations of the impact of texture within sensory marketing are rare, which might be another positive asset of this paper, particularly because texture turned out to be an important driver of marketing success in the present case.

Obviously, implications of our research may be transferred to related but undoubtedly not completely different product categories (e.g., cosmetics in general). As the predominant part of previous research focuses on vision (Hutmacher 2019), comparatively little is known about the role of other sensory modalities like texture. Previous work provides reason to assume that texture might play a vital role for other product categories as well – for instance, by representing one of the strongest drivers in food acceptance (Scott and Downey 2007) – as well as an important cue for food identification (van Stokkom et al. 2018). Having said this, texture may be perceived by means of touch, vision, and hearing and is regarded as multidimensional, incorporating attributes such as roughness, density, hardness, etc. (Klatzky and Lederman 2010). Hence, not every "component" of texture perception might have the same relevance for different product categories. Rather, the importance of texture attributes is known to be dependent on both the product and consumer (Meullenet 2004).

In regard to the relative importance of different sensory modalities for product evaluation (e.g., texture compared to smell, vision, or taste), one would likely find different patterns of results for different product categories and different types of consumers. For instance, an examination of the relative importance of texture, smell, and taste for the pleasantness of a yoghurt-like fermented oat bran product revealed that for young consumers, smell was the most important factor predicting overall pleasantness, while texture and taste were of minor importance. For elder consumers, smell and taste emerged as equally relevant in this context (Kälviäinen, Roininen, and Tuorila 2003). In comparison, work on the relative importance of appearance, smell, taste, and texture for overall liking of a fruit drink indicates a dominant role for taste, while smell emerged as the least important modality in this context (Andersen, Brockhoff, and Hyldig 2019).

Consequently, it should be emphasized that there is no universal hierarchy of senses (Majid et al. 2018), but rather, the relevance of sensory modalities varies (dramatically in some cases) with the individual consumer (Moskowitz and Krieger 1993), the product category, and the stage of usage (Schifferstein 2006). It is also subject to cross-cultural and historical variation (Hutmacher 2019). Against this background, we prefer to refrain from a "general statement" about the relevance of texture as compared to other sensory modalities for different product categories, especially when considering the lack of empirical investigations of the relative importance of different sensory modalities for relevant success variables, as well as the partly contradictory conclusions proposed by other work (see *Tab. 1a, 1b,* and *1c*).

Managerial implications. From a managerial point of view, the importance of texture highlights the considerable potential of product sampling because only the actual use of a body lotion guarantees that consumers will experience such a haptic stimulus. The interaction between texture and smell (and qualitative feedback from respondents) offers scope for designing different varieties of a body lotion. For instance, the design could depend on the season: a body lotion with vanilla aroma is perceived as thicker and thus protective, which makes such a lotion better suited during winter time. On the other hand, apple aroma is perceived as thinner and thus refreshing, which makes it better suited during summer time. Furthermore, colorizing a body lotion in green represents an easy way to improve its liking. In fact, our practice partner intends to implement some of our recommendations.

Smell has also turned out to have pronounced importance. Smell particularly influences applicability (e.g., infiltrates easily, easily spreadable), which might be an essential driver of purchase decision. Interaction effects between smell and other sensory attributes also turned out substantial, which underlines the prominence of smell via crossmodal correspondences.

Color is an important driver to catch a customer's attention at the point of sale (which was not investigated in this context). However, it turned out to be of least importance in the current study, although still relevant. Coloring a body lotion is very easily accomplished during production. At this point, the interaction of color with smell and texture should be considered: just changing its color (e.g., from yellow to green) might change the perception and evaluation of a body lotion. Thus, management might adopt a product portfolio that depends on seasonal offerings. Respondents in the preliminary study noted that preference for a certain thickness might depend on whether the product is used during winter (when thicker texture is preferred) or during summer time (when thinner texture would be preferred).

Limitations and further research. Certainly, we have to admit several limitations. We only considered short-term effects of sensory attributes and neglected habituation and particularly loyal consumer behavior. Thus, the results are more suited for trial purchase occasions or product innovations. As is the case for most experimental research, the laboratory setting diminishes external validity. In reality, there might not be such a clear distinction between exposures to different sensory modalities. For color and smell, adding control groups (i.e., white color, no smell) might have been advantageous. However, this would have increased the number of experimental groups from 8 to 18 when maintaining a full-factorial design, which is required when interaction effects are investigated. This would not have been tractable. In fact, convincing more than 320 people from a general population to come to a lab for participation in the study was already quite demanding. It is well known that congruency between different environmental conditions affects consumer behavior. This might also be the case for congruency between stimuli of different sensory modalities. The present study neglects this issue.

The limitations naturally point to further research. Other products and other sensory modalities might be considered, such as auditory stimuli when examining appliances, or flavor when investigating groceries. A systematic investigation of moderator/mediator variables would also be of interest, such as consumer characteristics and situational triggers. Conducting field studies would add realism, but it would probably be quite demanding. Interdisciplinary research with other fields such as neurosciences could point to an opposing direction that might also be very inspiring.

Notes

[1] Literature does not clearly distinguish between crossmodal correspondences, crossmodal associations, crossmodal interactions, and crossmodal effects. Thus, we will use these terms as synonyms.

[2] We are aware of the potential problems when comparing marginal effects in the presence of significant interactions. However, we point to pragmatic reasoning and the binary level for each variable.

[3] There is still substantial disagreement in the literature about what kind and how far-reaching these effects are; e.g., " [...] bottom-up processes can automatically capture attention towards multisensory events. Top-down attention can in turn facilitate the integration of multisensory information which leads to a spread of attention across sensory modalities" (Quak, London, and Talsma 2015, p. 110).

[4] We thankfully acknowledge that this issue was raised by one of the anonymous reviewers.

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