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REVIEW ARTICLE

Multisensory contributions to skin-cosmetic product interactions

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Abstract

The human face is one of the most salient regions of the body surface. Ratings of facial attractiveness, as well as judgements of a person's age, are influenced by the appearance of facial skin (not to mention the presence/absence of wrinkles). Unsurprisingly, many consumers spend huge amounts of money on trying to protect, maintain, and/or enhance their facial appearance. As highlighted by the evidence presented in this narrative review, both the skin and the cosmetic products that many consumers use are fundamentally multisensory in nature. The complex interaction between the particular skin site stimulated and the multisensory attributes of the product (e.g., when it is applied) can exert a number of effects on an individual's mood, their emotions, as well as on their self-perception (and self-confidence), over-and-above any functional effects that the cream or lotion may have on the skin itself. In this narrative historical review, the literature on the multisensory perception of facial skin is summarized and critically evaluated. Multisensory interactions taking place between the cosmetic product, its packaging, as well as its use/application at the sensory, cognitive, and emotional levels are all discussed.

KEYWORDS

crossmodal, face cosmetics, multisensory, olfaction, skin

Résumé

Le visage humain est l'une des régions les plus visibles de la surface du corps. L'apparence de la peau du visage (sans parler de la présence ou de l'absence de rides) influe sur l'évaluation de l'attrait du visage et sur le jugement de l'âge d'une personne. Il n'est donc pas surprenant que de nombreux consommateurs dépensent des sommes considérables pour essayer de protéger, d'entretenir et/ou d'améliorer l'apparence de leur visage. Comme le montrent les données présentées dans cette synthèse, la peau et les produits cosmétiques utilisés par de nombreux consommateurs sont fondamentalement multisensoriels par nature. L'interaction complexe entre le site cutané stimulé et les attributs multisensoriels

du produit (par exemple, lorsqu'il est appliqué) peut exercer un certain nombre d'effets sur l'humeur et les émotions d'un individu, ainsi que sur la perception de soi (et la confiance en soi), au-delà de tout effet fonctionnel que la crème ou la lotion peut avoir sur la peau elle-même.

INTRODUCTION

The perception of our own skin is a very multisensory phenomenon [1], and is affected both by sensory factors as well as by our mood and emotions, etc. While the majority of the somatosensory research that has been published to date has tended to focus on measures of tactile perception at the fingertips [2], there is emerging evidence that both the sensory acuity, as well as the spatial distribution of tactile/somatosensory receptors, differs markedly as a function of the skin site stimulated [3–7].

The face is a particularly interesting target for experimental research given that it is a skin site that we never see directly (at least not in the case of self-perception), only periodically via mirror reflection [8]. This makes it different from the hands, which are often in direct view, and represent perhaps the most studied skin site. At the same time, however, it is undoubtedly the most important visible site contributing to interpersonal communication [9]. The facial appearance (of the skin) also plays a hugely important role in determining ratings of a person's attractiveness, healthiness, age, etc. (e.g., [10–12]*; see [13] for a review). This is all the more important given the extensive body of research linking physical attractiveness with personal success [14, 15]. Indeed, the face has been described as: "the hallmark of our identity" ([16], p. 1). The critical role of the face as a skin site is also highlighted by the relative market size for skincare products, with facial skincare worth an estimated five times more than the market for body lotions and creams in Great Britain in 2022 [17], despite the much smaller total skin area covered.

While people often touch their face (e.g., as when applying creams, lotions etc., direct to their skin), it is not immediately clear whether people feel the skin of their face or rather are aware of their fingertips instead [18]? There are several relevant factors to consider here, including the shorter transduction latencies from the face to the brain than from the fingertip [19, 20], not to mention the question of whether an applicator of some sort is used to apply the product. The latter has also been shown to influence tactile perception [21]. Thermal changes on the skin surface due to the evaporation of a recently-applied cosmetic product, say, may also provide a salient temperature cue that can capture a consumer's tactile attention automatically (see [22]; though see also [23]).

In this narrative historical review (see [24, 25] on the strengths and appropriateness of such reviews), the literature concerning the multisensory perception of the skin on the face is summarized. In particular, this review highlights the differences in perceiving facial skin with respect to several other, better-studied, skin sites (such as, for example, the hands). Multisensory influences on the perception of cosmetic creams are then considered, before evaluating what happens when such multisensory products are applied to the skin of the face. A number of potential psychological (as well as quasi-pharmacological) mechanisms that might help to explain the resulting effects on bodily perception and mood/well-being are also identified [26].

SOMATOSENSORY CONTRIBUTIONS TO SKIN FEEL

The receptor organ for the sense of touch is the skin. The average adult male has around 18 000 square cm of skin, constituting an estimated 16%–18% of his body weight [27]. The skin intermediates between the external world and the primary somatosensory cortex helping to construct a mental representation of the body [2, 28]. Neurophysiological evidence has established the existence of somatosensory maps connecting mental body representations to afferent inputs: These somatotopic maps describe a three-way relationship between the size of the receptive fields (RFs), the extent of representation in somatosensory cortex, and tactile acuity [28, 29]. Importantly, skin regions such as the lips and fingertips have a much larger somatosensory neural representation, while other parts such as the face region with larger RFs, and smaller representational area on the cortex, exhibit lower tactile acuity (see Figure 1).

The skin contains a wide range of receptors coding for vibration, pressure, temperature, pain and, as has been uncovered recently, pleasure, as a result of the slow stimulation of the C-tactile afferents, the nerve receptors that generally respond to non-painful stimulation, such as, for example, light touch [1, 5]. Intriguingly,

*One article was even entitled 'You're only as pretty as you feel: Facial expression as a determinant of physical attractiveness.' [12].

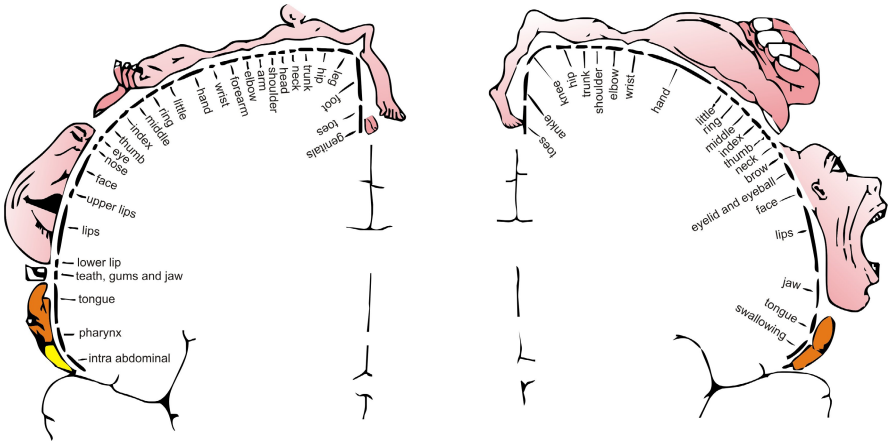

FIGURE 1 The Penfield Homunculus: a visual representation of the mapping of body space in the somatosensory cortex of the brain, with the size of the body representing the size of the area of cortex devoted to it, and hence the sensitivity of that region as well ([30]; cf. [31]; and [32] on the hedonic homunculus). Figure reprinted from [2].

interpersonal stroking tends to be targeted at stimulating the C-tactile afferents [33]. Is the same true for self-touch, one might ask, and what about when touching the skin of one's own face? What changes, if anything, when a hand-held applicator is used to apply a product to the skin instead [21]? Here it is worth noting that salient differences between self-touch, interpersonal touch, and external touch have been identified, especially highlighting the differences in tactile sensitivity and the emotional effects on pleasure and comfort in the literature [34–36].

Is our attention distributed differently to those body sites that are frequently seen (such as, for example, the backs of the hands) versus to those that are never seen directly [37]? Here, one also needs to consider how the sight of our hand touching our face, and moving across it when applying face cream in the mirror, may serve to capture one's visual attention [38]. Any such attentional capture might be expected to reduce the relative contribution of the non-visual senses to the perception of the action, not to mention its sensory consequences [39]. Taken together, therefore, all of these factors mean that it is difficult to predict a priori what a person's attention will be focused on, both in terms of the region of the body attended, as well as in terms of the sensory modality of input that may be prioritized, when applying a skin product to their own face while looking at themselves in the mirror.

MULTISENSORY CONTRIBUTIONS TO TOUCH

All of the senses contribute either directly or indirectly (and in a real-time, or delayed, manner) to the visual appearance of the skin, and to the haptic appreciation of skin tone. Previously, it has been shown how both contact/interaction sounds [40] as well as the presence of scent can independently influence people's perception of surface texture [41], be it of sandpaper, cloth swatches, or possibly even the perception of our own skin. At the same time, however, researchers have also demonstrated how the pleasantness of touch is influenced by everything from the presence of an ambient background odour (pleasant vs. unpleasant; [42]), through to any background music that happens to be playing at the same time ([43]; cf. [44]).

Vision

The visual cortex contains a greater neural representation associated specifically with pink skin tones than with other shades, thus facilitating the enhanced ability to discriminate subtle changes in facial blood flow (an important social signal), and so allows us to detect something about the emotional state, or arousal, of our conspecifics [9]. One might also think about blushing [45], which only occurs on the face [46–48]; this would seem to constitute another reason why facial skin should be considered somehow special in humans. Though, that said, there is still something of a crossmodal asymmetry here in that we typically feel the heat in our own cheeks while blushing, whereas we see it (the red coloration) in the faces of others [49]. So, even though we can't see our own face directly, it might nevertheless be expected that the consumer might exhibit enhanced sensitivity to, and hence their perception might be dominated by, colour cues when we evaluate the skin tone of our own face, say, as compared to the state of other skin sites?†

†Note how this visual relevance is much more pronounced than on the hands, say, where the vast majority of the multisensory perceptual research has been conducted [2].

Elsewhere in the field of cognitive neuroscience, researchers have demonstrated that the type and magnitude of sensory dominance depends, at least to a certain extent, upon the region of space in which stimuli are presented [50]. As such, one might wonder whether the kinds of crossmodal influences on the perception of the skin that have been documented to date (which have primarily been on the hands to date; see [2]) would necessarily be replicated on the face. Meanwhile, it is worth considering whether the visual cues contributing to tactile sensations in facial areas come from interpersonal interactions, particularly from the social responses of others (mirroring). Affective touch has been shown to enhance self-face recognition during multisensory integration [16]. Synchronized interpersonal multisensory stimulation also influences affective judgements about the face that is seen, including evaluations of greater attractiveness and trustworthiness [51]. Taken together, therefore, the results of studies such as these highlight the importance of the visual cues involved in social interactions to the multisensory perception of facial skin.

There is a separate line of empirical research demonstrating that visual signs of redness (i.e., irritation) can enhance perceived itch (cf. [52]). In fact, it is even possible to reduce the physical swelling of the skin (of the hand) in chronic regional pain syndrome (CRPS) patients simply by having them view the movement of their own affected limb through a minifying lens (see [53]). Such results clearly demonstrate the sometimes profound physiological effects that visual stimulation can have on body/skin perception, and even on our physiology (see also [54], for a particularly striking example). Meanwhile, simply viewing the relevant body part can significantly enhance tactile acuity [55]. For instance, the participants in the latter study exhibited enhanced tactile acuity for the forearm when viewing the stimulated body-part, compared to viewing an object placed in the same position or else being blindfolded. This effect has now been replicated in a series of follow-up studies [56–58], also controlling for possible confounds related to the distribution of an individual's spatial attention.

Sound

The crossmodal influence of the sound made when rubbing our hands together on perception of the skin is known as the 'parchment skin illusion' [40, 59]. Changing the loudness, and/or boosting/cutting certain sound frequencies, while people rub their hands together dramatically changes their perception of how moist/clammy versus dry/parched their own hands feel. Note that such crossmodal effects are time-locked to the synchronous presentation of sound and tactile stimulation, arguing that they reflect a genuine multisensory integration effect, rather than some form of crossmodal priming (cf. [60]). It would be an interesting question for future research to determine whether the same illusion would also be obtained were the sound of one of our hands touching our face to be boosted instead; And, were such a crossmodal influence on skin-feel to be observed (as it presumably would), whether it would apply equally to the skin of the hand doing the touching and the facial skin that is being touched?

An even more striking version of this illusion, known as the 'marble hand illusion', was reported by Senna et al. [61]. In this case, the sound of marble being tapped was presented as the participants' own skin was tapped by the experimenter. Remarkably, many people report that their own skin starts to feel somehow 'marble-like'. Note here that the majority of our actions generate sonic cues which, though often not noticed, can nevertheless still influence our perception of our own bodies (see [62], for a review).

Scent

A large body of scientific research published over the last half century or so has demonstrated that scent, seemingly no matter what the source (i.e., ambient or personal), can influence people perception – both our perception of ourselves but also, and more frequently studied, our perception of others (see [13] for a review). Judgements of facial attractiveness, gender, affect, and also age (albeit to a lesser extent) have all been shown to be influenced by olfactory cues. However, one of the striking (and perhaps counterintuitive) points to emerge from the research that has been published to date is that it does not seem to matter how the scents are delivered, nor to what source they happen to be attributed (if any) for robust crossmodal effects to be observed (see [13, 63] on this point). While much of the research on (multisensory) attractiveness published to date has addressed the role of scent on people's perception of others (see [13] for a review), a few studies of self-perception have appeared in the literature. For instance, one study demonstrated enhanced self-confidence in a group of young men who had worn a scented body spray/deodorant for 48 h as compared to those who had not [64].‡ In this case, the difference was apparent to a group of women who evaluated short videos made by the men (though the effect was not apparent from static photos).

‡At this point, one might consider whether it ought to be harder to modify the perception of the self than of other people, given the much greater lived experience we have of ourselves, as compared to others (cf. [40]).

Previously, researchers have demonstrated that wearing a scented face mask (e.g., incorporating the scent of pink grapefruit) can lead to other people seen visually being perceived as 'looking' younger (e.g., [65, 66]; though see [13], for a critical appraisal of the evidence on which this particular patent claim appears to have been based). At the same time, however, none of the crossmodal fragrance research that has been published to date has yet attempted to assess the role of ambient/personal scent (i.e. as opposed to product scent) specifically on the perception of the skin (e.g., of the face) rather than on general ratings of (facially-assessed) attractiveness, age, health, etc. As such, this also represents an intriguing area for future research.

Scents crossmodally influence tactile perception. However, compared to other crossmodal correspondences (e.g., between vision, touch, smell, and taste), the correlation between tactile perception and odour is, seemingly rather more indirect. For instance, Demattè et al. [41] demonstrated that the presence of a pleasant versus unpleasant fragrance exerted a significant impact on the perceived softness of cloth swatches evaluated in a psychophysical study, as well as in on-street testing. Elsewhere, however, Koijck et al. [67] failed to demonstrate a significant crossmodal effect of scents on the perceived tactile roughness of sandpaper. Here, though, one might consider whether the crossmodal interaction between scent and tactile perception depends on the interconnectedness of the sensations; After all, most people presumably do not necessarily expect sheets of sandpaper to smell, unlike, clothing after the wash, or the skin after the application of a fragranced skincare product.

Gustation

Surprising though it might seem, fruit and vegetable consumption can beneficially affect the visual appearance of the skin. In particular, Tan et al. [68] reported that the daily consumption of a fruit and vegetable smoothie (for a period of 6 weeks) altered facial skin colour at 4 weeks. The results revealed a large increment in skin yellowness, and a small increase in skin redness. The suggestion in this case was that the carotenoids that are mostly found in fruit and veg. (and which cannot be synthesized in the body) end up being deposited in skin thus resulting in a yellower appearance as a result (in this case in an Asian population of Malaysian Chinese participants).§ Meanwhile, French researchers have recently demonstrated both chronic and immediate effects of consuming refined carbohydrates on facial attractiveness [69]. The researchers suggest that their results may have been mediated by an increase in age appearance for women and a decrease in perceived masculinity for men.

Interim summary

Taken together, the evidence that has been published to date demonstrates that the perception of facial skin is both highly multisensory but also potentially importantly different from what has been documented to date at other skin sites. Indeed, much the same point has been made by Duncan et al. [70] who noted recently that texture perception is a fundamentally multisensory phenomenon (see also [71] for a review). Note here also how the sound of application, and of rubbing the skin, not to mention smelling any associated scent, are likely to be more perceptible for the skin of the face¶ than for those other skin sites (such as, for example, the feet) that happen to be situated further away from the ears and nose. However, to date, the combined effects of scent and sound of skin cream application on people has yet to be studied. It would, for example, be interesting to investigate whether combining such cues in a congruent manner would lead to additive, or even superadditive, effects on perception [73]. The link to the extensive literature on the well-being effects of aromatherapy massage should be noted here [63, 74] – though, of course, in the latter case, tactile stimulation tends to be more prominent, and it tends to involve interpersonal rather than necessarily self-touch (cf. [34]).

Skin perception is fundamentally multisensory; In fact, the non-tactile senses (somewhat ironically) may actually exert a more pronounced influence than the skin senses or somatosensation. Indeed, the receptors in the skin more often do a better job of telling us about the material qualities of external surfaces and objects (see [75], for a review).** At the same time, however, while our skin may well feel like a continuous and uniform surface, the research shows that the underlying physiology and phenomenology is actually quite different, not just in terms of its sensitivity, but also in terms of the quality, and affective tone of the resulting sensations when different parts of the skin surface are touched ([77, 78]; see [2] for a review).

§Importantly, this change in skin appearance may also have a dermo-protective effect.

¶Note that the same argument can also be made in relation to multisensory haircare products [72].

**Note that touch is the only one of our senses where we can shift our attention between what we feel and what is being felt [76].

Before closing this section, it is worth noting that as many as half of the population in Europe complains from sensitive skin [79, 80]. At present, however, it is unclear what role multisensory interactions may play in contributing to sustaining, or potentially ameliorating, the condition. Although such complaints are by no means restricted to the face [81], some individuals report that their condition can be triggered in by the application of skin creams and lotions.

COSMETIC PRODUCT-SKIN INTERACTION

There has long been commercial interest in the addition of fragrance to a range of Home and Personal Care (HPC) products [82–88]. Below, we focus on cosmetic products and take a closer look at both the tactile (somatosensory) and multisensory contributions to the feel (and appearance) of skin creams and lotions. The focus is primarily on the sensory and emotional nature of the underlying effects.

Tactile properties of cosmetics products

Several research groups have developed descriptive analysis methods specifically for skincare products in both trained panels and amongst regular customers [89–91]. Relevant descriptors that have emerged from such research include terms such as: Appearance, pick-up and rub-out, residual appearance, and tactile feel; Gloss, wetness, spreadability, sticky (afterfeel), slipperiness (afterfeel) have also been identified as relevant descriptors by those working in this space. For, as Civille and Dus ([90], p. 83) note: "Understanding the tactile feel of lotions, creams and cosmetics in the hand and on the skin requires a valid and reliable sensory evaluation method which discriminates and describes textural properties." Researchers have also been working to develop a lexicon of affective touch descriptors [92]. Understandably, there has been much interest in trying to predict the sensory properties of the emollients used in cosmetics and their correlation with physicochemical properties [93, 94]. One of the challenges to bear in mind though when working in this area is that skin care products are different from most other tactile stimuli in that they can actually alter the physical properties of the skin, such as by increasing its hydration [22, 95, 96]. Of course, it should be noted that these tactile impressions of a skincare product and its interaction with the skin are likely to reflect the integration of multisensory cues, as has been demonstrated in the case of stickiness perception [97, 98].

Research on the tactile properties and perception of skincare products differs from other stimuli in that the tactile experience of skincare products may depend on, or be altered by, subjective differences in the application of the product to the skin. On a related note, the Kao Co. in Japan conducted several studies to examine whether simply adopting a more pleasurable skincare routine could help improve the effectiveness of skincare products on the skin's appearance [99]. Female customers were instructed to touch their facial skin softly with the palms of both hands for 30 s, remove their hands, and rest for 30 s, after completing their daily skin care routine. The results showed that by generating more pleasurable sensations through tactile stimulation (e.g., covering the face with the palms of the hands) during the skincare routine, the body's oxytocin levels were elevated, and skin conditions (skin texture, uniformity of skin tone, radiance, and smoothness) also improved. Warmth from the palm that helps the absorption of the product or the massage-like tactile stimulation that benefits the effects of the facial treatment [100, 101]. Nevertheless, the pleasantness of facial touch is certainly worth considering as part of the beneficial effects of a cosmetic experience that involves self-touch.

Separately, there is obviously also a question as to what effect such products, once applied, will have on the rheological properties of the skin itself ([102–105]; see [22] for a review). Guest et al. [22] have provided an extensive review of the research in this area focusing, in particular, on the perceptual and sensory-functional consequences of skincare products. Other researchers, meanwhile, have conducted rheological studies to objectify sensations occurring when cosmetic emulsions are applied to the skin [106–108]. One other point to note here concerns the likely crossmodal effects of the feel of the product packaging itself on the customers' experience of the product itself ([21]; and [109] for a review).

Multisensory contributions to perception of products

Just like the perception of our own skin, the perception of the feel of cosmetic products is a fundamentally multisensory phenomenon, and the scent, visual appearance, etc. of the product are likely to impact the customer's experience. Here we are reminded of Neff's [110] suggestion that the most successful new products should appeal at both a sensory and emotional sense to as many senses as possible. Fragrance and colour are clearly both crucial sensory attributes of cosmetics products and, by default, the most frequently explored aspects [111, 112]. Indeed, many products are often rated as more appealing once a pleasant fragrance has been added to the

formulation [113], though such fragrance in most cases is, of course, unlikely to be directly relevant to maintaining the integrity of the skin itself.

At a basic level, the incorporation of scent may serve both to eliminate malodour, as well as present a pleasant odour that helps to enhance the user's mood and/or sense of well-being [114]. One particularly interesting example of the use of fragranced products is in the case of scented face creams, given the proximity of the product's application site to the nose. The incorporation of a relaxing scent may help to relax the customer, when the scented product is applied to the face, and by so doing, temporarily smooth the visual signs of wrinkles [115]. Indeed, over the last couple of decades, a relevant literature has started to emerge on the role of fragrance on the perception of cosmetic products [116, 117].

Importantly, the presence and type of fragrance has been shown to influence the sensory perception of cosmetic formulations [118]. Researchers have looked for potential correlations between specific odours and textures in the context of cosmetics products. For instance, Kikuchi et al. [119] found that lip balm was perceived as being smoother when scented with lemon than when scented with vanilla. The presence of an unpleasant scent has also been observed to decrease the pleasantness of the touch of a brushstroke [42]. Clearly, the diversity of scents and textures that have been used in the research that has been published to date has added to the difficulty of examining the interaction between these two senses.

There is research to suggest that more than merely the presence of odour itself, it may also matter whether the scent happens to be congruent with the other sensory attributes of the product. Directly related to the question of the importance of scent-texture congruency, Bourdier et al. [117]†† recently conducted a study to examine whether a specific cosmetic texture was preferentially associated with a particular fragrance and showed that such fragrance-texture congruence positively influenced the user's appreciation of the product as well as their well-being when compared to an incongruent sensory pairing. More specifically, their results showed that high touch/smell congruence (determined on an individual basis) was positively associated with “pleasure” and “comfort” scores for cream products and skin-gel-based products. This congruence effect was moderated by product familiarity,‡‡ with the increasing times of product use modifying both congruence and pleasure ratings ([117]; See also [121]). Real-life use influenced congruency and appreciation of these products. Skin cream and skin gel with a range of fragrances that were assessed by individual participants in terms of their congruency with the texture of the product. The 19 participants who took part in the home-based part of the study had two fragrance-texture combined products: 1-week of daily use and pre- and post-assessment of product appreciation and well-being; However, no effect on participants' mood was reported.

When it comes to the evaluation of cosmetics products, vision, touch and smell are considered the major senses and they crossmodally interact with each other to influence the multisensory perception process. Looking at the crossmodal influence of vision and smell, Barkat et al. [111] conducted a study on the odour and colour of cosmetic products measuring both the subjective judgements and autonomous nervous system response measures. Lipsticks and nail varnishes were presented in a range of colours (white, brown, red, orange, and pink) and odours (cf. [122]). The results revealed that adding odour to cosmetic products can considerably enhance the appeal of a product. In particular, the positive effect of fragrance was stronger in the case of lipstick than for nail varnish. The rose and strawberry perfumes added to the pink varnish and the red lipstick, respectively, were the preferred combinations as rated by the group of female participants who took part in the study. Meanwhile, in another study, Turek [123] demonstrated that simply adding colour to a face cream can lead to enhanced product ratings amongst consumers.

Several researchers have argued that the crossmodal interaction between smell and touch can together modify the hedonic perception of cosmetic products ([42, 124]; cf. [125]).§§ In one of the most impressive studies to have been conducted to date, French researchers conducted studies in the lab and at-home. Crossmodal interactions between olfaction and touch affecting well-being and perception of cosmetic creams [124]. Unfragranced, low fragrance, and normal fragrance level versions of the products were evaluated on the face and on the arm. The results clearly demonstrated the importance of the olfactory component on textual perception of skin care products. Two experiments were conducted in France and two in China. The female participants were either encouraged to try the creams on

††They argue that touch and smell are key in cosmetic product evaluation.

‡‡At the same time, however, one might also wonder about what role habituation to an odour plays in terms of reducing any impact of olfactory cues on multisensory product perception [120].

§§Elsewhere, it has been shown that the weight and colour of HPC product packaging significantly influence perceived fragrance intensity and expected product efficacy [126, 127], providing extra evidence to the multisensory crossmodal influence of vision, smell and even touch (weight sensation).

their hand, as it they were testing them in the store, or on their face, to imitate an at home facial skin care routine. Both odour and texture had significant effects on well-being, liking, and Just About Right ratings. Although the results varied by country and skin site stimulated, cream with added odour generally increased reports of well-being, global liking, and texture (and sometimes also affected texture ratings of face cream itself) (see Table 1 for a summary of results).

Crossmodal congruency

As the results reviewed in the preceding section make clear, crossmodal congruency appears to play an important role in the consumers' appreciation of multisensory skincare products, be it the congruency between scent and touch [128], or else between fragrance and vision ([129]; see [130], for a review). Ultimately, of course, it is important to recognize the fact that crossmodal congruency operates between multiple senses as well as at multiple levels (e.g., sensory, emotional, and conceptual; [130]). Here, for example, one might consider how the congruency between scent and gender fits in [128, 131]. Crossmodal congruence between multiple senses is one way to understand how one modality, such as smell may crossmodally influence the perception of touch despite being unrelated. As with other crossmodal congruency findings, those products that present crossmodally congruent sensory attributes/impressions (and which are thus processed more fluently by consumers) are likely to give rise to the most hedonically-positive product experiences. Generally speaking, the more harmonized, or congruent, the sensory cues the better, and the more fluently the customer will be able to process the multisensory product proposition. While the former phenomenon is generally referred to as crossmodal congruency [130], the latter is known as 'processing fluency' [132]. What counts as congruent is generally considered to result from prior associative learning between the relevant sensory elements. That said, there may also be a more semantic, object-based, basis for certain of the crossmodal correspondences that have been documented to date.

Sonic factors

The sonic properties of cosmetic products have rarely been explored experimentally. In the case of beauty products, there is little evidence of the contribution of sound to the overall perception and appreciation of the product. Nevertheless, Guest et al.'s [40] work on the parchment skin illusion would appear to suggest that the impact of a facial cream on the skin might be influenced by the sonic qualities of the user's interaction when rubbing/feeling their skin after the application of a product. Such considerations might link to the question of what impact the actual application of a skincare product has over-and-above the evaluation of the product in its packaging? Meanwhile, Romagny et al. [133] have recently provided new perspectives and possibilities for studying sound in cosmetic products, showing a clear perceptual difference between lipstick closing sounds and no strong cultural difference between France and China. Moving beyond, the sensory qualities of the product itself, the sound of opening, as well as the sound (and feel) of the packaging are also important. For example, the sound of using (e.g., spraying) HPC products has been shown to affect their perceived efficacy [134].

Cognitive factors

As well as the multisensory properties of the cosmetic product itself, there are also various semantic/branding related effects that should be considered. According to the results of one intriguing study, those participants who were told that they were applying a "rich moisturizing" skin cream rated it as more pleasant than a "basic cream." Furthermore, this subjective difference was also reflected in functional magnetic resonance imaging (fMRI) activations to touch in parietal cortex area 7, the insula, and the ventral striatum [135, 136].¶¶ The label effect highlights the top-down cognitive influences on tactile perception. Meanwhile, it is also easy to imagine how branding might affect the consumers' emotional response to perfumed skincare products [138, 139]. Branding information is presumably likely to be much more salient in the mind of the consumer when they are using a skincare product that they have purchased than in the typical laboratory study where all branding is eliminated to focus solely on the sensory properties of the product. Ultimately, therefore, a remarkably wide range of factors, both sensory and more cognitive, have been shown to influence the pleasantness of touch [43, 140–142].

¶¶Another fMRI study compared the response of sensory areas during a passive touch, either after application of a cosmetic product on the skin or when the skin alone was touched [137]. The first procedure activated different sensory areas in the brain than the second, but the responses of emotional areas were not examined.

TABLE 1 Summary of published studies that have assessed the impact of the multisensory properties of skincare products.

Study	*N*	Stimuli, sensory manipulations, and purpose of research	Experimental methods	Results & Comments
Barkat et al. [111]	20 female M_{age} = 47 years	Lipsticks and nail varnish of different colours: brown, red, orange, pink, and white (control) and each associated with two different odours Purpose: • Correlation between subjective psychophysical judgements and psychophysiological measures • Goodness of match between colour and odour	Psychophysiological measurements and psychophysical assessment Within-group design	Arousal power of perfumed cosmetics is stronger than that of the odourless product. Combining congruent odour to a colour cosmetic product make its pleasant power increase. Psychophysical and psychophysiological results not significantly correlated.
Gonçalves et al. [118]	50 participants of both genders	Cream forms: Cream versus gel Fragrance: Floral versus fennel versus fragrance free Purpose: • How different fragrances affected skin feel, tackiness, and spreadability of cream	Affective testing of products Cream and gel conditions were between-group	Cream formulation with fennel fragrance received the highest number of positive comments.
Kikuchi et al. [119]	20 female M_{age} = 22 years	Lip balm with different fragrances: lemon versus vanilla versus control Purpose: • Influence of olfactory impressions on the perceived effects of lip balm	Subjective ratings Within-group design	The balm with lemon essence rated as significantly smoother than the ones with vanilla or without natural essences. The balm with vanilla essence rated as significantly stickier than the ones with lemon or without natural essences.
Courrèges et al. [124]	Study 1: 60 French women M_{age} = 47 years	Face cream texture: High (HV) versus low viscosity (LV) Face cream odour: Base, standard fragranced, half standard fragranced Purpose: • The interaction of cream viscosity and odour in skin care product evaluations	Hand application Within-group design	Added odour increased well-being, liking, oiliness, and ratings of opacity of cream.
	Study 2: 60 French women M_{age} = 45 years		Face application Within-group design	Liking was higher for LV cream. HV cream was rated to be too oily and opaque. Added odour increased liking.
	Study 3: 65 Chinese women M_{age} = 41 years		Hand application Within-group design	HV cream was rated to have higher well-being compared to LV cream. Added odour increased liking.
	Study 4: 65 Chinese women M_{age} = 42 years		Face application Within-group design	For unfragranced conditions, HV cream was preferred; for standard fragranced conditions, LV cream was preferred.
Gabriel et al. [149]	15 female	Two compositions with aqueous continuous phase containing a low amount of oil and having a similar consistency Purpose: • Testing EEG as a tool evaluating emotions while applying cosmetic product on the skin	EEG measurement Within-group design	Emotional valence towards cosmetic products detected using EEG.

(Continues)

TABLE 1 (Continued)

Study	*N*	Stimuli, sensory manipulations, and purpose of research	Experimental methods	Results & Comments
Bourdier et al. [117]	24 women and 5 men	Textures: cream/skin-balm – solid; skin-gel/dry oil – liquid; skin- gel/cream – aqueous; dry oil/skin-balm – oilier Fragrances: six fragrances each representing one olfactory family • Fruity: grape • Green: Bamboo • Citrus/Woody: Bergamot • Spicy/Food: Coffee • Oriental: Date • Floral: Freesia Purpose: • Crossmodal congruence and sensory pleasure	Free description and home use evaluation	Crossmodally congruent products result in the highest hedonic response. Real-life use or familiarization with a product can influence not only the degree of crossmodal congruence but also overall cosmetic product appreciation.

MECHANISMS UNDERLYING MULTISENSORY SKIN PERCEPTION

Several potential (non-exclusive) mechanisms might be at play as far as explaining the influence of applying a fragranced cosmetic facial product on people's self-perception is concerned. Jellinek [143] outlined several putative mechanisms by which odours might exert their effects on the human psyche, including: The *quasi-pharmacological mechanism*, quasi-pharmacological because the concentrations of substances entering the organism through nasal mucosa, lungs, or skin are much smaller than the usual pharmacological modes of application; *The semantic mechanism*, whereby odours that happen to have been associated with emotional encounters previously may subsequently come to trigger (or prime) the associated emotion when presented again (e.g., in isolation; [144]); *The hedonic valence mechanism*, the suggestion here being that odours affect hedonic valence (though it is somewhat unclear whether this should be thought of as referring to the hedonic valence of stimuli, such as a skin cream, or the state of the consumer that Jellinek is referring to; [145]); and finally, *the placebo mechanism*, where the effect depends on what people have been told, or believe about an odour [13, 146].***

Several studies have attempted to look at autonomic system (physiological) activity in response to the presentation (and/or application) of fragrance and fragranced products [111, 116, 147–149]. For instance, an electroencephalography (EEG) study by Lombardi and Ratti [150] demonstrated differences in various mental states (i.e., engagement, excitement, frustration, and meditation) after the application of three lip balms with different emollients. At the same time, however, a large body of research has shown that ambient scent can affect people's mood as well as their sense of well-being ([23, 74, 151] for reviews; see also [152]). Note that when people are in a better mood, they tend to give elevated hedonic ratings in general, including presumably, concerning skin/product perception [143, 149].

Certain scent may influence a person's mood/well-being, while others may exert more of a semantic role, by priming associated thoughts and feelings [143]. Particular scents may also perhaps be associated with older people (or historical situations; think of the scent of patchouli, or the smell of Palma violets) nowadays, or how the smell of lilies has been suggested to remind elderly individuals of funerals; [153]. One might consider this as an example of the Proustian memory, and links to the literature demonstrating the impact of olfactory cues in triggering autobiographical memories [154]. Neuroimaging research has demonstrated

***Note that branding can be thought of as a kind of placebo effect.

that the representation of facial attractiveness that exists in the orbitofrontal cortex (OFC) can be modulated by the presentation of a pleasant scent [155, 156]. Such results therefore imply a genuine perceptual/affective component to the crossmodal effect of fragrance on facial attractiveness, too. It remains an open question, though, as to what proportion of the lift to attractiveness ratings, or the small reductions in rated age that have been documented in the literature [157], are specifically attributable to olfaction's influence on the perception of the skin of the face itself, rather than to a more holistic judgement of the face.

CONCLUSIONS

As highlighted by this narrative review, the application of a cream or lotion to the face is a very complex and multisensory interaction, and is thus difficult to model empirically, given the sensory, cognitive and emotional factors that are at play. Nevertheless, the research outlined here clearly demonstrates that the skin of the face is different from other parts of the body surface in several important respects: It is one of the skin sites that we do not see directly (cf. [37]), and which has long served an important signalling function [9]. The face plays a key role in terms of influencing judgements of a person's attractiveness [158–161], though see [64], their health [162, 163], their emotional state [9], and even their age ([157]; see [63], for a review), although, as was noted earlier, the latter effects would appear to be somewhat weaker.

There is a growing recognition of the benefits associated with the sensorial, as much as with the functional, properties of cosmetic skincare products ([164, 165]; see Table 1). The research also emphasizes the importance of optimizing the crossmodal congruency of scent, visual appearance, and texture, for those wishing to deliver the best multisensory product experience (one that appeals at both a rational and emotional level; [110]), along with potentially beneficial effects on the customer's self-perception, their mood, and even their sense of well-being [164]. Researchers have recently developed means to measure any individual differences in active smelling when evaluating products [166], and such individual differences in the need for smell may represent an intriguing possibility for effective market segmentation in the years ahead.††† There is also growing interest in the role of neurocosmetics‡‡‡ in skincare (see [170] for a review). To measure the emotional satisfaction of consumers' more objectively, researchers have started to combine neurological measurements with deep learning method to recognized consumers' emotional responses to cosmetics and skincare products [171, 172]. Neuromarketing and consumer neuroscience are likely both going to become more important approaches to research and marketing in this area in the years ahead [173]. At the same time, however, although improved autonomic/electrophysiological measures have been developed by researchers over recent years, it nevertheless still remains unclear whether the most useful (and practical) results come from such novel objective measures, from more traditional methods of subjective report, or perhaps from some combination of the two approaches depending on the specific question that is being asked. Furthermore, it remains an intriguing question to consider the extent to which different methods may help to determine the relative contributions of the different mechanisms that have been put forward to explain the various effects attributed to the application of fragranced facial skincare products. At the same time, it also makes sense to remain mindful of the possible influence of task demands, context effects, and experimenter expectancy effects in the behavioural phenomena that have been documented to date [174]. Future research should also further investigate the impact of cultural background on the crossmodal influence of scent (cf. [175]). The role of fashion trends, if any, might also be an area that merits further study.

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CONFLICT OF INTEREST STATEMENT

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†††It is perhaps also worth considering how this relates to the Need for Touch (NFT) scale that has been developed in the marketing literature over the last couple of decades [167–169].

‡‡‡Neurocosmetics are defined as nontoxic, bioactive topical products that contain ingredients that are designed to work neurologically, with Schinus terebinthifolia extract and Sacha inchi oil (Euphoryl™ O3) currently considered as functional neurocosmetic ingredients.

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