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Review Article

Recent developments in the sensorial assessment of cosmetic products: a review

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Synopsis

Cosmetic development is not exclusively guided by notions of rational effectiveness but also by notions of sensoriality. Thus, the sensorial properties of a cosmetic product are studied using internationally recognized discriminating or descriptive methods. Descriptive sensory profiling is an essential tool in this process as it allows an experienced panel to assess the qualitative and quantitative characteristics of a product. The results obtained with this method enable to get a more accurate image of the product. However, given the new demands of the industrial world and the new innovation paths (shorter development times, complex products or willingness to include the consumers in the process) a need to access new methods has arisen. These 'alternative' methods that offer product positioning, ratings and attribute citation frequency, can be implemented with either a panel of experts or with consumers. The flash profile, the pivot® profile or the check all that apply (CATA) are just a few of the methods that the cosmetic professionals have started to test. This article reviews the methods used in the sensory assessment of cosmetic products. The analysis carried out shows that the complementarity application of sensory assessment is essential in the upstream innovation phase of a product.

Résumé

Le développement des cosmétiques n'est pas guidé exclusivement par des notions rationnelles d'efficacité et de sécurité mais également par des notions de sensorialité. Ainsi, les qualités sensorielles des produits cosmétiques sont étudiées au moyen de méthodes discriminatives ou descriptives reconnues internationalement. Le profil sensoriel descriptif est l'outil essentiel de cette démarche puisqu'il permet l'évaluation des caractéristiques sensorielles qualitatives et quantitatives d'un produit par un panel entrainé. Les résultats obtenus par cette méthode permettent d'obtenir une image sensorielle très précise du produit. Cependant face à de nouvelles exigences du monde industriel et des nouvelles voies d'innovation: temps plus court de développement, produit complexe ou volonté d'intégrer les consommateurs dans le processus, un besoin a émergé pour avoir accès à de nouvelles méthodes. Ces méthodes dites alternatives proposent des positionnements produits, des classements, des fréquences de citation des attributs, elles peuvent être mises en place avec des panels experts ou des consommateurs. Le profil flash, le profil pivot® et le check-all-that-apply (CATA) sont autant de méthodes que les professionnels de l'univers cosmétique ont commencé à tester. Cette revue fait le point sur ces méthodes appliquées dans l'évaluation sensorielle des produits cosmétique. L'analyse effectuée permet de montrer l'intérêt de la complémentarité de leur utilization pour les phases amont d'innovation produit.

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Introduction

The cognitive process put in place when consumers interact with a cosmetic product can be divided in two key steps. First, the consumers perceive the characteristics of the product, that is colour, perfume and texture, through their sensory system. This information is then integrated so that the consumers, through this physiological process, can identify a symbolical value or feel a positive emotion [1]. Therefore, a sensory assessment of these products is a prerequisite to accepting or rejecting them. Many cosmetic companies spend a considerable part of their budget on developing new products that will be better adapted to the needs and desires of the consumers [2]. Companies capable of developing discriminating products with regard to the sensory system, as well as carrying out studies adapted to this problematic can create a significant competitive advantage and thus stand a better chance of success [3]. Consequently, the methods that allow the assessment of sensations are essential to guarantee that a product will be successful on the market.

There is a wide array of literature on the characterization of sensory cosmetic product attributes [4–6] as well as on global product appreciation [7]. In practice, subjects trained to qualify and often quantify sensory attributes are asked to describe the products studied. The standard sensory method used for this application is the quantitative descriptive profiling, which allows to obtain accurate sensory images of the products [8]. The results obtained with this method can be compared with those obtained with a product preference study: a preference mapping that links the sensory attributes to the consumers' hedonic expectations can be drawn up [9]. Nowadays, the quantitative descriptive profiling method is widely used to validate the formulation from the product development process. However, there are limitations, as the time to train the panel. Due to these critical points, this method cannot always be used in the upstream product development phases despite it being very helpful in the innovation process. Searchers have tried to suggest

alternative methods by pointing out other considerable weaknesses, such as the list of fixed attributes or the need to have a panel trained on the latter. Indeed, some authors think that using a forced common language can considerably deplete the sensory information of a product universe. Since 1984, alternatives to the quantitative descriptive profile [10] have allowed to avoid this pitfall as the operating method allows each subject to create one's own list of attributes. In a study carried out in 2006 on a lip balm [11], the formulation ingredients were successfully screened using a free profiling method. This demonstrated that less time is required at the beginning of the development phase to select and validate the sensory attribute lexicon when using a free profiling method. It is also interesting to note that over 20 years separate the publication of the 1984 free profiling and the 2006 study, as today development times are shorter and subjected to fiercer competition. Therefore, it is essential to use faster methods that can integrate the consumers' needs: the new sensory methods. These new methods have been reviewed in recent articles or books [12–14]. As these methods often result from new developments of former methods, they can be somewhat complex to present. Some of these methods, as well as a brief definition, are presented in Table I. The napping method [15] and the polarized sensory positioning [16] are both issued from the free sorting method, that is the association of products with seemingly discriminating sensory attributes for the panellist. Methods that aim at showing the similarities between products are often non-verbal methods. The flash profile [17] and the pivot® profile (Thuillier 2007) are both derived from the free profiling method as the panellists are free to use their own sensory attributes for comparative purposes. The last method, the check-all-that-apply (CATA), is essentially used with consumers who are presented with a list of attributes that can be selected once the consumers think these match the product being studied.

A thorough description of these alternative methods, instead of the conventional profile, can be found in the aforementioned works. This article aims at reviewing the literature available on the methods applied to the assessment of cosmetic products: the flash profile, the pivot® profile and the CATA by first giving an overview of the fundamentals of the quantitative descriptive sensory profile.

Classical quantitative descriptive sensory profile

Descriptive sensory methods have been used since the 1950s and seek to better identify all the sensations brought out when assessing each product. These methods focus on highlighting the similarities and differences between the products, assessing the intensity of the characterizing attributes and presenting these results on a sensory map (Fig. 1).

Table I Specificities of the new sensory methods

Methods	Specificities
Free sorting	Association of products with similar attributes (non-verbal)
Napping	Derived from the free sorting but takes into account the distance by placing them on a A3 sheet (non-verbal)
Polarized sensory positioning (PSP)	Compares with regard to prototypes Takes into account the distances (non-verbal)
Temporal dominance of sensations (TDS)	Temporal analysis of the dominance of the sensory attributes (non-verbal)
Flash profile	Free profile and descriptive rating (verbal)
Pivot® profile	Free profile and compares to a reference (verbal)
CATA	Qualitative descriptive analysis (verbal)

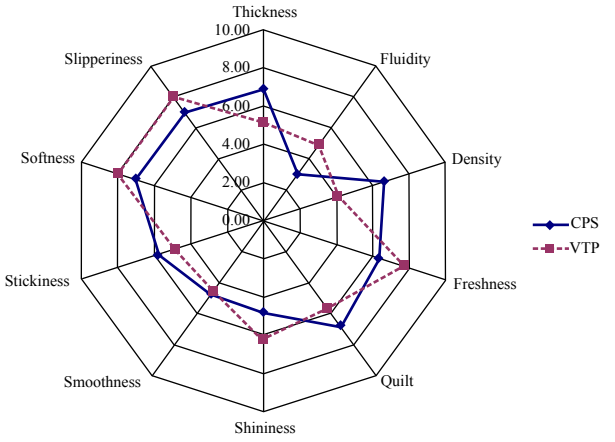

Figure 1 Sensory image of two cosmetic products [4].

Although the quantitative descriptive sensory profile is the most used [8], there are many others, some of which even have registered brand names such as QDA®, [18] or Spectrum TM [19]. Although originally developed for the food industry, the scientific community started using these methods as of the 1970s to assess the products issued from the cosmetic industry [20]. Furthermore, standards organizations, which are usually more inclined to developing methods for other sectors, have come up with guides on the characterization of cosmetic products. In the 1990s, the ASTM published the *Standard Guide for Two Sensory Descriptive Analysis Approaches for Skin Creams and Lotions*, the latest version of which was published in 2011 [21]. This organization has since completed its catalogue with guides for the assessment of shampoos [22], conditioners and deodorants. More recently, the AFNOR has published the *Application guide of the sensory analysis standards for cosmetics products* [23], which gives the methodological specificities implemented for the sensory analysis of the intrinsic characteristics of these types of products. Unlike the ASTM guide, this guide is more transversal and describes how discriminating, descriptive and hedonistic methods are implemented to assess the various products (e.g. make-up, skincare or perfume).

Regardless of the guide or publication, the various steps required to train a panel to the quantitative descriptive sensory analysis remain the same:

Step 1: choosing the product universe

Gather various products of the universe studied, so the panellists can study them. This product appropriation phase is essential to identify and characterize the sensorial diversity of a universe. According to the different authors, the average number of products is of 15–20 as the panellists can then be presented with products that have different sensorial characteristics. In a study carried out to assess the sensorial characteristics of lipsticks, there were 15 products selected: among which glosses, lip balms and lipsticks of different brands and prices [5]. In another study on nail polish,

there were 17 products, which included gels, water-based nail polish and nail lacquer [24].

Step 2: setting up the panel

Recruit enough panellists to have a robust statistical analysis of the results. The number of judges comprising the jury usually varies from 10 to 20. There are no specific jury selection criteria (skin quality: dry or greasy) as it is a product that is studied. However, the panellists must not have any aversion to the product tested [23].

Step 3: building the lexicon and referential

Create a list of terms with the panel that can thoroughly describe the product appearance, perfume or texture. Limit these descriptive terms to 15 or 20 that will complete the product universe lexicon and select the products references. The quantitative descriptive sensory profile cannot be carried out without a lexicon and a referential. The lexicon serves as a attribute instruction manual, which includes all the attributes used, their definition and how to assess them (skin preparation, application zone [21]. The reference compiles a set of samples of the different materials that represent the intensity range of the sensory perceptions belonging to the various sensory channels (tactile, visual...). This step can take hours or weeks, as it is essential to obtain a consensus on the definition of the attribute and on the reference chosen. However, existing references and validated methods can be used to save time on the preparation of the lexicon and referential, for example Le Champ des Odeurs© by Noël Jaubert used in the perfume assessment [25] or the Référentiel EBITouch© [26], which allow an efficient sensory assessment of skincare products.

Step 4: training and validating the panels' performance

Train the panellists on the attributes, their definition and their application. Have the products assessed following standardized protocols and pre-defined scales. Validate the panel's performance in terms of discriminating power and repeatability. The performance level of the descriptive panel and the quality of the data provided are vital for the marketing decisions or for research purposes. A powerful set of tools is essential to monitor the panellist's performances and the panel's performances on a whole. As the analysis of variance (ANOVA) is a very versatile statistic tool, it has been the most widely used [27] for monitoring. Even though the training and validation time of the panel vary with the complexity of the product and the number of attributes, authors agree on a duration that can range from 30 [4] to over 100 h. In fact, the panel training and the final writing up of the attribute definition are often combined in this step. Having a pre-existing referential with clear and concise definitions allows saving considerable time.

Once the expert panel trained and validated, the tests using the quantitative descriptive sensory profiling method can be carried out. Ideally, the objective of this method is to give a detailed description of the object without any hedonistic judgement. The trained panel identifies the descriptive attributes that are then quantified. So far, it remains the most performing technique to accurately characterize the sensory dimensions of a product. Some examples of its use can be found in some of the works on this subject, and Table II below presents some of the most recent examples.

When observing the examples given in Table II, it can be noted that:

- The sensory profile is carried out on raw materials to anticipate on the behaviour in the formulated product [28]
- Sensory profiles have been carried out for a certain number of cosmetic products. Besides skincare products, there is a growing number of studies on make-up products and more specifically lipsticks: generating a lexicon and reference [5], [32] or instrumental correlation [29]. These studies are motivated by the sensory performance and comfort texture provided by each of these products.
- Marketing teams use the sensory profiling method as their communication tool (soft as velvet) [31] or to define the consumer's preferences. In the latter case, the most classical approach is called preference mapping, which links the results of a sensory profile carried out by expert panellists and the hedonistic assessment of these same products by a an expert panel [9].
- There is an increasing number of instrumental correlation trials between sensory attributes and metrological criteria. The results obtained generally show that there is a partial correlation that depends on the product universe tested [29]. An instrumental technique is used to determine the physicochemical properties can lead to screening better adapted formulas while anticipating on the sensorial response. Although this method allows decisions to be made faster, a panel is still required.

Other uses of the classical sensory profile

Besides the alternative methods examined below, there are teams trying to use the sensory profile to assess cosmetic products in an

Table II Recent applications of the sensory profile to cosmetic products

Article	Conclusions
A combined approach in characterization of an effective w/o hand cream: the influence of emollient on textural, sensorial and *in vivo* skin performance	The sensorial qualities of emollients, that is the smoothness, stickiness and thickness are correlated to the sensory qualities of the formulated products. [28]
Characterization of lipsticks by sensory and texture analysis: relationships with make-up benefits	A significant breakthrough has been made to match make-up properties like the greasy effect and, more expectedly, the hardness of a lipstick with instrumental measurements [29].
Terminology development and panel training for sensory evaluation of skincare products including aqua cream	The greasy and sticky items influence the Korean consumers' degree of satisfaction [30].
Contribution of the sensorial evaluation of velvet fabric in cosmetic emulsions to the sensorial universe	Many texture attributes are common to fabrics and cosmetic products and thus allow a marketing communication in attractive sensory universes [31].

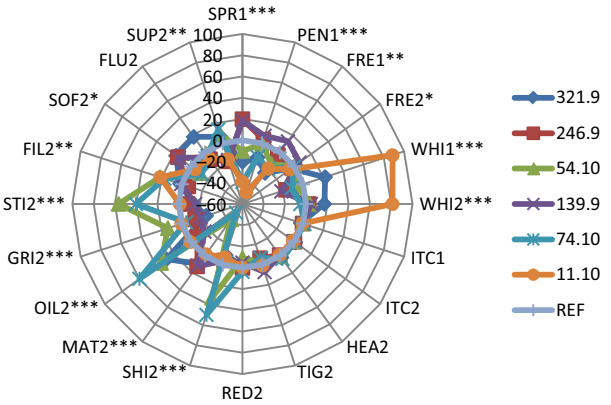

Figure 2 Sensory profiles of differences between skincare products and a reference (with regard to the reference: * = significant 5%, ** = highly significant 1%, *** = very highly significant 0, 1%) [26].

'unclassical' way by either placing the reference product in the assessment protocol or by working with consumers.

The deviation from reference method is a variation of the conventional profile, as it imposes a reference in the protocol and the panellist assesses the sensorial characteristics of the studied product with regard to this reference in a comparative randomized design [4]. (Fig. 2). For example, used in cosmetology field by I.Bacle and their collaborators, each product can be compared by pair against the reference, in half-face or half-head, during different sessions, to give profiles two by two [33]. (Fig. 2).

In the sensorial image generated by this method, the reference takes values 0 on each attribute (circle representation) and the studied products take values more or less than those of the reference (Fig. 2). This comparative method takes advantage to help the panellists in their qualitative and discriminating approach. However, it should be noted that the profile of the reference must be an intermediary one [33].

Recently, there has been a growing number of sensory profiles carried out with consumers, which require more panellists than for an expert panel (>50). L.Dreyfuss and their collaborators have recruited four panels of consumers (60 on average) for a study on ten skincare products. On the one hand, this study aimed at comparing the semantic used in each country (China, France, Italy and Portugal) and, on the other hand, at verifying the reliability of the consumer descriptions. Despite their lack of training, the four panels presented good discriminating and consensus qualities. The cross-cultural study demonstrated that there was a good discriminating quality overall but a moderate consensus [34].

In another comparative study between an expert panel (12 people) and a consumer panel (103 people) carried out for the perfume universe [35], twelve perfumes were analysed using attributes that had been generated by the panel. There were twenty-one attributes in total, among which 'odour intensity', 'freshness', 'honey' and 'caramel' are presented. The results of each panel were compared using the confidence ellipse method. These analyses demonstrated that each panel gave similar results regarding discrimination, consensus and reproducibility.

To conclude on these first studies, quantitative descriptive sensory profiles can be carried out with consumers. Indeed, despite there being more varied results, these are compensated by the number of panellists recruited. Furthermore, the method presents several benefits: it allows directly understanding what consumers perceive and is less time-consuming than a study with sensory experts.

The flash profile

The flash profile was developed as a means to reduce the long and complex protocol involved with the sensory profile by lightening it. When performing a classical descriptive analysis, the objective is to characterize and compare the products of a same universe by identifying the most discriminating attributes. The flash profile was developed mainly so the products could be positioned depending on their discriminating characteristics after a reduced number of sessions. It combines the free profiling method and a classification method [34]. With the free profile, no common attribute list is imposed on the panellists and they are therefore free to use their own words to describe the products [34]. The major difference is that the panellist will then qualify and quantify the product as in a conventional profile. With the flash profile, once the attributes have been generated, the panellists will sort the products by attributes and describe the differences between groups of products. By doing so, they highlight similar product groups in a sensory space. Directly comparing the attributes through classification emphasizes the relative differences [13].

The flash profile is organized following the steps below:

Step 1: selecting the products

In a flash profile, the judges must have access to all the products as of the first session as they are going to carry out a classification. There are usually fewer than 15 products to avoid sensorial saturation [35]. Authors generally compare 8–12 products; indeed, below 8 products, the domain is too restricted, and therefore, it is better to carry out a conventional profile, and above 12, in addition to the sensorial fatigue, it is extremely difficult to avoid assessment mistakes between the products.

Step 2: generating attributes

The judges are presented with products in the first session from which they will generate attributes that they deem the most discriminating for the product universe. They can generate as many attributes as they want, the only requirement is that they do not use any hedonistic terms. At the end of the session, the panel leader gathers all the lists to draw up an exhaustive list. The objective is not to get a consensus but to present the judges with new attributes that they had not identified [12, 35].

Step 3: assessing and analysing the results

In the second session, the judges will classify the attributes according to those deemed the most discriminating. Among the products, there can be a product repeated to verify the panel repeatability. This process is carried out by attribute and not by product.

The rank of each attribute and each product is then analysed. As the data obtained are comparable to that obtained with the free profile, similar statistical methods can be applied, the most common being the generalized procrustes analysis.

Authors strongly recommend working with expert panels familiar with the quantitative descriptive processes [36]. However, some studies present flash profile with consumers. For instance, a sensory assessment of eleven anti-ageing facial creams was carried out

using different methods: flash profile method, the classical conventional profiling method and the free sorting method [37]. For the conventional profile, there were eleven expert panellists who assessed all the sensory dimensions (odour, colour and texture) of the products: three product groups were formed. For the flash profile, there were seven panellists who generated fewer attributes and did not really take into account the odour and sensations when applying or the after feel. Despite the flash profiling and free sorting methods not being as complete in this study, they could nevertheless provide more sensorial trends for the products. Hence, the flash profiling method appears appropriate for the characterization of punctual range of products, competitive product universes or exploratory approaches linked to the conception and formulation of new products.

As with the conventional profile, nowadays, the studies are not only carried out with experts, but also with consumers. In a study, six professional experts (perfume makers) alongside eighty-nine consumers carried out a flash profile on twelve perfumes. The results showed that the consumers were able to use the flash profiling method and to generate attributes that are not hedonistic, that is freshness or intensity. However, there are fewer product groups (4 groups) than with the experts (5 groups) [38].

To conclude on the flash profile, its use is relevant in the cosmetic field when one wants to rapidly position the products with regard to their sensorial differences, as there is no need to train the panel on the attributes. Different weaknesses can be pointed out: the necessity to evaluate all the products at the same time, the impossibility to add a product afterwards and the saturation effect encountered by assessors. For the products of interest, this method will be followed by a classical conventional profile to have a more accurate sensorial characterization.

Finally, the flash profile can also be used with consumers to identify the verbatims that better characterize the product with regard to the consumer profile targeted. This can then be followed by a more precise communication.

The pivot® profile

Conventional sensory analysis techniques require fine product discrimination and potential panel repeatability. Consequently, a list of selected and validated attributes is imposed. With these techniques, the panellists are not free to choose the attributes for the product universe during the assessment phase, and therefore, the only differentiation that can be made is a quantitative one using the intensity differences. The pivot® profile, which was first developed to qualify the sensorial richness of champagne [39], allows the subjects to retain their free expression through a protocol that imposes a comparison with a reference product: the pivot. This method combines the free profile and the comparative test. It is organized as such:

Step 1: selecting the products

The pivot product must be selected within the family of products to be assessed. The selection of this pivot product is crucial issue, and it has been demonstrated through modelling [39] that the ideal pivot is a combination of all the products to be assessed. However, should it be otherwise, there should not be any significant negative impact on the quality of the description. As the products are always compared in pairs, with regard to the reference product, there is no risk of sensorial saturation, and therefore, no maximum number of products has been set. Indeed, given that there are only two products compared and that one of these products is the reference, the subjects will always remember the significance of the attributes, regardless of the duration of the sessions, and furthermore, they will not suffer any memory loss caused by an in-depth expertise [39]. No minimum number of product has been set either; indeed should there be only 2 products then one will have to be considered as the pivot and vice versa (the enumeration will then be reversed) to allow a multidimensional representation of the four products (Fig. 3).

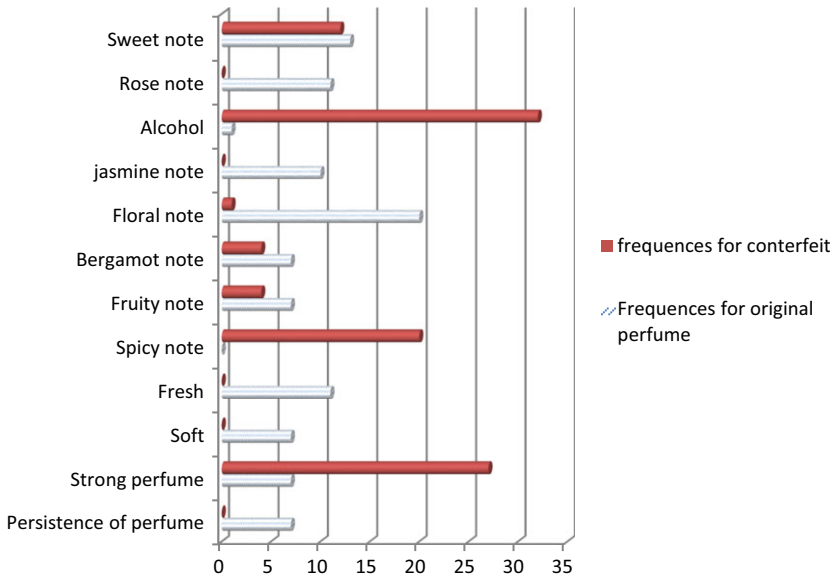

Figure 3 Histogram of the frequency in a pivot® profile for a perfume and its counterfeit.

Step 2: assessing

To assess the sensory characteristic, the pair, and the pair only (i.e. the product to assess and the pivot product) must be presented simultaneously.

Following a sensory phase approach (Table III), each panellist will then fill in a table indicating which attribute (or property or prototype qualifier) they deem 'more' present in the sample tested or 'less' present with regard to the pivot.

Step 3: analysing the results

The results can be analysed by either grouping the terms by category using a specialized dictionary or thanks to the field experts' know-how.

The qualifiers are then counted to obtain the frequency of words with '+' and words with '−' by product and assessment phase. The 'less' frequency must then be subtracted from the 'more' frequency for each word cited. These counts are then reduced to positive values by adding the absolute value of the negative maximum. With these operations, each product (as well as the panellists if needed) can then be characterized qualitatively, but not only, as each attribute can also be quantified for each product based on a frequency gradient similar to the intensity scale for the conventional profiles. The phase or phases results are either presented in frequency histograms, or more synthetically in a correspondence analysis (Fig. 4) [12].

Table III Example of table to enter the attributes in a pivot® profile

	+	−
Aspect		
Grip		
Application		
After application		

The pivot® profiling method was first developed by B. Thuillier for champagnes [40] as field experts already used that method to compare products. B. Thuillier, along with the panel of the Ecole de Biologie Industrielle (Cergy, France), has since used this technique for the highly complex sensory products that are perfume and cosmetics. This sensory assessment method can be carried out with field expert panellists or field-related panellists as well as with consumers. A study on counterfeit perfumes was thus carried out [41]. Twelve panellists compared two perfumes: the original and its counterfeit. The results of this study demonstrated that the original perfume was characterized by jasmine and rose notes, whereas the counterfeit smelt strongly of alcohol and spicy (Fig. 3). This first study showed that the fastness of this method and its considerable discriminating powers are the result of characterizing ordinal values.

The pivot® profile was also carried out with consumers (60). The objective was to generate terms connected to the perfumes being compared to the pivot. In this study, the pivot was composed of an equal-mass mix of seven perfumes. Figure 4 is an illustration of the results of a factorial correspondence analysis. It represents the variability of the data with an expression for axes 1 and 2 of 78% of the total inertia, reflecting a very good representation of the information. This representation allows to identify the interrelations of the attributes, words used in the analysis. The products (with numbers) are also represented in this graph. Then, one can describe these products based on their position towards the descriptors and the meaning of the axes. The axis centre draws the pivot product; the more an attribute or a product deviates from this point, the more it differs from the latter in the sense of the direction of the nearest attributes. Despite the differences and subjectivity of each individual, the results (Fig. 4) were coherent with regard to the terms expressed by the consumers [42].

The first studies carried out with this recent method prove that the latter is useful for a fast and efficient sensory positioning of

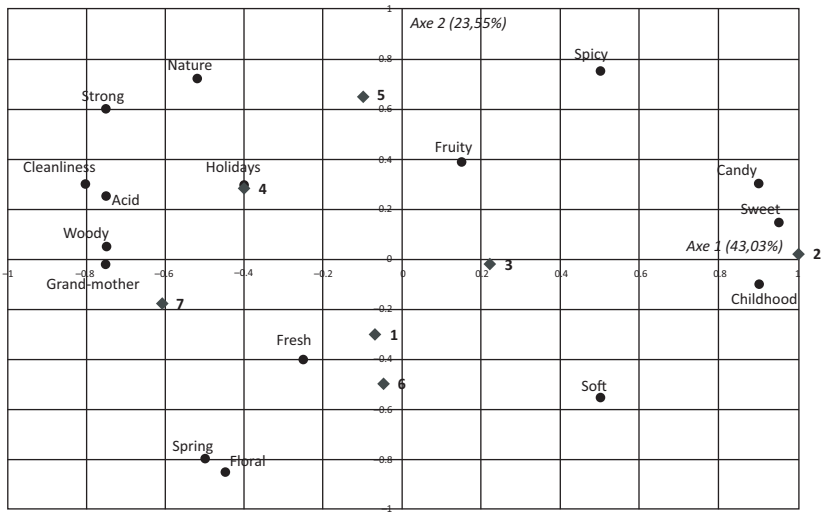

Figure 4 Factorial correspondence analysis of the results for a pivot ® profile realized on different perfumes.

complex products such as perfumes, and also that given this fast positioning, the pivot® profile is perfectly adapted for studying competitors in a product universe. However, the choice of the pivot product when no mix is possible remains a sensitive issue in this method.

Check-all-that-apply (CATA)

Today, the cosmetic industry wants the consumers to actively take part in the descriptive assessment, and sometimes in the conception, of cosmetic products. Therefore, it is essential that the methods available allow the consumer to quickly qualify the products. The check-all-that-apply (CATA) method was designed for consumers rather than panellists [43]. Each consumer receives a questionnaire with attributes to choose from. Should the participants have to give a global grade to the each product in the study, further analyses should be considered (e.g. the preference modelling). These can then be linked to the buying intent, or even to an acceptability concept.

The method follows these steps:

Step 1: products and questions

This method is always applied for a same product universe. The number of products studied varies according to the consumers' sensorial saturation (6–10). The way to generate questions is only slightly formalized. Hence, some authors only select the sensory attributes with a trained panel and then present the consumers with them [44]. The consumers can also be gathered and the items can be collected in a focus group approach. The consumers can also generate questions in a preliminary free sorting characterization of the product universe [45].

- Sensory attributes: oily, greasy and sticky.
- Emotions: well-being and pleasure.
- Effect on the skin: dries the skin and moisturizes.
- Application: cream for greasy skin and eye contour.
- Product positioning: luxury and cheap..

Step 2: assessing the products

In this assessment method, the consumers are monadically presented with the products (singularly in succession). They usually assess the hedonic aspect and then select the items presented in a table (Table IV) that best characterize the product, without any notion of scale (figure...). There are generally between 20 and 40 questions. The number of questions and their order seem to have an impact on the product assessment. This should be taken into account as it may otherwise create a bias [46]. Furthermore, the studies relating to these questionnaires show that the respondents can only focus at the beginning, which implies that the attributes at the end of the questionnaire will be less selected. Consequently, it appears essential to present both the questions and the products randomly [47].

Table IV Example of CATA questionnaire for a skincare product

Intense odour	Rich touch	Day cream
Aqueous touch	Leaves my skin greasy	Floral odour
Leaves my skin soft	Luxurious cream	Night cream

Step 3: results and analysis

The questions selected are usually analysed by adding the number of times the answer was selected. A multiple factor analysis (MFA) is then carried out on these answers to identify the connection between the terms and products and thus to obtain a sensorial map of the samples [48].

A correspondence analysis can then be used to show how the samples and the CATA questionnaire terms are connected; to do so, the factors similar to the main component analysis must be extracted. The graph obtained represents the 'distance' between the categories. Thanks to this analysis, a sensorial map of the samples can be drawn up, and the similarities and differences between the samples and the modalities that characterize them can then be determined.

The check-all-that-apply (CATA) method has only very recently been used for the sensory assessment of cosmetic products, and the Montevideo chemistry school (Uruguay) has published many studies with regard to this. In a study, sixty-nine consumers were presented with six emulsions formulated differently. For each cream, the consumers gave an appreciation score and answered a forty-two-question CATA questionnaire. The questions focused on sensory, emotions and efficiency as well as on skin target or price positioning. Twenty-six of the questions were discriminating, thirteen of which in the sensory category, hence demonstrating that consumers can discriminate products essentially according to their sensory attributes [49]. The same result was achieved in yet another study with consumer-based methods: CATA questions and a conventional profile [45].Two consumer groups of fifty people tested six cosmetic emulsions formulated differently. With each method, the differences in the consumer's perception of the sensory characteristics of the emulsions assessed could be detected.

To conclude on the CATA method, it is powerful enough to allow distinctions between products at a sensory level but also with regard to the other quality attributes perceived. However, its main limitation is that it establishes citation frequencies rather than classifications or intensities. As with all the methods carried out with consumers, more assessors are required for the CATA than for a sensory panel.

Conclusion

In this increasingly competitive innovation context, the cosmetic industry has tried to implement a product design process that integrates the users' expectations [50]. The sensory qualities of a product are essential today and consequently sensory analysis methods are being used more and more. As of the 1980–1990s, cosmetic companies implemented the sensory assessment to validate the formulation of cosmetic products. The discriminating methods, such as the triangular test [51], support the ingredient substitution problematic. With the quantitative descriptive profile, the global sensory specifications of a product can be determined and these can be verified against the market expectations [8]. The alternative methods presented in this article are being developed to allow faster sensory positioning and earlier screening of the prototype products. With these methods, the consumers' perception can also be integrated in the upstream process. All these methods have advantages and inconveniences. The advantage of

flash profile is to provide a product map in a very short time, but the main inconvenience is that it not suitable for large numbers of products because of saturation effect. Pivot© profile also allows to obtain a sensory map very quickly, but the critical point is the choice of the reference product which has to be very central in terms of sensory characteristics [52]. CATA is very simple to understand for the assessors, but the main limitation is that the analysis is performed on nominal data less powerful than quantitative data [12].

Sensory assessment allows the various teams involved in the innovative projects, that is marketing, R&D and quality, to adopt a common method dedicated to creativity, development and production of cosmetic products. This method involves a set of diversified sensory tools, which allow a reasoned methodological choice and products better adapted to the needs. Therefore, the sensory assessment methods will be used earlier and thus support the projects more efficiently.

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