Article

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Abstract

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How do you feel when you smell this? Optimization of a verbal measurement of odor-elicited emotions

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ABSTRACT

The Geneva Emotion and Odor Scale (GEOS) was developed to measure the subjective affective experience (i.e., feeling) elicited by everyday odors. This study aimed to adapt the GEOS to commercial and development needs and had a threefold objective: (i) to verify whether the number of measurement terms in the GEOS questionnaire could be reduced; (ii) to investigate the suitability of this new questionnaire to differentiate the feelings evoked by the odors of different fragranced and flavored products; and (iii) to verify whether the measurement of feelings with this tool could add information to more traditional consumer liking measures. The original and modified questionnaires yielded comparable results for different shampoos. Results of characterizing various product categories with the new questionnaire indicated that it is relevant to differentiate the feelings evoked by odors from fragranced and flavored products, which can be perceptually distinct or similar. In addition, the verbal measurement of feelings provides insight into consumer liking, improving the discrimination of products that have similar liking scores.

1. Introduction

Odors can generate pleasant or unpleasant experiences, as demonstrated in the literature (Schaal et al., 1998; Schleidt, Neumann, & Morishita, 1988), and the hedonic determination of an odor has recently been proposed to be the key function of olfaction (Yeshurun & Sobel, 2010). Odors have the powerful ability to spark off vivid emotional autobiographical memories (Chu & Downes, 2000), and after an odor has been associated with an emotional experience, it is able to evoke the associated emotions when later encountered, which in turn can lead to an alteration of thoughts and behavior (Epple & Herz, 1999; Millot & Brand, 2001). Odors can also influence moods such that pleasant odors can induce positive moods, whereas unpleasant odors can induce negative moods (Rétiveau, Chambers, & Milliken, 2004; Schiffman, Miller, Suggs, & Graham, 1995). Interestingly, odors seem to trigger physiological effects and induce activation or relaxation states by provoking changes in physiological parameters such as heart rate or skin conductance (Alaoui-Ismaili, Robin, Rada, Dittmar, & Vernet-Maury, 1997; Alaoui-Ismaili, Vernet-Maury, Dittmar, Delhomme, & Chanel, 1997; Bensafi et al., 2002a, 2002b; Delplanque et al., 2009; Ilmberger et al., 2001).

Although the powerful effect of odor as an elicitor of emotions and emotional memory is well established, there was, until recently, no systematic, empirically derived taxonomy of olfactory-induced emotions. As a consequence, researchers applied models and measures from nonolfactory areas of emotion research to measure olfactory-induced emotion. In most studies, participants are asked to verbally report their emotions, meaning that they are to report their feelings by choosing, from a predetermined list, the affect terms that describe what they feel in response to the odor. In most cases, the supposed emotionally relevant terms reflect either basic emotion theories or dimensional models.

Basic (or discrete) emotion theories postulate the existence of a small number of so-called basic emotions characterized by emotion-specific response patterns (Ekman, 1984; Izard, 1993; Tomkins, 1984). In this case, depending on the version of the theory that is adopted by the author, the number of proposed terms may vary from 6 (*anger, disgust, fear, sadness, surprise, happiness*; e.g., Alaoui-Ismaili, Robin, et al., 1997; Vernet-Maury, Alaoui-Ismaili, Dittmar, Delhomme, & Chanel, 1999) up to 22 (*shame, jealousy, fear, anger, sadness, pride, hope, relief, boredom, contempt, admiration, disgust, desire, disappointment, love, dissatisfaction, amusement, stimulation, satisfaction, unpleasant surprise, enjoyment, pleasant*

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surprise; e.g., Desmet, 2005; Desmet & Schifferstein, 2008). Dimensional theories, on the other hand, reduce emotions to positions in a two-dimensional valence by arousal space or a three-dimensional space that includes potency (e.g., Lang, Greenwald, Bradley, & Hamm, 1993; Russell, 1980; Wundt, 1909). In this case, the affective terms are chosen to characterize the underlying two or three dimensions (e.g., *arousing*, *pleasant*, *powerful*: Bensafi et al., 2002a, 2002b; Chebat & Michon, 2003; Herz, Schankler, & Beland, 2004; Heuberger, Hongratanaworakit, Böhm, Weber, & Buchbauer, 2001; Jonsson, Olsson, & Olsson, 2005; Pössel, Ahrens, & Hautzinger, 2005; Schifferstein & Tanudjaja, 2004; Warrenburg, 2005). However, as explained hereafter, we claim that neither model is able to provide detailed explanations or predictions for some of the central features of olfaction-induced emotional feeling.

Indeed, discrete emotion theories focus on a small number of universal, evolutionarily continuous basic emotions, in particular, anger, disgust, fear, enjoyment, sadness and surprise (Matsumoto & Ekman, 2009). These emotions have major functions in the adaptation and adjustment of the individual to events that have potentially important consequences for his or her physical and psychological integrity (Matsumoto & Ekman, 2009). Olfactory research adopting those theories focus mainly on physiological signatures induced by odors (e.g., Alaoui-Ismaili, Robin, et al., 1997; Alaoui-Ismaili, Vernet-Maury, et al., 1997; Collet, Vernet-Maury, Delhomme, & Dittmar, 1997; Robin, Alaoui-Ismaili, Dittmar, & Vernet-Maury, 1998, 1999; Vernet-Maury et al., 1999), but rarely explore the causal mechanisms underlying differences in emotion elicitation (often implying schema-driven response selection by emotion-specific neuromotor programs; see Matsumoto & Ekman, 2009). Empirical evidence suggests that it is unlikely that human emotional experiences elicited by odors are based on a limited number of neuromotor programs resulting in specific emotional facial expressions or physiological response patterns, as postulated by the discrete emotion theory (see Chrea, Grandjean, et al. (2009) for further discussion). Furthermore, odor stimuli that evoke emotions produce a rich set of highly differentiated physiological and motor response signatures, as well as various feeling states and verbal descriptions. In many cases, these responses, states and descriptions do not match basic emotion categories such as anger, fear, or sadness (Alaoui-Ismaili, Robin, et al., 1997; Chrea, Grandjean, et al., 2009; Desmet, 2005; Robin et al., 1999). For instance, Desmet and colleagues (2008) showed that reports of experienced pride, sadness, anger, fear and jealousy were the least important during food consumption (sweet snack, savory snack and pasta meal) or that shame, pride, hope, relief, fear, anger, sadness and jealousy were the least experienced emotions in response to fine fragrances (Desmet, 2005). Their interpretation was that those emotions are least experienced because the motivational, social or contextual conditions needed for their elicitation were not fulfilled. This point, as already highlighted elsewhere, suggests that many proposed emotional terms derived from basic emotion theories are not very relevant, underlying the importance of a term's selection procedure (see also King & Meiselman, 2009) to specifically target the odor-elicited emotional state.

Similarly, research that uses dimensional models has allowed the recording of physiological differences associated with verbally reported pleasantness and arousal produced by an odor (e.g., Bensafi et al., 2002a, 2002b) and the investigation of underlying brain structures associated with each dimension (Anderson et al., 2003). But dimensional theorists make little attempt to present an explanatory framework to predict the occurrence of such responses in a consistent manner, and they disagree about the number and the nature of the dimensions that provide an optimal framework for studying emotions (see Fontaine, Scherer, Roesch, & Ellsworth, 2007). Moreover, projecting the odor-elicited emotions onto a bidimensional grid of pleasantness and arousal loses most of the important qualitative differences between the effects of different types of fragrances, a point also raised by Desmet (2005). Thus, the use of a simple valence by arousal representation may not be sufficient to answer relevant questions related to odor-elicited emotions.

We have suggested so far that asking respondents to choose between basic emotion labels or rating feeling states on valence and activation dimensions is not optimally suited to study the affective phenomena associated with odors (for a more complete discussion on this topic, see also Chrea, Grandjean, et al. (2009) or Zentner, Grandjean, and Scherer (2008) concerning the musically evoked emotions). Recently, Chrea, Grandjean, et al. (2009) questioned the suitability of those two types of models to account for the specificity of rich, differentiated emotional feelings experienced in response to odorous substances, and they developed a new set of scales, the Geneva Emotion and Odor Scale (GEOS, Chrea, Grandjean, et al., 2009). Two studies were conducted to investigate the nature and the organization of the semantic space associated with the affective subjective experience or feeling in response to odors. The authors narrowed the number of terms from 480 (extracted from the literature on emotions and on olfaction, including the terms derived from the dimensional and the basic emotion models) to 73 by asking participants to rate the terms for their relevance to describe an affective state induced by an odor ("in your opinion, is this term relevant for describing an emotional state you have already experienced when smelling an odor in the past?") on a continuous scale. The authors then narrowed the number of terms from 73 to 36 by presenting 56 odors and asking respondents if "the terms were relevant to describe their emotional state while smelling the presented odor". Importantly, the reduction and the organization of the terms were based on an empirical, data-driven approach (using exploratory and confirmatory factorial analyses) according to the respondent behavior when facing the odor alone, without imposing any particular theoretical organization on the data (i.e., basic emotion or two-/three-dimensions), nor any specific context. The 56 everyday odors were a balanced mix of familiar–nonfamiliar, pleasant–unpleasant, and edible–nonedible, with a large variety of odor qualities (food, perfumery, body, or nature related).

These studies suggest that the structure underlying feelings of odors is highly differentiated and differs from the taxonomy used to refer to habitually experienced emotions in everyday life. For example, guilt, shame, anger and sadness, which are found to be frequent emotions in everyday life (Scherer, 2004), did not appear to be very relevant to describe affective states elicited by everyday odors (see also Desmet (2005) for fine fragrances). More precisely, the resulting emotional model, GEOS, contains 36 representative terms grouped into six dimensions with factorial analyses. The dimensions are illustrated by seven terms related to "Sensuality" (Desire, Romantic, Sensual, In love, Excited, Admiration and Sexy); five terms related to "Relaxation" (Relaxed, Soothed, Reassured, Light and Serene); six terms related to "Pleasant feeling" (Pleasant, Well-being, Pleasantly surprised, Feeling awe, Attracted and Happiness); seven terms related to "Refreshment" (Revitalized, Energetic, Refreshed, Stimulated, Invigorated, Shivering and Clean); three terms related to "Sensory pleasure" (Nostalgic, Mouthwatering and Amusement); and eight terms related to "Unpleasant feeling" (Dirty, Unpleasant, Disgusted, Unpleasantly surprised, Dissatisfaction, Sickening, Irritated and Angry). Those findings suggest that subjective affective experiences or feelings induced by odors are structured around a small group of dimensions that represent the respondents' feelings in relation to the different functions of olfaction, i.e., ingestion, avoiding environmental hazards, and social communication (see Stevenson (2010), for a review).

The global objective of the studies presented in this paper was to investigate how the GEOS scale could be adapted to commercial and development needs. Nowadays, consumers are looking for emotional sensorial experiences and they tend to buy brands they

feel emotionally connected with (Thomson, 2008). In a competitive market environment, pleasantness and performance might not be enough. The challenge is therefore to create fragrances and flavors that are not only pleasant and perform well, but that also reinforce the emotional benefits in harmony with the marketing mix (claim, advertising message, positioning and brand). To best adapt GEOS to commercial and development needs, we first needed to reduce the number of terms to conduct quicker screening tests in sensory booths without losing the psychometric properties of the full set of scales. We also needed to verify whether the modified questionnaire would be relevant to depict the feelings induced by fragranced and flavored products because GEOS was established with everyday odors. Therefore, our objective was threefold: (i) to check whether the GEOS questionnaire could be slightly modified by reducing the number of measurement terms to the most relevant of the six dimensions; (ii) since the original GEOS questionnaire was established with everyday odors, to investigate the capability of this new questionnaire to differentiate feelings evoked by fragranced and flavored products from our industry; and (iii) to verify whether the measurement of feelings with such a tool could add information to the more traditional consumer liking measure. The GEOS model was elaborated with a French and Swiss population and is relevant for these cultures, but might be less relevant for other cultures and will need to be validated for them. Therefore, all the sensory tests presented in this study were conducted with French and Swiss participants.

2. Construction of a new questionnaire

2.1. Methods

2.1.1. Participants

In total, 99 participants (from 25 to 45 years old, 65% female, French and Swiss nationalities) were recruited in different departments of the Firmenich, SA Company, at different locations around Geneva. They were not paid for their participation and completed a consent form.

2.1.2. Questionnaire

On the basis of the complete version of the GEOS questionnaire (Chrea, Grandjean, et al. (2009)), we developed a new questionnaire by selecting the three most representative terms of each dimension (i.e., highest loadings derived from the factor analyses) that were the most consensual (as measured with Cronbach's alpha). Therefore, instead of rating 36 terms, respondents rated only six series consisting of three terms, as follows:

- "Happiness – Well-being – Pleasantly surprised" for the "Pleasant feeling" dimension.
- "Romantic – Desire – In love" for the "Sensuality" dimension.
- "Disgusted – Irritated – Unpleasantly surprised" for the "Unpleasant feeling" dimension.
- "Relaxed – Serene – Reassured" for the "Relaxation" dimension.
- "Nostalgic – Amusement – Mouthwatering" for the "Sensory pleasure" dimension.
- "Energetic – Invigorated – Clean" for the "Refreshment" dimension.

For readability, all terms are presented here in English; however, they were presented in French to the participants.

2.1.3. Procedure

We conducted two different tests to evaluate a set of 12 shampoos with 78 participants using the original GEOS questionnaire (OR) with the initial 36 emotional terms and 76 participants using the modified questionnaire (MOD) with six series of three terms (as presented before). Two different panel sessions were conducted for each test/questionnaire in sensory booths. One of the 12 shampoo samples was presented during the two sessions to verify the reproducibility of the measure. All shampoos were randomly presented in blind coded, neutral packaging. For each sample, respondents were asked to indicate the pertinence of each listed emotional term (OR) or series of three emotional terms (MOD; providing six ratings) to describe their feelings while they smelled the fragrance of the shampoos on 10 cm linear scales (from 0 = "not relevant at all" to 10 = "extremely relevant"). Data were collected on paper sheets and recorded with FIZZ software (Biosystèmes, Couternon, France).

2.1.4. Statistical analyses

First, to examine to what extent respondents agreed about their reported feelings induced by the olfactory stimuli when using the original or the modified questionnaires, we evaluated the interrater agreement for each questionnaire by computing the Cronbach's alpha based on the ratings of each stimulus for each dimension. Participants that did not complete all the sessions were excluded form interrater agreement analyses, those later being performed with respondents who rated all the products ($n = 32$ for OR; $n = 44$ for MOD). Moreover, we estimated the equivalence of the two questionnaires by computing the Guttman split-half coefficient for participants who rated all the products with the two questionnaires ($n = 16$). If the questionnaires are perfectly similar, we would expect them to be perfectly correlated (i.e., $r = 1$). Less than perfect equivalence leads to less than perfect correlations.

Second, in order to make the two questionnaires comparable, we reduced the number of terms of the original questionnaire to six by averaging the ratings of the terms belonging to the same dimension for all participants ($n = 99$). We also computed the mean product ratings and obtained two matrices containing the mean ratings for 12 products and six variables corresponding to the six emotional dimensions.

Third, in order to check whether the two questionnaires share a common structure, we computed a multiple factor analysis (MFA, Escofier & Pagès, 1984). The relationship between the two structures derived from the MFA was then estimated by computing the RV coefficient (Robert & Escoufier, 1976). The closer to 1 the coefficient is, the closer the structures of the two matrices.

2.2. Results

2.2.1. Interrater agreement

Participants who rated all the products showed high agreement for both questionnaires (Cronbach's $\alpha = .94$ for OR, $n = 32$ and Cronbach's $\alpha = .93$ for MOD, $n = 44$), indicating good reliability of each version. Moreover, results showed that the two versions of the questionnaire were highly correlated (Guttman split-half coefficient, $r = .904$) for participants who rated all the products with the two questionnaires ($n = 16$).

2.2.2. Multiple factor analysis

As illustrated in Fig. 1, the dimensional representation of the projected emotional dimensions (86% of the information) showed good superimposition of information from the two questionnaires and showed close positioning of the two questionnaire variables for the six dimensions. As illustrated in Fig. 2, the dimensional representation of the projected shampoos again showed close positioning of the products evaluated by using the two questionnaires, especially for products 9 and 10. This figure also shows good reproducibility for product 2, which was presented in two different sessions. The calculated RV coefficient (RV = .731, $n = 99$) confirmed the similarity of the two matrices and indicated similar positioning and conclusions for the products.

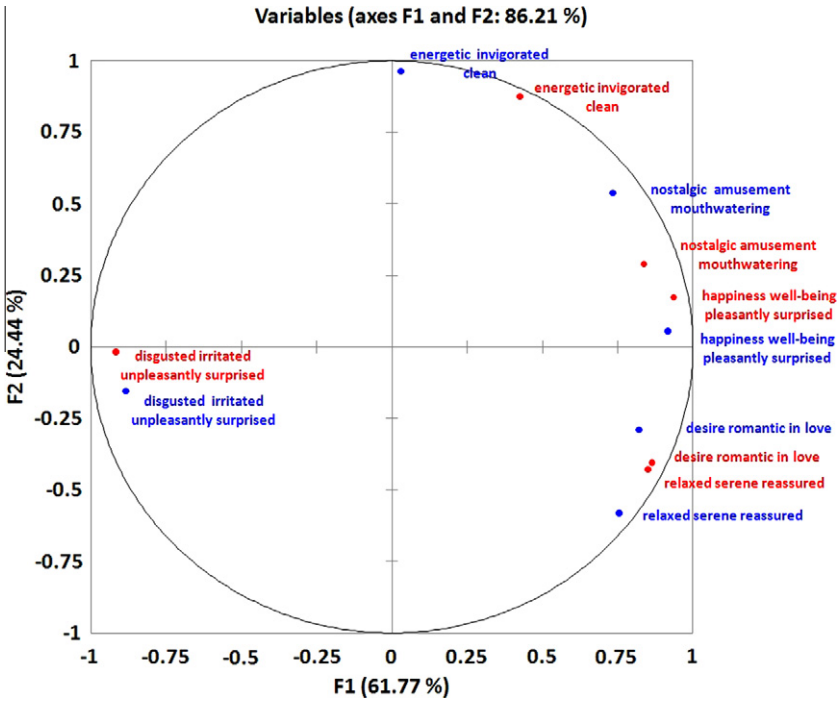

Fig. 1. Two-dimensional mapping resulting from the MFA performed on the original and the modified questionnaires; representation of the six emotional variables for both questionnaires (OR in blue and MOD in red). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

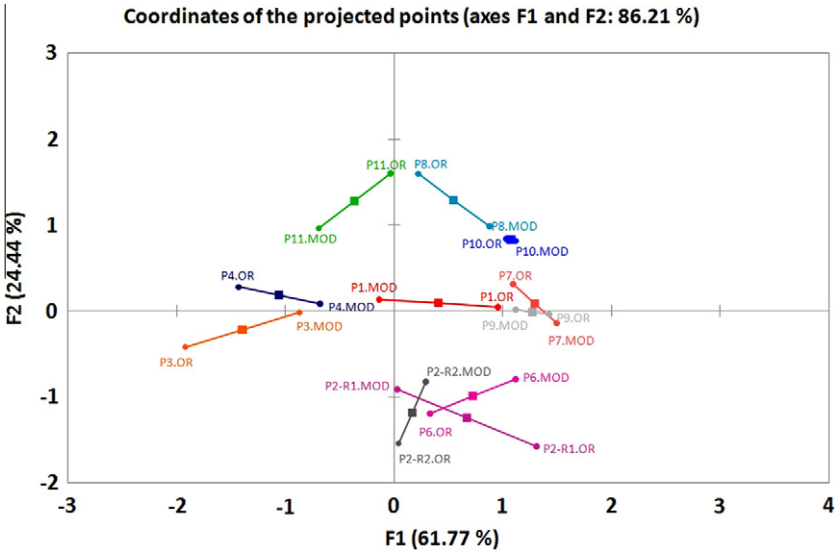

Fig. 2. Two-dimensional mapping resulting from the MFA performed on the original and the modified questionnaires; representation of the 11 products (product 2 being repeated).

The two questionnaires yielded comparable results, as illustrated by the interrater agreement and the MFA. We therefore decided to use the modified questionnaire, which allows easier and quicker tests for the respondent, providing an adapted tool for product development and screening tests.

3. Validation of the new questionnaire for different product categories

3.1. Methods

Several experiments were conducted with various product categories such as flavored product sets (strawberry flavors), fine fragrances and perfumery oils. These product sets were selected to cover a broad range of olfactive notes. The strawberry flavors were the most similar of the products (varying only in flavor profile from, e.g., green to jammy), whereas fine fragrances and perfumery oils had more differences (mix of oriental, floral, citrus and chypre fine fragrances and mix of floral, fruity, woody and aromatic perfumery oils, as categorized by perfumers). For readability and simplicity, we do not present all the results derived from these experiments, but focus on several examples that significantly illustrate our research questions.

3.1.1. Participants

Thirty-one respondents (25–45 years old, 55% female, French and Swiss nationalities) participated in the evaluation of six straw-

berry flavors in one session. The strawberry flavors were applied in acidified syrup (.01% of citric acid and 8% of sugar syrup in water). Sixty-one respondents (25–45 years old, 64% female, French and Swiss nationalities) participated in the evaluation of six fine fragrances that were presented during one session with olfactive pens filled with the required fine fragrances. Thirty-three respondents (25–45 years old, 70% female, French and Swiss nationalities) participated in the evaluation of six perfumery oils presented in one session with olfactive pens filled with the required perfumery oils. All the participants were recruited in different departments of the Firmenich, SA Company at different locations around Geneva. They were not paid for their participation and completed a consent form.

3.1.2. Procedure

Panel sessions were conducted in sensory booths and the products were presented in blind conditions. While they smelled the fragrance or tasted the flavor of each sample, participants were asked to indicate the pertinence of the six series of three emotional terms to describe their feeling (providing six ratings) on 10 cm linear scales (from 0 = "not relevant at all" to 10 = "extremely relevant") by using the modified questionnaire. The scales and their respective representative terms were displayed on a computer screen with FIZZ software (Biosystèmes, Couternon, France). The participants were also asked to rate the perceived familiarity, intensity and liking of the different products on 10 cm linear scales.

3.1.3. Statistical analyses

First, we examined to what extent the respondents agreed about their reported feelings induced by the different products by computing Cronbach's alpha based on the ratings of each stimulus for each dimension.

Second, to answer our question about whether the modified questionnaire is relevant to discriminate the feeling induced by flavored and fragranced products, we estimated the discrimination level by conducting two analyses of variance (ANOVAs). First, a Greenhouse Geisser (G–G) corrected repeated measures ANOVA was conducted to verify whether the products were differentially rated as a function of the dimension. Then, when appropriate, a two-way ANOVA, with "Subject" and "Product" as factors, was conducted by emotional dimension to identify the emotional dimension on which the products were differentiated. This analysis was followed by a Duncan mean comparison to identify products that were significantly differentiated at the 95% confidence level.

3.2. Results

3.2.1. Strawberry flavors

The calculated Cronbach's alpha ($\alpha = .68$) indicated a reasonable panel agreement when evaluating the six strawberry flavors.

The G–G corrected repeated measures ANOVA with Dimension (six levels) and Product (six levels) as within-subject factors on the individual ratings ($n = 31$) revealed a significant Dimension × Product interaction [$F(25,750) = 2.28$; $p < .001$; $\eta^2 = .07$], showing that the products were differentially rated as a function of the dimension.

The G–G corrected repeated measures ANOVA with Product (six levels) as within-subject factor, conducted for each emotional dimension, indicated a significant product discrimination for the "Disgusted – Irritated – Unpleasantly surprised" dimension (see Table 1). The participants gave significantly higher scores to the "Disgusted – Irritated – Unpleasantly surprised" feelings when they tasted the "green" and "floral" strawberry flavors than when they tasted the "fruity" and "cooked" strawberry flavors. The participants were able to perceive differences despite strawberry flavor similarity.

3.2.2. Fine fragrances

The calculated Cronbach's alpha ($\alpha = .92$) indicated a very good panel agreement when evaluating the subsequently analyzed subset of six fine fragrances categorized as "oriental–vanillic", "oriental–floral", "citrus–aromatic", "floral–muguet" and "floral–fruity–green" for two of them.

The G–G corrected repeated measures ANOVA with Dimension (six levels) and Product (six levels) as within-subject factors on the individual ratings ($n = 61$) revealed a significant Dimension × Product interaction [$F(25,1500) = 6.81$; $p < .001$; $\eta^2 = .1$], showing that the products were differentially rated as a function of the dimension.

The G–G corrected repeated measures ANOVA with Product (six levels) as within-subject factor, conducted by emotional dimension, indicated a significant product discrimination for three of the emotional dimensions (see Table 2). For example, the participants gave significantly higher scores to the "Happiness – Well-being – Pleasantly surprised" feelings when they smelled the "citrus, aromatic" fine fragrance than when they smelled the two "oriental–floral" and "oriental–vanillic" fine fragrances. These two oriental fine fragrances were rated differently on the "Disgusted – Irritated – Unpleasantly surprised" dimensions; the "oriental–vanillic" fine fragrance obtaining the highest scores in relation to the "Disgusted – Irritated – Unpleasantly surprised" feelings. Participants also gave significantly higher scores to the "Energetic – Invigorated – Clean" feelings when they smelled the "citrus–aromatic" fine fragrance.

3.2.3. Perfumery oils

The calculated Cronbach's alpha ($\alpha = .94$) indicated a very good panel agreement when evaluating the subsequently analyzed subset of six perfumery oils: basil, cumin, jasmine, mandarin, pepper and vanilla.

Table 1
Duncan mean comparison related to the "Product" factor from a two-way ANOVA related to the six strawberry-flavored solutions.

	Fruity strawberry	Floral strawberry	Cooked strawberry	Creamy strawberry	Green strawberry	Wild strawberry	*F* ratio	*p*-Value (η^2)
Happiness – Well-being – Pleasantly surprised	4.87	3.95	4.99	4.62	3.15	4.67	1.9	.09
Romantic – Desire – In love	3.58	3.17	4.14	3.61	2.68	3.74	1.16	.32
Disgusted – Irritated – Unpleasantly surprised	1.55^{C}	3.15^{AB}	1.46^{C}	1.86^{BC}	3.49^{A}	2.51^{ABC}	3.57	<.01 *(.10)*
Relaxed – Serene – Reassured	3.29	2.69	4.04	3.39	2.16	3.07	2.25	.05
Nostalgic – Amusement – Mouthwatering	3.51	3.31	3.88	4.33	3.19	3.80	0.68	.64
Energetic – Invigorated – Clean	3.11	3.14	3.93	2.84	3.08	4.31	1.66	.14

Means with all different letters are significantly different at the 95% of confidence level from a Duncan mean comparison.

Table 2
Duncan mean comparison related to the "Product" factor from a two-way ANOVA related to the six fine fragrances.

	Oriental–vanillic	Citrus–aromatic	Floral–muguet	Floral–fruity–green	Floral–fruity–green	Oriental–floral	*F*-ratio	*p*-Value (η^2)
Happiness – Well-being – Pleasantly surprised	3.95^{C}	6.56^{A}	6.16^{AB}	5.55^{AB}	6.30^{AB}	5.15^{BC}	4.86	<.001 *(.14)*
Romantic – Desire – In love	4.00	5.08	5.05	4.56	5.59	5.47	1.74	.12
Disgusted – Irritated – Unpleasantly surprised	4.49^{A}	1.26^{B}	1.26^{B}	1.77^{B}	1.91^{B}	2.29^{B}	6.90	<.001 *(.18)*
Relaxed – Serene – Reassured	3.28	4.57	5.24	4.08	4.06	4.92	2.13	.06
Nostalgic – Amusement – Mouthwatering	3.92	4.41	3.28	3.35	4.53	4.77	1.95	.08
Energetic – Invigorated – Clean	3.28^{D}	7.18^{A}	5.92^{AB}	6.06^{AB}	5.13^{BC}	4.11^{CD}	13.75	<.001 *(.18)*

Means with different letters are significantly different at the 95% of confidence level from a Duncan mean comparison.

Table 3
Duncan mean comparison related to the "Product" factor from a two-way ANOVA related to the six perfumery oils.

	Basil	Cumin	Jasmine	Mandarin	Pepper	Vanilla	*F*-ratio	*p*-Value (η^2)
Happiness – Well-being – Pleasantly surprised	3.35^{B}	2.74^{B}	5.73^{A}	6.71^{A}	3.53^{B}	6.62^{A}	22.02	<.001 *(.42)*
Romantic – Desire – In love	1.68^{C}	1.61^{C}	4.83^{A}	3.74^{B}	1.87^{C}	4.91^{A}	20.92	<.001 *(.41)*
Disgusted – Irritated – Unpleasantly surprised	4.28^{AB}	5.25^{A}	1.80^{C}	1.14^{C}	3.67^{B}	1.27^{C}	19.60	<.001 *(.39)*
Relaxed – Serene – Reassured	2.13^{B}	1.23^{B}	4.55^{A}	4.75^{A}	2.15^{B}	5.21^{A}	19.63	<.001 *(.39)*
Nostalgic – Amusement – Mouthwatering	3.68^{CD}	2.83^{DE}	4.30^{BC}	5.35^{AB}	2.41^{E}	6.22^{A}	12.05	<.001 *(.28)*
Energetic – Invigorated – Clean	2.65^{C}	1.48^{D}	3.82^{B}	6.31^{A}	3.08^{BC}	2.89^{BC}	21.27	<.001 *(.41)*

Means with different letters are significantly different at the 95% of confidence level from a Duncan mean comparison.

The G–G corrected repeated measures ANOVA with Dimension (six levels) and Product (six levels) as within-subject factors on the individual ratings ($n = 33$) revealed a significant Dimension × Product interaction [$F(25,800) = 18.56$; $p < .001$; $\eta^2 = .36$], showing that the products were differentially rated as a function of the dimension.

The G–G corrected repeated measures ANOVA with Product (six levels) as within-subject factor, conducted by emotional dimension, indicated a significant product discrimination for all six emotional dimensions (see Table 3). For example, the participants gave significantly higher scores to the "Disgusted – Irritated – Unpleasantly surprised" feelings when they smelled cumin and basil oils, whereas they gave significantly higher scores to the "Happiness – Well-being – Pleasantly surprised" feelings when they smelled jasmine, mandarin and vanilla oils. In addition, mandarin oil obtained the highest scores in relation to the "Energetic – Invigorated – Clean" feelings and vanilla oil obtained the highest scores in relation to the "Nostalgic – Amusement – Mouthwatering" and the "Relaxed – Serene – Reassured" feelings.

In sum, the questionnaire revealed clear differences in the feelings induced by products that were different in olfactive characteristics, such as the fine fragrances and the perfumery oils, as well as, to a lesser extent, products closer in sensory profile, such as the strawberry flavors.

4. Comparison of the emotional feeling with the liking responses

4.1. Methods

We used the same data as previously described in the validation of the new questionnaire.

4.1.1. Statistical analyses

Among all the odors that were evaluated by the respondents, many of them were already differentially evaluated on the basis of a simple liking judgment. This latter case does not constitute a challenge to differentiate the feeling that they induced. Since the objective of the following analyses was to exemplify the capability of the model in providing additional insight into respondents' liking, we only focused on the emotional profile of odors pairs that did not significantly differ on the basis of the liking ratings. We computed repeated measures ANOVAs with the product (two levels) as a factor on the ratings obtained for each dimension and for the liking.

4.2. Results

4.2.1. Strawberry flavors

Among the six different strawberry flavors, some (e.g., the "wild" type and the "green" type) that did not differ on the basis of their liking ratings [$F(1,30) = 1.08$; ns] globally differed in the feelings they evoked [$F(5,150) = 2.28$; $p < .05$; $\eta^2 = .07$]. In this particular case, the wild type obtained slightly higher ratings on the "Happiness – Well-being – Pleasantly surprised" dimension [$F(1,30) = 3.82$; $p = .059$; $\eta^2 = .11$].

4.2.2. Fine fragrances

We selected two perceptually different perfumes (a floral–fruity–green and an oriental–floral) that were evaluated by the same panel of participants ($n = 61$). Although those fragrances did not differ significantly in liking [$F(1,60) = .73$; ns], they differed in the feelings they induced [see Fig. 3, $F(5,300) = 8.94$; $p < .001$; $\eta^2 = .13$]. Indeed, the "floral–fruity–green" perfume evoked significantly higher feeling ratings in the "Energetic – Invigorated – Clean" dimension [$F(1,60) = 17.04$; $p < .001$; $\eta^2 = .22$] and lower feeling ratings in the "Nostalgic – Amusement – Mouthwatering" dimension [$F(1,60) = 6.4$; $p < .05$; $\eta^2 = .09$] than did the "oriental–floral" perfume.

We also checked whether the use of the model could provide additional insight into consumer liking even when the perfumes were classified in the same perceptual category. We thus selected two different perfumes that perfumers classified as belonging to the floral–fruity–green family and that were rated by the same participants ($n = 61$). The analysis revealed that these perfumes differed in the feelings they induced [see Fig. 4, $F(5,300) = 3.89$; $p < .01$; $\eta^2 = .06$], with one perfume evoking significantly higher

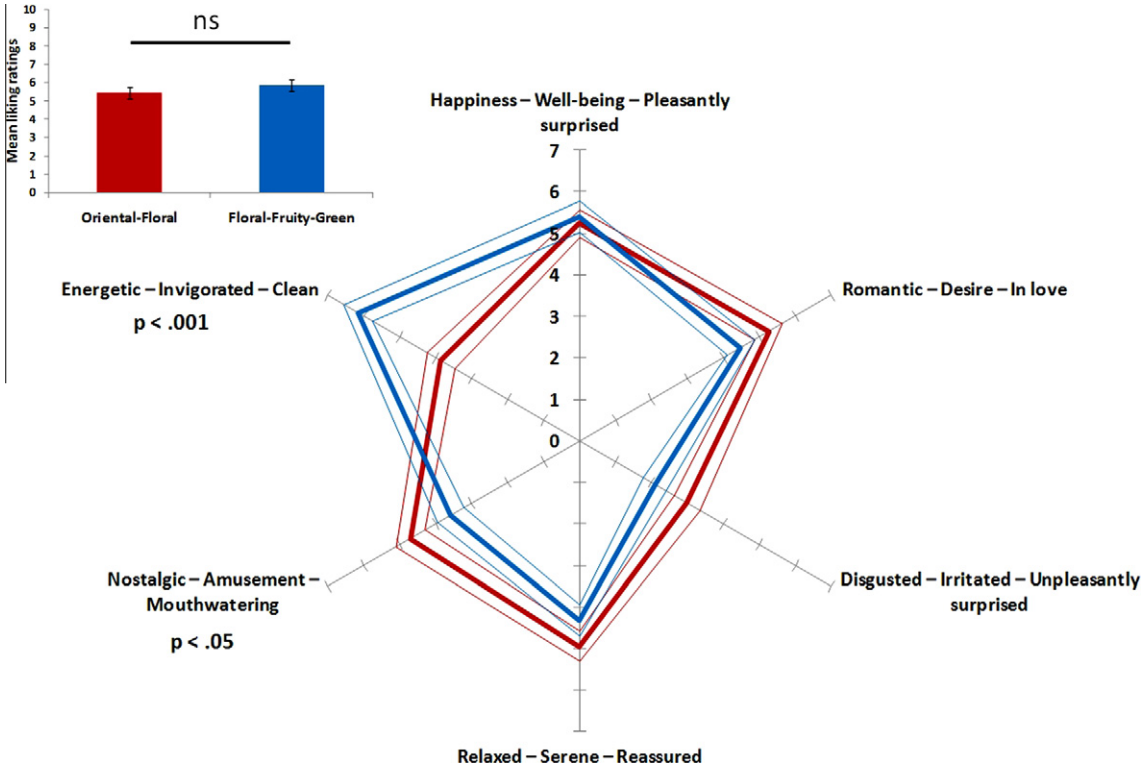

Fig. 3. Mean subjective liking ratings (±SEM; upper left histogram) and mean (thick lines) GEOS ratings (±SEM) for the oriental–floral (in red) and the floral–fruity–green (in blue) fine fragrances. ns = not significantly different at the 95% of confidence level. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

feeling ratings in both the "Nostalgic – Amusement – Mouthwatering" [$F(1,60) = 4.89$; $p < .05$; $\eta^2 = .07$] and the "Romantic – Desire – In love" [$F(1,60) = 4.91$; $p < .05$; $\eta^2 = .07$] dimensions than the other perfume did, though the two fragrances did not differ in their liking ratings [$F(1,60) = .86$; ns].

4.2.3. Perfumery oils

In order to check whether the additional insight given by the model was not specific to the perfumes, we also selected two perceptually different perfumery oils (mandarin and jasmine) that were evaluated by the same panel of participants ($n = 33$). Although those oils did not differ significantly on their liking ratings [$F(1,32) = .53$; ns], they differed in the feelings they induced [see Fig. 5, $F(5,160) = 7.42$; $p < .001$; $\eta^2 = .18$]. Indeed, the mandarin evoked significantly higher feeling ratings in both the "Energetic – Invigorated –Clean" [$F(1,32) = 27.28$; $p < .001$; $\eta^2 = .46$] and the "Romantic – Desire – In love" [$F(1,32) = 4.39$; $p < .05$; $\eta^2 = .04$] dimensions than the jasmine did.

5. Discussion

We observed that the feelings can be measured by using the most relevant terms of each GEOS dimension as applied in our new questionnaire and that these feelings provide comparable information on the products when using the complete GEOS questionnaire. Our analyses also revealed a consensual use of the two questionnaires. Thus, considering the need for fast and accurate tools in our market environment, the new questionnaire based on only six series of three terms appeared to be better adapted to product development and screening tests. In addition, we demonstrated that this new questionnaire is adapted to the measurement of feelings for different perfumery and flavor products and provides reproducible, discriminating and consensual results. This point was, at first glance, challenging because the GEOS model was not specifically developed for fine fragrances, for instance, and it would not have been surprising to observe no significant and reliable difference in the feelings they induced. However, on the basis of a good panel agreement and the capacity of the modified questionnaire to isolate differential feelings, we can argue that the modified questionnaire based on GEOS constitutes a good tool to differentiate feelings induced by fine fragrances. Yet, the empirical demonstration that this questionnaire could be or not be optimally suited for the study of verbally reported emotional reactions for fine fragrances or other specific category of fragranced products remains to be done.

However, it must be noted here that according to our objective to gain knowledge in the feeling in response to odors, all the flavors, fragrances or perfumery oils were presented without mentioning either any brand or any specific packaging. This point of particular importance, already highlighted by other scientists for fine fragrances (Desmet, 2005), as well as the fact that we do not investigate whether the respondent was a consumer of the product or not (King & Meiselman, 2009), strongly limits the knowledge emerging from these studies to the feelings in response to the odor itself. In particular, it could be interesting to investigate whether the less relevant emotional terms, which would require specific motivational, social or contextual conditions to be evoked, could emerge as more relevant in response to odors when such conditions are fulfilled. Thus, further studies are needed to test the suitability of such a model in response to products associated with contextual information.

Interestingly, some of the emotional profiles seemed to be related to the olfactive characteristics of the products even for blind testing; e.g., citrus fine fragrances or perfumery oils, that could contain a noticeable trigeminal note, obtained higher scores in

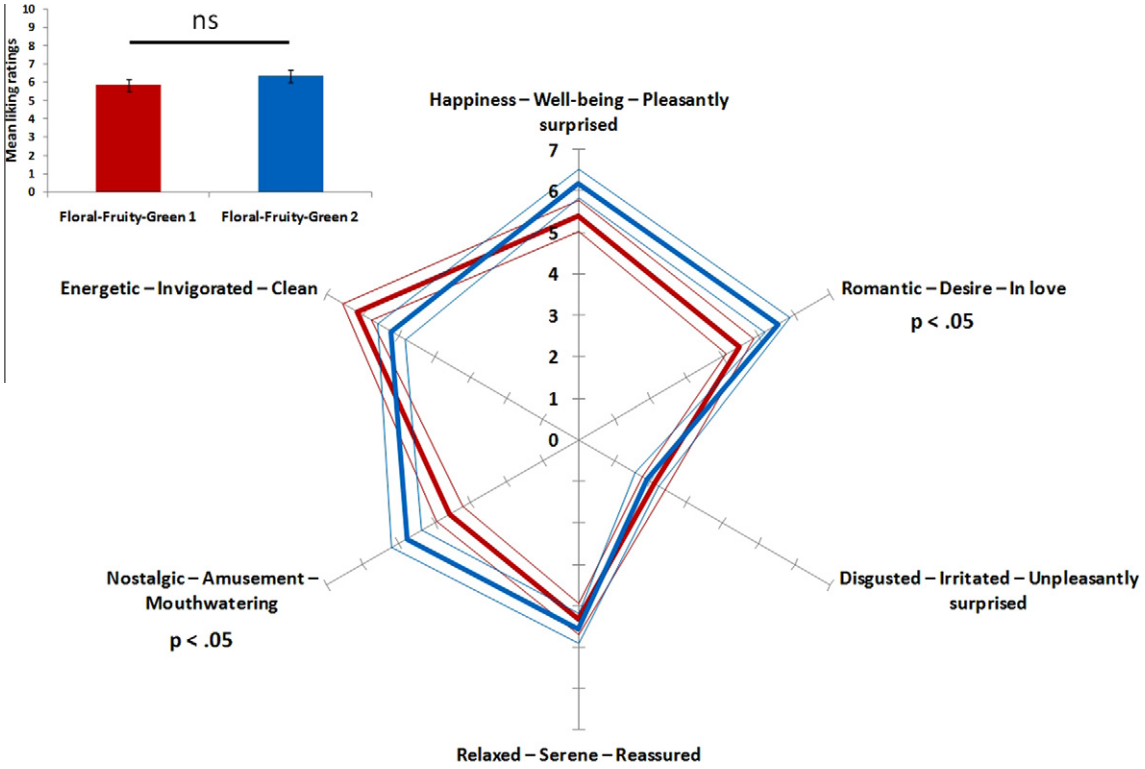

Fig. 4. Mean subjective liking ratings (±SEM; upper left histogram) and mean (thick lines) GEOS ratings (±SEM) for two floral–fruity–green fine fragrances. ns = not significantly different at the 95% of confidence level.

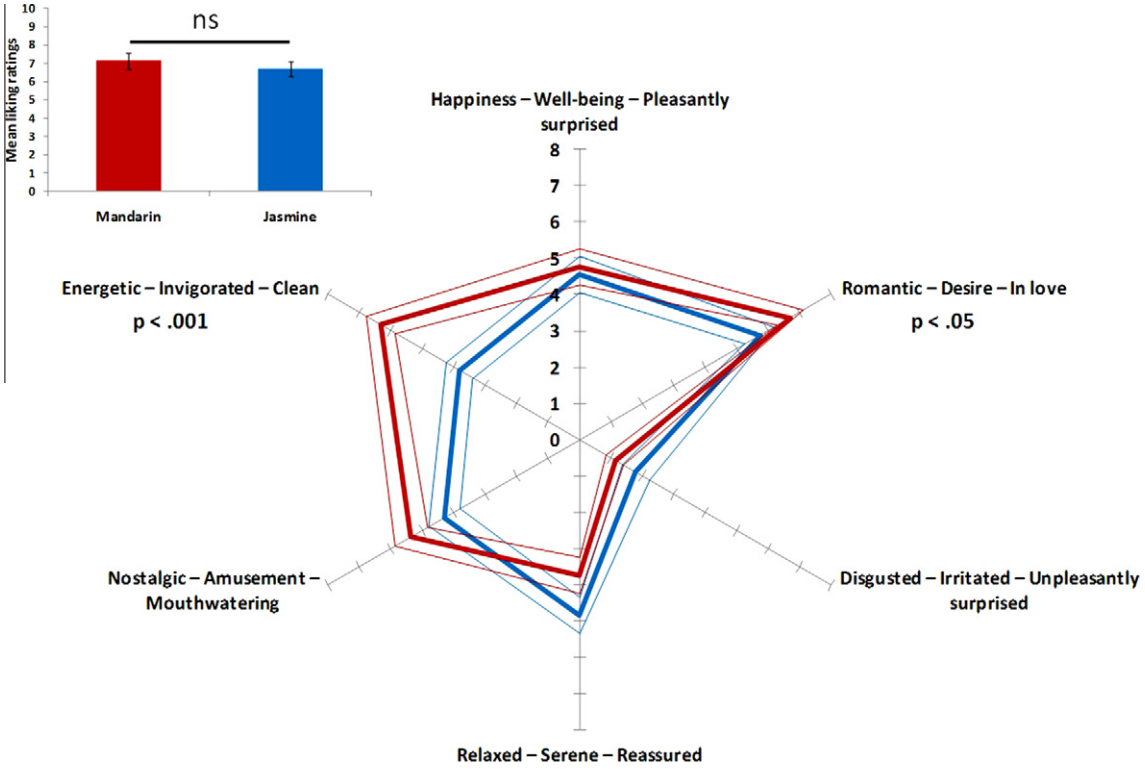

Fig. 5. Mean subjective liking ratings (±SEM; upper left histogram) and mean (thick lines) GEOS ratings (±SEM) for the mandarin (in red) and jasmine (in blue) perfumery oils. ns = not significantly different at the 95% of confidence level. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

relation to the "Energetic – Invigorated –Clean" dimension. Thus, to a certain degree, some affective changes produced by the fragrance seem to be related to the intrinsic quality or chemical properties of the perfume (see also Chrea, Grandjean, et al., 2009). In

this framework, a few studies have argued that olfactory preferences are indeed partly engraved in the physicochemical structure of the odorant (Khan et al., 2007; Mandairon, Poncelet, Bensafi, & Didier, 2009). Desmet and Schifferstein (2008) also emphasized the role of the sensory attributes in the elicitation of food-related emotions. By contrast, other studies have underlined the extent to which the affective response to smells can be modulated by associative learning (Herz et al., 2004) and even by cognitive processes such as decision making (Coppin, Delplanque, Cayeux, Porcherot, & Sander, 2010). In this framework, citrus' higher scores in relation to the "Energetic – Invigorated –Clean" dimension could be explained by an over-learned association between "lemon-like" odors and concepts of energy or cleanliness through, for instance the massive exposition to advertising. Further studies are needed to assess the relative contribution of each factor in subjective affective experience to odors, and GEOS, or its modified version, could constitute a good measurement tool in this respect.

More than being efficient to measure the feelings induced by different perfumery and flavor products, the modified version of GEOS is able to discriminate between different affective responses for products that did not differ in liking. Many different groups of scientists have now underlined the need for more reliable and discriminative measures of feeling than the liking or the acceptability ratings (e.g., Desmet & Schifferstein, 2008; King & Meiselman, 2009; Rétiveau et al., 2004; Warrenburg, 2005). Moreover, this capability is not restricted to very different products (two floral–fruity–green fine fragrances eliciting two different emotional profiles) or to a specific product category, because it was observed for fine fragrances as well as for perfumery oils. Among the different products that were tested, some of them did not differ on the basis of both the likings' judgment and the feelings report. These latter cases mean either that the feelings evoked by those products were indeed not different from each other, or that the scale was not precise enough to reveal such differences. The exact quantification of the sensitivity of the tool to precisely detect different feelings associated with odors is a great challenge for the future. Systematic studies that should certainly couple the verbal measurements with other physiological or behavioral indicators remain to be done to gain information about differential odor-elicited emotions.

However, our results are in line with those from Warrenburg (2005), who demonstrated that vanilla and clementine that were evaluated as equally pleasant differed in the sense that clementine was more stimulating, whereas vanilla was more relaxing. Our findings also complement the conclusions drawn by Rétiveau et al. (2004) in a study on fine fragrances. Indeed, the latter authors found that three fragrances with similar hedonic values but different qualitative notes produced three differentiated affective responses among the respondents. From these findings, we can thus expect that GEOS and its modified version account for more fine-grained differentiated affective states than the traditional liking ratings do.

6. Conclusion

Reliability of the GEOS has been well established, with robust evidence that a domain-specific set of scales is relevant for the measurement of feelings elicited by odors. However, in the context of product development and screening, we need quick and efficient measurements. In this study, we validated the relevance of a new questionnaire developed by using six series of three of the most relevant terms of GEOS dimensions. We have been able to show that this new questionnaire yielded comparable results to the original questionnaire and provided reproducible, discriminating and consensual data for different fragranced and flavored product categories. We demonstrated that this measure is relevant for products tested out of context, in blind conditions and in sensory booths. In addition, we showed that this measure of feelings can help us to better discriminate our products than can traditional consumer liking measures and can also better position our products in harmony with the emotional benefit elicited by the fragrance smelled in blind conditions.

As this model has been elaborated in a French-speaking population, further studies are needed to validate the GEOS model for different cultures following the same procedure and to investigate whether the affective terms and the semantic affective space are similar across cultures. In addition, we could speculate about the ecological validity of these kinds of measurements because they were obtained in a laboratory context. Indeed, we might have obtained uniform and smooth emotional responses in the sensory booth context compared with more expressive and contrasted emotional responses that could be obtained in a more specific context. It is therefore important to better understand how a fragrance reinforces an emotion caused by a situation or expectation and to further investigate how this measurement of feelings can affect liking and emotional reinforcement from a marketing mix perspective.

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