Construction of an Ideal Map (IdMap) based on the ideal profiles obtained directly from consumers

Thierry Worch*a,b, Sébastien Léb, Pieter Puntera, Jérôme Pagèsb

*OP&P Product Research, Utrecht, The Netherlands
bLaboratoire de Mathématiques Appliquées, Agrocampus Ouest, Rennes, France

Abstract

In this paper, the Ideal Mapping technique is presented. It is similar to the preference mapping technique using the quadratic model proposed by Danzart. Indeed, both methods start from the sensory product space (i.e. they are both called "external" maps) and aim at defining areas within the product space that would satisfy a maximum number of consumers.

However, many differences are observed between the maps. Among them, there is (1) the nature of the maps (based on hedonic ratings vs. ideal profiles), (2) the way they are constructed (individual models vs. variability of the ideal profiles), (3) their meanings (liking zones vs. ideal zones) and (4) the proportion of consumers they would satisfy (high vs. low).

The application of both methodologies on the two examples shows that the IdMap is rather a complement to the PrefMap than a substitute. When the final ideal product (i.e. satisfying a maximum number of consumers) belongs to the product space (e.g. perfume dataset), the IdMap confirms the PrefMap solution. When the final ideal product is located outside the product space (e.g. croissant dataset), the IdMap can be seen as an extension of the PrefMap.

© 2012 Elsevier Ltd. All rights reserved.

1. Introduction

In sensory analysis, a common practice is to ask a panel of experts or trained panelists to rate the products tested on a set of pre-defined attributes (Quantitative Descriptive Analysis or QDA, Stone, Sidel, Oliver, Woosley, & Singleton, 1974). Meanwhile, consumers evaluate the same products and rate them according to their liking (Central Location Test or CLT). From these two tests, two different types of information concerning the products are collected: the sensory profile on one hand and the hedonic scores on the other hand.

In order to better understand the consumers’ hedonic judgments, and more especially which sensory attributes influence positively or negatively their liking, an analysis joining these two types of information – sensory description and hedonic judgments – is performed. For instance, the two tables can be combined and analyzed simultaneously. This is the principle of the preference mapping techniques (Greenhoff & MacFie, 1994) which became important in the process of product development as it guides for products’ improvement.

In practice, two types of preference mapping technique exist (Carroll, 1972). These two techniques differ according to the point of view adopted:

- if the focus is on the hedonic data – the sensory information being projected as supplementary within the preference space – an internal preference mapping (or MDPref) is performed;
- if the focus is on the sensory profiles of the products, the hedonic scores being then regressed on the sensory dimensions, an external preference mapping (or PrefMap) is performed.

In both cases, several derivatives exist. For the internal preference mapping, there are the Consumers’ Preference Analysis (CPA; Lé, Husson, & Pagès, 2006) or the Landscape Segmentation Analysis (LSA, Ennis, 2005). For the external preference mapping, the diversity mainly lies in the choice of the model explaining the individual liking scores in function of the sensory dimensions (Schlich & McElwan, 1992). It can be more or less complex, going from the linear model to the quadratic model proposed by Danzart (1998).

At the present time, the model proposed by Danzart (noted here as PrefMapD) is the standard model used in external preference mapping. It allows constructing a surface plot at the panel level (as an addition of individual surface plots obtained from each consumer) in which the profiles of an ideal product which belongs to the area where a maximum proportion of consumers would like...
the product can be estimated (Danzart, 2009; Mao & Danzart, 2008).

Although many external preference mapping studies involving all types of products have been published in the recent years (for a short review, see Van Kleef, Van Trijp, and Luning (2006)), it is subject to many criticisms. Among them can be mentioned (Faber, Mojet, & Poelman, 2003):

- only the two first sensory dimensions are used to explain the liking scores. Hence, some relevant information is discarded, which can lead to “irrelevant” models for a non-negligible number of consumers;
- adding extra dimensions in the circular, elliptic or quadratic models can over-fit the liking scores. In this case, the optimization of the products can be due to a small proportion of consumers only, as only a low number of degrees of freedom are available for the estimation of the parameters.

Therefore, other multi-table analyses such as Multiple Factor Analysis (MFA, Couronne, 1996; Escofier & Pagès, 2008), PLS regression (Husson & Pagès, 2003) or the L-PLS regression – when extra information concerning the consumers is available – (Lengard & Kermit, 2006) have been proposed.

In this paper, we propose a variation of PrefMap when sensory data is collected according to the Ideal Profile Method (IPM, Worch, 2011; Worch, Lé, Punter, & Pagès, 2011). In this case, the consumers provide three types of information: the sensory profiles (i.e. how consumers perceive the products), the hedonic scores (i.e. how they like the products) as well as their ideal profiles (i.e. what are the consumers’ expectations). This technique takes into consideration the sensory profiles of the products and the ideal profiles directly provided by consumers for the construction of the map.

2. Materials and methods

2.1. Notation

The same notation as the one used in the paper from Worch, Lé, Punter, and Pagès (2012) checking for the consistency of the ideal data obtained from the IPM are used here. Hence, we denote in the rest of the article (the vectors are in bold):

\[ y_{jp}: \text{intensity perceived by the consumer } j \text{ for the product } p \text{ and the attribute } a; \]
\[ y_{jpa}: \text{vector or intensities perceived by the consumer } j \text{ for the } P \text{ products and the attribute } a; \]
\[ Y_{jpa}: \text{average over the index } p; \text{ average intensity perceived by the consumer } j \text{ on attribute } a \text{ over the } P \text{ products. (Table 1) } \]
\[ Z_{jpa}: \text{ideal intensity of the attribute } a \text{ provided by the consumer } j \text{ after testing the product } p; \]
\[ z_{jpa}: \text{vector of ideal intensities of the attribute } a \text{ provided by the consumer } j \text{ for the } P \text{ products; } \]
\[ z_{jpa}: \text{average over the index } p; \text{ average ideal intensity of the attribute } a \text{ provided by the consumer } j \text{ over the } P \text{ products. } \]
\[ h_{jp}: \text{hedonic judgment provided by the consumer } j \text{ for the product } p; \]
\[ h_{jpa}: \text{vector of hedonic judgments provided by the consumer } j \text{ for the } P \text{ products. } \]

The difference between consumers related to a different use of the scale is not of great interest here. The averaged ideal profile from each consumer is hence corrected by subtracting, for each attribute, the averaged intensity that the consumer perceived for the entire set of products (Eq. 1). The corrected averaged ideal profile is denoted \( z_j \).

\[ z_{jpa} = y_{jpa} - \bar{y}_{jpa} \quad (1) \]

Note: The term corrected refers to a geometric translation of the ideal ratings according to the consumer’s use of the scale. It is performed in order to readjust all the consumers’ scales together. In other words, corrected refers to corrected for the scale use. In the rest of the document, we denote as corrected ideal profile the ideal profile from a consumer which has been corrected from the use of the scale using Eq. (1).

2.2. Materials

To illustrate the methodology presented below, two datasets obtained from the IPM are used: the perfume (Worch, Lé, & Punter, 2010) and the croissant datasets.

Perfume: It concerns 12 luxurious women perfumes among which two were duplicated (Table 2). Each product has been rated on 21 attributes (listed in Table 2) by 103 Dutch consumers. For each perfume and each attribute, both the perceived and ideal intensities have been rated on a line scale. After rating each product on perceived and ideal intensity, overall liking was rated on a structured 9-point category scale. The 14 samples were presented in monadic sequence, taking care of order and carry-over effects (MacFie, Bratchell, Greenhoff, & Vallis, 1989) in two 1-h sessions.

Croissant: Following the same procedure, nine croissants have been tested by 151 Dutch consumers (Table 3). Each product has been rated on 26 attributes (Table 3). For confidentiality reasons, the product names and their differences in the recipes will not be mentioned here.

Table 1

<table>
<thead>
<tr>
<th>Consumer</th>
<th>Product 1</th>
<th>...</th>
<th>Attribute a</th>
<th>...</th>
<th>Attribute A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product 1</td>
<td>...</td>
<td></td>
<td>y_{jpa}</td>
<td></td>
<td>y_{jpa}</td>
</tr>
<tr>
<td>Product p</td>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product P</td>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2

<table>
<thead>
<tr>
<th>Products</th>
<th>Type</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angel</td>
<td>Eau de Parfum</td>
<td>Intensity</td>
</tr>
<tr>
<td>Cinema</td>
<td>Eau de Parfum</td>
<td>Freshness</td>
</tr>
<tr>
<td>Pleasures</td>
<td>Eau de Parfum</td>
<td>Jasmine</td>
</tr>
<tr>
<td>Aromatics Elixir</td>
<td>Eau de Parfum</td>
<td>Rose</td>
</tr>
<tr>
<td>Lolita Lempicka</td>
<td>Eau de Parfum</td>
<td>Chamomile</td>
</tr>
<tr>
<td>Chanel No. 5</td>
<td>Eau de Parfum</td>
<td>Fresh lemon</td>
</tr>
<tr>
<td>L’Instant</td>
<td>Eau de Parfum</td>
<td>Vanilla</td>
</tr>
<tr>
<td>J’Adore (EP)</td>
<td>Eau de Parfum</td>
<td>Citrus</td>
</tr>
<tr>
<td>J’Adore (ET)</td>
<td>Eau de Toilette</td>
<td>Anis</td>
</tr>
<tr>
<td>Pure Poison</td>
<td>Eau de Parfum</td>
<td>Sweet fruit</td>
</tr>
<tr>
<td>Shalimar</td>
<td>Eau de Toilette</td>
<td>Honey</td>
</tr>
<tr>
<td>Coco Mademoiselle</td>
<td>Eau de Parfum</td>
<td>Caramel</td>
</tr>
</tbody>
</table>
2.3. Methods

The construction of the Ideal Map is based on the methodology of the PrefMapD. Therefore, a comparison of results obtained from both methodologies is also presented.

2.3.1. IdMap

2.3.1.1. Definition of the product space. Like for PrefMapD, the IdMap takes as starting point the sensory product space. Thus, the IdMap is defined as an external map which is directly comparable to PrefMapD.

The product space is created from the averaged sensory profiles $y_{pa}$ (Table 4a). It is obtained by multivariate analysis (Principal Component Analysis, MFA, Generalized Procrustes Analysis, etc.). In this case, PCA is used.

2.3.1.2. Projection of the corrected ideal products from each consumer and of the liking scores on that space. In this product space, the corrected ideal products $\tilde{z}_{jpa}$ obtained from each consumer are projected as supplementary entities (Table 4b). The distribution of the projection of these ideal products provides a first idea on the direction to take to develop an eventual ideal product satisfying a maximum of consumers (Fig. 1).

2.3.1.3. Creation of the IdMap as a density map. To create the IdMap, a first solution consists in measuring the density of points (i.e. ideal products) projected in each zone of the space (Fig. 2).

However, the low density of points projected ($P_{1J}$ for full designs) does not allow the creation of a map which would be as precise as the one obtained with PrefMapD. Indeed, a high resolution (i.e. square the space in a high number of small zones) only

<table>
<thead>
<tr>
<th>Table 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>List of products and attributes in the croissant study.</td>
</tr>
<tr>
<td>Products</td>
</tr>
<tr>
<td>Croissant 1</td>
</tr>
<tr>
<td>Croissant 2</td>
</tr>
<tr>
<td>Croissant 3</td>
</tr>
<tr>
<td>Croissant 4</td>
</tr>
<tr>
<td>Croissant 5</td>
</tr>
<tr>
<td>Croissant 6</td>
</tr>
<tr>
<td>Croissant 7</td>
</tr>
<tr>
<td>Croissant 8</td>
</tr>
<tr>
<td>Croissant 9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization of the data used for the definition of the sensory space (a) with projection of the corrected ideal profiles as supplementary entities (b), and of the liking scores as supplementary variables (c).</td>
</tr>
</tbody>
</table>

![Fig. 1. Projection of the corrected ideal products provided from the consumers on the sensory product space.](image-url)
associates each individual zone with a very small number of projections while a low resolution (i.e., squaring the space in a lower number but wider zones) creates a “gross” map.

Moreover, this procedure does not take into account important information concerning the variability of the ideal profiles provided by the same consumer. Indeed, the IdMap created based on the density does not consider the origin of the projections: in this case, no difference is made whether the ideal products in a same zone are provided by one or many consumers.

Let’s consider 100 consumers providing 10 ideal profiles each. One thousand points are hence projected on this map. An ideal product belonging to a zone of the space regrouping 10% of the projections can either be linked to a large number of consumers (one point per consumer), or to a small number of consumers (the 10 ideal profiles of 10 consumers). In these cases, the impact is not the same since the creation of such ideal product will not affect the same population (100 vs. 10 consumers).

2.3.1.4. Smoothing procedure: use of confidence ellipses around the averaged ideal products. In order to take into account the variability within consumers of their ideal ratings, a confidence ellipse is constructed around the averaged ideal profile provided by each consumer (Husson, Lê, & Pagès, 2005). These confidence ellipses are obtained by partial bootstrap on the products tested.

In practice, a random sampling with replacement of \( P_0 \) among the \( P \) tested products is performed (usually, \( P_0 \) is equal to \( P \)). For each consumer, the corrected ideal profile averaged over the \( P \) products is computed and projected as illustrative on the sensory space. This corresponds to answering the following question: “where the corrected averaged ideal product of a consumer would be projected if, instead of rating it according to the \( P \) products, he would rate it according to the \( P_0 \) products?”

This simulation step is iterated many times (500 times in practice) and the confidence ellipses containing 95% of the projections are constructed around each consumer (Fig. 3).

Note: In this situation, the consumers are associated to one unique ideal profile that they described \( P \) times with a certain variability highlighted by the confidence ellipses. When the products tested are from different categories (e.g., milk and dark chocolate), consumers might provide multiple ideals. In such situation, the IdMap should be performed on the larger subset of products corresponding to one unique ideal.

For each point of the sensory space, the amount (in percentage) of ellipses covering that area is computed. In other words, for each point of the space, the proportion of consumers having an ideal in each area of the space is measured (Fig. 4).

In order to facilitate the interpretation of the results, a color code is associated to each zone of the space: the larger the proportion of consumers in an area of the space, the lighter the color.

2.3.1.5. Creation of the IdMap. Finally, the external Ideal Map including contour lines associated with the proportion of consumers is constructed (Fig. 5).

2.3.1.6. Notion of weight for the consumers. In theory, a large confidence ellipse means that the product is associated with a large variability. In our case, a large variability can be interpreted in two ways:
Inversely proportional to the size of its corresponding ellipse. Each consumer is associated with a weight which is larger (resp. smaller) area of the sensory space is covered.

However, if one assumes that wide confidence ellipses correspond to instability of the ideal ratings, the \( wIdMap \) is recommended. However, if one assumes that wide ellipses correspond to instability of the ideal ratings, the \( wIdMap \) is preferred.

### 2.3.1.7. Definition of the ideal product

For the \( \text{PrefMapD} \), the coordinates corresponding to the maximum proportion of consumers overlapping can be extracted. By using the inverse formula from the PCA – which aims at estimating the sensory profile of a product based on the coordinates on the map – a potential profile of the ideal product can be estimated based on these coordinates.

This procedure can also be applied to the \( \text{IdMap} \) technique. As the individual ideal profiles are known, one could also use as ideal product the averaged ideal profile calculated directly from the consumers sharing an ideal product in this area of the map.

### 2.3.2. Comparison of the \( \text{IdMap} \) and the \( \text{PrefMapD} \)

Although both methodologies (\( \text{IdMap} \) and \( \text{PrefMapD} \)) are similar, the nature of the data involved differs. And it is especially according to this difference that both techniques are compared.

### 2.3.2.1. Link between the maps (a priori)

According to Worch et al. (2012), a consumer is consistent if the ideal product provided shares similar characteristics with the preferred product.

Thus, in the sensory space, the projection as illustrative of the ideal profiles provided by a consumer must be close to the preferred product. To check that, the corrected ideal profiles of the consumers (Table 4b) on one hand and the hedonic scores on the other hand (Table 4c) are, respectively, projected as supplementary entities and supplementary variables on the sensory space (Table 4a). For a panel composed of consistent consumers, the distribution of the consumers within the correlation circle (hedonic) is coherent (i.e. going in the same direction) with the distribution of the projections of their ideal profiles within the sensory space.

This double projection provides a first visual impression about the relationship between \( \text{IdMap} \) and \( \text{PrefMapD} \). However, it is only approximate as the one to one relationship is not further studied here.

### 2.3.2.2. Liking threshold and definition of the \( \text{PrefMapD} \) and \( \text{IdMap} \) maps

In this study a product is defined as liked by a consumer if the consumer considered would like it more than a certain threshold value. Similarly, each consumer is associated to an area of liking corresponding to the area of the sensory space which contains products he/she would like.

The construction of the \( \text{PrefMapD} \) depends on the threshold value (also called liking threshold), as it determines whether a product belonging to the sensory space would be liked or not by each consumer.

In practice, for a given consumer, each point of the space is associated with a product whose liking score is estimated based on a model defined for that consumer. This estimation of the liking score is compared to the liking threshold: if the estimation is larger (resp. smaller) than the threshold, the product corresponding to this point of the space is liked (resp. rejected) by the consumer.
The larger the threshold, the smaller the surface of liking for each consumer. Thus, increasing the threshold reduces the chances of overlap between individual areas of liking, hence reducing the proportion of consumers sharing a common ideal.

In this paper, the standard threshold is considered for PrefMap\(D\). It corresponds to the averaged hedonic rating \(h\) each consumer provided to the products. In practice, this threshold means liking on average half of the product space for each consumer. Thus, the liking area defined for each consumer is wide and is not defining a maximum-liking area for the standard PrefMap\(D\).

The use of such a threshold does not occur with the IdMap. However, it is possible to influence (to a lesser extent) the proportion of consumers sharing a common ideal by adjusting the size of the individual confidence ellipses: the larger the individual ellipses, the higher the chances of overlap. The size of the ellipses depends on several parameters:

- the variability of the ideal profiles provided by a consumer;
- the \(p\)-value used to create the ellipses (by default, the ellipses contain 95\% of the projections, and reducing this proportion reduces the size of the ellipse);
- the number of products used for the resampling: increasing the number of products in the resampling procedure reduce the size of the ellipses;
- at some extent, the application of weight to the ellipses as in the wIdMap.

In practice, the confidence ellipses cover only a small area of the product space. By definition, this liking area corresponds to maximum liking (i.e. ideal product) for each consumer. Thus, we are talking about ideal area with the IdMap.

The theoretical difference in the meanings of the individual liking and ideal areas in PrefMap\(D\) and IdMap is related to the threshold used. This threshold as well as the surface of the area in each map are schematized Fig. 6.

2.3.2.3. Comparison of the results through the estimated ideal profiles obtained. Besides the visual comparison of the maps obtained with the two techniques, one can also compare the sensory profiles of the ideal products both methods would generate.

However, a one-to-one comparison of the ideal profiles might not be sufficient, as references are needed. To enrich the comparison, the sensory profiles of the tested products are added to the comparison. These sensory profiles are standardized on each attribute (Eq. 2a), and the same transformation is applied to the sensory profiles of the estimated ideal products (Eq. 2b).

Standardization of the sensory profiles of the tested products
\[
\frac{(y_{pa} - \bar{y}_a)}{\sigma_{y,a}} \quad (2a)
\]

Standardization of the sensory profiles of the ideal products
\[
E_{pa} - \bar{y}_a / \sigma_{y,a} \quad (2b)
\]

The \(P + 2\) standardized products are represented graphically.

![Fig. 6. Theoretical difference in the “threshold” used to define the individual acceptance area for PrefMap\(D\) (left, a) and IdMap (right, b). Note: the arrow shows that for the PrefMap\(D\), the acceptance threshold can be adjusted.](image)

Table 5

Properties and definition of the maps obtained with PrefMap\(D\) et IdMap.

<table>
<thead>
<tr>
<th></th>
<th>PrefMap(D)</th>
<th>IdMap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ideal Profiles</td>
<td>Indirect</td>
<td>Direct</td>
</tr>
<tr>
<td></td>
<td>Globally estimated from an aggregation of individual data</td>
<td>Directly measured at the consumer level, and then aggregated</td>
</tr>
<tr>
<td></td>
<td>No possible validation</td>
<td>Direct validation through the study of the consistency of the individual data</td>
</tr>
<tr>
<td>Space considered</td>
<td>Product space only (the individual estimations belong to the product space)</td>
<td>Extended product space (the individual ideal data can be outside the product space)</td>
</tr>
<tr>
<td>Interpretation issues</td>
<td>Models: - Strong dependence to the individual models - Low number of degrees of freedom</td>
<td>Ellipses: - Size: large ideal area or unstable ratings? - Homogenization of the ellipses? (use of individual weights)</td>
</tr>
<tr>
<td>Proportion of consumers (contour lines)</td>
<td>Mechanic dependence to the threshold considered</td>
<td>Mechanic dependence to the size of the ellipses</td>
</tr>
<tr>
<td></td>
<td>High when the threshold is low: there is a risk of finding unstable maxima</td>
<td>Generally low by construction as it corresponds to a common ideal for a group of consumers</td>
</tr>
<tr>
<td>Meanings of the map</td>
<td>Area of non-rejection (rather than area of preference) when the threshold is low</td>
<td>Ideal area for each consumer</td>
</tr>
</tbody>
</table>
2.3.2.4. Properties of the different maps. The properties of the different maps obtained according to PrefMapD and IdMap are summarized Table 5.

3. Results

The methodology presented above is applied to the perfume and to the croissant datasets.

3.1. Measure a priori of the link between the maps

The consistency of the ideal and hedonic data is measured visually in the sensory space by projecting simultaneous the corrected ideal products from each consumer as supplementary entities and the hedonic ratings as supplementary variables.

In the perfume example, the projection of the hedonic ratings as supplementary variables highlights homogeneity of the panel, the majority of consumers preferring the products located on the negative part of the first dimension (Fig. 7). Meanwhile, the projection of the corrected ideal products also suggests homogeneity of the panel, the majority of the points being located along the negative part of the first dimension.

In the croissant example, the projection of the hedonic ratings as supplementary variables highlights more heterogeneity than in the perfume example (Fig. 8). However, most of them point to the lower right corner of the space (positive side on the first dimension.

![Fig. 7. Projections as supplementary entities (left) of the corrected ideal profiles and as supplementary variables (right) of the liking ratings on the sensory space (perfume example).](image1)

![Fig. 8. Projections as supplementary entities (left) of the corrected ideal profiles and as supplementary variables (right) of the liking ratings on the sensory space (croissant example).](image2)
and negative side on the second dimension). The projection of the individual ideal profiles (as supplementary entities) in the same space shows homogeneity of the consumers in their ideal products, the majority of them being projected into the lower right corner of the sensory space.

As the repartition of both projections is consistent in both examples, one can a priori expect some similarities in the results of the IdMap and the PrefMapD.

### 3.2. Comparison of the maps

In order to construct the different maps, the sensory space has to be defined. This space is obtained by PCA performed on the sensory profiles of the products (Table 4a).

As it is often the case in PrefMapD, only the first two dimensions are considered in this case.

#### 3.2.1. Perfume example

In the perfume example, the first plane of the PCA (Fig. 9) summarizes 85% of the information. The first dimension opposes J’Adore and Pleasures described as fresh and fruity to Shalimar and Angel described with stronger oriental notes. The second dimension opposes Angel and Lolita Lempicka described with sweet notes to Aromatic Elixir.

The PrefMapD (Fig. 10) highlights a stronger liking area along the negative part of dimension 1. Thus, the most liked products are J’Adore and Coco Mélange. The homogeneity of consumers mentioned previously is highlighted here by the large proportion of consumers liking these products. Indeed, 80% of the consumers would like J’Adore and Coco Mélange more than average.

However, one can find an “empty” area in which the corresponding product would be liked by more than 90% of the consumers. This corresponds to a local ideal product.

The IdMap (Fig. 11a) provides similar results, the ideal area shared by a maximum of consumers being also located on the negative part of first dimension. However, this local ideal product seems a little bit less “extreme” along this dimension than the one obtained with the PrefMapD. It is shared by 38% of the consumers.

In this example, the ratio in size between the smallest and the largest ellipse is about 1–50. In other words, consumers do not rate their ideal with the same variability, which means that they do not have the same weight in the construction of the map. To adjust the map according to those differences, consumers are homogenized before constructing the map.

The IdMap is shown in Fig. 11b. In this case, the ideal product shared by a maximum of consumers (35%) is located in a similar area as for the IdMap. Here, the consensus areas are globally smaller than for the IdMap, although they correspond to similar proportions of consumers.

By using the inverse formula in the PCA, the potential sensory profiles of the ideal products obtained with the PrefMapD and IdMap are estimated. In the PrefMapD, this ideal product is located
at coordinates (−3, 1), while in the \( \text{IdMap} \), it is located at (−0.9, 0.6). The sensory profiles thus obtained are given Table 6.

In order to better evaluate the differences between these two profiles, they are standardized on each attribute according to the profiles of the tested products and represented in Fig. 12. The differences between these two products being mainly observed on the first dimension, the attributes are ordered according to their coordinates on this dimension (in decreasing order). For a better comparison, the standardized profiles of the products tested are also shown.

The two estimated ideal profiles belong to the product space. The ideal intensity ratings are in the same order of magnitude as the products tested. A more systematic comparison per attribute of the difference between the perceived and ideal intensities allows product’s improvement. However, this is not done here.

#### Table 6

<table>
<thead>
<tr>
<th>Attribute</th>
<th>( \text{IdMap} )</th>
<th>( \text{PrefMapD} )</th>
<th>( \text{IdMap} )</th>
<th>( \text{PrefMapD} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensity</td>
<td>59.0</td>
<td>56.4</td>
<td>Caramel 25.1</td>
<td>24.6</td>
</tr>
<tr>
<td>Freshness</td>
<td>52.2</td>
<td>56.0</td>
<td>Spicy 36.7</td>
<td>34.0</td>
</tr>
<tr>
<td>Jasmine</td>
<td>39.6</td>
<td>40.7</td>
<td>Woody 27.0</td>
<td>24.2</td>
</tr>
<tr>
<td>Rose</td>
<td>38.1</td>
<td>39.7</td>
<td>Leather 21.1</td>
<td>18.6</td>
</tr>
<tr>
<td>Camomile</td>
<td>29.1</td>
<td>28.7</td>
<td>Nutty 28.0</td>
<td>26.5</td>
</tr>
<tr>
<td>Fresh_lemon</td>
<td>33.5</td>
<td>37.2</td>
<td>Musk 32.5</td>
<td>29.9</td>
</tr>
<tr>
<td>Vanilla</td>
<td>33.1</td>
<td>33.3</td>
<td>Animal 20.2</td>
<td>18.5</td>
</tr>
<tr>
<td>Citrus</td>
<td>30.2</td>
<td>31.5</td>
<td>Earthy 20.0</td>
<td>17.6</td>
</tr>
<tr>
<td>Anis</td>
<td>24.9</td>
<td>24.6</td>
<td>Incense 26.5</td>
<td>23.9</td>
</tr>
<tr>
<td>Sweet_fruit</td>
<td>32.0</td>
<td>34.0</td>
<td>Green 27.1</td>
<td>28.7</td>
</tr>
<tr>
<td>Honey</td>
<td>26.6</td>
<td>26.6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 11. \( \text{IdMap} \) (left, a) and \( \text{wIdMap} \) (right, b) obtained for the perfume dataset.

Fig. 12. Sensory profiles of the ideal products obtained with \( \text{PrefMapD} \) and \( \text{IdMap} \) standardized according to the profiles of the products tested in the perfume example.
Although both sensory profiles are very similar, the ideal product obtained from the PrefMapD is a little bit more “extreme” for some attributes than the one obtained from the IdMap.

3.2.2. Croissant example

In the croissant example, the first plane of the PCA (Fig. 13) summarizes 55% of the information. The first dimension opposes the products 7, 6 and 8 described as eat, overall taste, musty taste and lamination to the products 4, 2 and 3 described as firm, moist of crumb and butter and fatty taste. The second dimension opposes the products 3 and 6 defined by shape, bending and consistency of size to the product 9 defined by saltiness, overall aroma and internal color.

The PrefMapD (Fig. 14) highlights an area of maximum liking in the lower right corner of the plane (positive side of the dimension 1 and negative side of the dimension 2). This corresponds to the results shown in Fig. 8. Sixty to seventy percent of consumers would be satisfied with a product belonging to that area. In comparison to the perfume example, this proportion is relatively low. This can be explained by the greater heterogeneity of the consumers in this example.

Although there is a potential ideal product in the lower right corner of the plane, the map seems to highlight that the maximum proportion of consumers liking a product has not been reached, a higher proportion being eventually defined for a product falling outside the sensory space.

In the IdMap (Fig. 15a), the area containing the ideal product satisfying a maximum of consumers is also located in the lower right corner of the space. However, this ideal area is defined outside the product space as it is more extreme along the 2nd dimension.

Here again, the ratio in size between the smallest and the largest ellipse is about 1–50. The solution obtained after balancing consumer together is also shown here.

The results of the wildMap (Fig. 15b) are similar to the one of the IdMap. The ideal product satisfying a maximum of consumers is also located in the lower right corner of the sensory space. However, in this case, areas of consensus are less well defined and the proportions of consumers are slightly decreasing.

By using the inverse formula in the PCA, the potential sensory profiles of the ideal products obtained with the PrefMapD and IdMap are estimated. In the PrefMapD, this ideal product is located at coordinates (4.3; 1) while in the IdMap, it is located at (4.3; −4.5). The sensory profiles thus obtained are given Table 7.

The standardized ideal profiles are shown Fig. 16. The difference being mainly along the second dimension, the attributes are ordered in decreasing order along this dimension.

It shows which attributes (and how) should be changed to improve the products tested. It appears here that the intensities overall taste and musty taste should be reduced while sweetness, butter taste and butter aroma should be intensified. And the ideal profiles obtained with PrefMapD and IdMap differ mainly for the attributes musty taste, overall aroma and saltiness for which IdMap requires less intensity while for lamination, shape, consistency of size and bending it requires more intensity to get closer to the ideal.

Fig. 13. Sensory space obtained for the croissant dataset.

Fig. 14. PrefMapD for the croissant dataset.
Fig. 15. IdMap (left, a) and wIdMap (right, b) obtained for the croissant dataset.

Table 7
Estimation of the sensory profiles of the ideal products obtained with PrefMapD and IdMap (croissant example).

<table>
<thead>
<tr>
<th></th>
<th>IdMap</th>
<th>PrefMapD</th>
<th>IdMap</th>
<th>PrefMapD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>63.3</td>
<td>61.7</td>
<td>Crispiness</td>
<td>46.7</td>
</tr>
<tr>
<td>Height</td>
<td>59.8</td>
<td>60.5</td>
<td>Lamination</td>
<td>48.0</td>
</tr>
<tr>
<td>Bending</td>
<td>67.2</td>
<td>47.0</td>
<td>Firmness</td>
<td>65.9</td>
</tr>
<tr>
<td>Shape</td>
<td>62.2</td>
<td>50.9</td>
<td>Moistness_crumble</td>
<td>61.5</td>
</tr>
<tr>
<td>Twist</td>
<td>60.9</td>
<td>42.9</td>
<td>Eat</td>
<td>33.1</td>
</tr>
<tr>
<td>Consistency_shape</td>
<td>40.7</td>
<td>40.9</td>
<td>Butter_taste</td>
<td>54.4</td>
</tr>
<tr>
<td>Consistency_size</td>
<td>56.0</td>
<td>54.1</td>
<td>Overall_taste</td>
<td>25.5</td>
</tr>
<tr>
<td>Layers</td>
<td>58.1</td>
<td>56.9</td>
<td>Sweetness</td>
<td>39.3</td>
</tr>
<tr>
<td>Gloss</td>
<td>49.0</td>
<td>49.6</td>
<td>Saltiness</td>
<td>25.5</td>
</tr>
<tr>
<td>External_color</td>
<td>53.4</td>
<td>55.1</td>
<td>Fatty_taste</td>
<td>42.8</td>
</tr>
<tr>
<td>Internal_color</td>
<td>37.7</td>
<td>43.6</td>
<td>Musty_taste</td>
<td>21.3</td>
</tr>
<tr>
<td>Butter_aroma</td>
<td>54.0</td>
<td>50.5</td>
<td>After_taste_intensity</td>
<td>43.3</td>
</tr>
<tr>
<td>Overall_aroma</td>
<td>28.0</td>
<td>30.7</td>
<td>After_taste_length</td>
<td>41.9</td>
</tr>
</tbody>
</table>

Fig. 16. Sensory profiles of the ideal products obtained with PrefMapD and IdMap standardized according to the profiles of the products tested in the croissant example.
4. Conclusions

The Ideal Mapping technique is similar to the external preference mapping technique. However, the nature of the data used is different: for PrefMapD the sensory profiles of the products are combined to the hedonic scores while in the IdMap, the sensory profiles of the products are associated to ideal ratings. For that matter, the objectives of the techniques are different: the PrefMapD is used to define zones of maximum liking, and eventually market opportunities while the IdMap aims at defining (estimated or directly) the profile of an ideal product that could be used to guide product developers for the improvement of their products. Moreover, the IdMap can also be used to find clusters of consumers based on their ideals.

In the construction of the maps, the major difference between both techniques is related to the meaning of the liking area defined for each consumer. In the PrefMapD, the individual surfaces are obtained by comparing the estimations to a threshold. As the standard value of this threshold corresponds to the average hedonic rating provided by each consumer for all products, the individual surfaces are large. Hence, they cannot be considered strictly as ideal area. In the IdMap, the individual surfaces are smaller as they correspond to the ideal surface for each consumer. A consequence is that the proportion of consumers overlapping is decreased in this case.

In order to get more similar maps (especially in terms of proportions of consumers), one could raise the threshold in the PrefMapD. The liking areas thus defined correspond to areas where only potentially highly liked products are considered for each consumer, which corresponds more to an ideal area for each consumer. And by raising the threshold, the individual surfaces of liking are reduced, which also reduces the likelihood of overlap between consumers.

As opposed to PrefMapD, the IdMap does not require to model the hedonic ratings in function of the sensory descriptions. The variability of the ideal ratings provided by each consumer is used to define individual ideal surfaces from which the map is constructed. The confidence ellipses thus obtained can eventually be balanced together depending on the point of view adopted (IdMap).

Thus, the IdMap is rather a complement than a substitute for the PrefMapD. It is therefore recommended to combine both techniques, PrefMapD being thus used to validate IdMap. Meanwhile, IdMap can enrich PrefMapD.

Indeed, one can expect here that the two maps are:

- close and consistent if the ideal product obtained with PrefMapD belongs to the product space;
- consistent and going in the same direction when it is defined outside the product space.

In the two examples considered, the results from IdMap and PrefMapD are consistent. The information provided by the two maps is complementary (especially in the croissant example). Specifically, when the ideal product is defined outside the product space, the sensory profile provided directly from the IPM is more stable than the ideal profile estimated from PrefMapD.

In practice, with the PrefMapD, ideal profiles can also be estimated outside the product space. However, this procedure is not advised as the validity of the estimation is questionable for products outside the range of values (models being calibrated to a certain range). More precisely, there is a risk that the quadratic effects become predominant and the more the product is extreme (and hence far from the product space), the more the products is liked by the consumers.

For that reason, the estimation of an ideal product outside the product space seems more valid with IdMap. In this case, the interpretation still should be done cautiously as consumers have not been confronted with such product. A validation step which consists in creating a product closer to this part of the space and to test it again with the same consumers to ensure a higher liking is obtained.

In these two examples, the consumers are homogeneous in their ideal and hedonic ratings. No clusters were found here. However, in a situation where the panel of consumers is heterogeneous, one may consider to segment the panel in homogeneous group of consumers first before applying the methodology proposed here on each cluster separately. This corresponds to the standard methodology for analyzing consumer data when the panel is heterogeneous.

References


