Alternative methods of sensory testing: working with chefs, culinary professionals and brew masters

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17.1 Introduction

Chefs, brewers and related professionals occupy a particular role in society – they work with the transformation of some of the most basic matters of our lives. They are part highly skilled workers and part artists with a vision for the end result of their transformation. In general, they work with their senses and have a highly educated palate. However, in the hectic work environment of the restaurant kitchen or the brewery, there is little tradition for formal sensory tests. In the development lab, when prototyping new foods or beverages, there is time, but little money and tradition for sensory tests. To take sensory methods to this new territory outside the well-known facilities of the sensory laboratory is a terrifying task. Will the knowledgeable experts and educated palates ridicule the sensory profession? Will they understand the method, and the value it can give them in their work? Will they understand the results? Will they think the results are too obvious, and not worth spending the time on?

Those were some of the thoughts that rummaged around in the brain of the first author some years ago, when we first attempted to move fast sensory methods out of the sensory laboratory and into the real life of brewers and chefs.

17.2 Background: fast descriptive methods and persons with no formal sensory training in sensory tests

Descriptive analysis is known to produce detailed, robust and repeatable results, as documented by numerous scientific publications (for a review on the topic, see Dijksterhuis and Byrne, 2005; Murray *et al.*, 2001). However, it also has certain drawbacks. First, it is a very slow method, particularly because of the extended training phase. Second, it is a very expensive method. Maintaining a sensory panel is generally not affordable for small and medium-sized enterprises (SMEs) in the food industry,

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and can be a significant spending also for larger manufacturing companies. Third, it is possible that trained sensory panellists experience the product differently from the other professionals, such as chefs of brewers, or the sensory panellists may take into account sensory characteristics that may be irrelevant for the consumers (Ares *et al.*, 2010), thus providing high quality results but with lower external validity.

In order to address these drawbacks, a number of alternative descriptive methodologies have been proposed over the years, most of which require little or no training and are easily implementable with trained panellists, with other groups of professionals, and even with consumers. The idea that consumers (or generally untrained subjects) can be used for descriptive tasks – traditionally a highly controversial topic among sensory scholars (Moskowitz *et al.*, 2003) – is increasingly accepted due to three factors:

1. Strong evidence that untrained respondents, such as consumers, can provide valid and meaningful sensory (descriptive) information (e.g. Bruzzone *et al.*, 2012; Worch *et al.*, 2010);
2. Methodological developments that facilitate the collection and analyses of such responses;
3. A general consensus that a deeper consumer involvement at an early stage in the product development life-cycle is beneficial to the success of food products development (Grunert *et al.*, 2008; Stewart-Knox and Mitchell, 2003; Trijp *et al.*, 2008; van Kleef *et al.*, 2005).

A useful way to classify rapid descriptive methodologies, according to recent reviews on the topic (Valentin *et al.*, 2012; Varela and Ares, 2012), is the distinction between verbal-based methods and similarity-based methods. Verbal methods can be based on both monadic and concurrent evaluations of a number of products on individual sensory descriptors. Examples of this class of methodology are Free Choice Profiling (Williams and Langron, 1984), its Flash Profile variant (Dairou and Sieffermann, 2002) and check-all-that-apply (CATA) questionnaires (Adams *et al.*, 2007). Similarly to descriptive analysis, these methods produce a descriptive sensory profiling of the products, while bypassing the time-consuming steps of attribute and scaling alignment that is a key aspect of descriptive analysis (Valentin *et al.*, 2012).

In the second class of methods, similarity-based, respondents are presented with all products simultaneously, and give a global evaluation expressed as the perceived inter-product differences. These methods are sometimes defined "holistic," because they require the respondent to consider the product as a whole, unlike the "reductionist" verbal-based methods which require respondents to decompose the stimulus into multiple descriptors. In reality, some similarity-based methods may include a verbalization task, but this occurs only after the global evaluation, and the output is usually not used to build the perceptual space beyond simple correlational measures. The simplest (and probably best known) of these methods is the free sorting task (Lawless, 1989; Lawless *et al.*, 1995), which has been applied for sensory evaluation of beers, and is reportedly applicable with trained panellists and consumers alike (Chollet *et al.*, 2011). Another important similarity-based method is projective mapping (Risvik *et al.*, 1994), the first method to introduce the idea of expressing product differences as Euclidean differences by means of projection onto a two-dimensional space. Various adaptations and modifications of the original projective mapping technique have been proposed, the best known of which is napping® (Pagés, 2003, 2005). It is important to remark that this solution provides a sensory configuration that is not necessarily driven by the sensory variables with the strongest structure, but by those that are relatively more important for the respondent. Accordingly, some authors have observed that this method can be thought of as producing both quantitative and qualitative sensory information (Chollet *et al*., 2011). The terms napping and projective mapping are sometimes improperly used as synonyms in the literature; Appendix 1 provides a description of the differences between the two methods.

When working with expert tasters from different professions, such as brewers and chefs in these case studies, it may be necessary to change the location to accommodate their participation. Although there have been numerous systematic studies of fast sensory methods, and how the results fare compared to conventional descriptive analysis (see e.g. Dehlholm, 2012; Delarue and Sieffermann, 2004; Perrin *et al*., 2008), there has been no systematic evaluation of the effect of the test location. The effects can thus only be estimated based on sound sensory methodology considerations, and text books regarding this are good to consult (e.g. Lawless and Heymann, 2010). In general, the most important factors for a successful descriptive sensory profile is that the samples should be served blind, the respondents should not discuss their results and the respondents should carry out the task in a room suitable for sensory analysis, most often according to ISO-standards (ISO-8589:2007, 2007). The necessary considerations when carrying out descriptive analysis in a development kitchen, or a meeting room in a brewery, is thus to make sure that the respondents do not discuss the samples while they evaluate them, and that in general they disturb each other as little as possible. In general, chefs and food professionals like to discuss the food they test, and in particular, they discuss the quality of the samples. Silence during tasting is not to be assumed, so careful and repeated instructions need to be given. The effects of carrying out tests in less optimal physical environments are smaller than the effects of respondents discussing the samples during tasting. The main focus has been to go where the brewers and chefs are, and instruct them carefully to decrease bias from other respondents. We present the methods and results from two cases:

1. Brewers and beer novices assessing a set of Danish craft style beer
2. Exploring the world of spice blends and pastes with chefs and other food experts

The cases are presented and discussed individually, after a short description of the applied data analysis methods and the considerations in that connection.

17.3 Data analysis of projective descriptive methods

Data obtained by napping are usually analysed by multiple factor analysis (MFA), a multivariate data analytical technique that seeks the common structure between several blocks of variables (i.e. the individual panellists in a napping task) describing the same observations (the samples), see FactoMineR's website for further information (Husson *et al*., 2008; Lé and Husson, 2008; Lê *et al*., 2008). MFA can be thought of as a principal component analysis (PCA) in two steps. The main difference between them is that MFA takes into account individual differences, rather than averaging the data (Nestrud and Lawless, 2008).

MFA starts by computing an initial PCA on each individual matrix X_j, containing the sample coordinates for individual respondents, and subsequently transformed into a new matrix $X_{NEW\,j}$ such that:

$$X_{NEW\,j} = \frac{1}{\sqrt{\lambda_1^j}} \times X_j$$

where λ_1^j represent the first eigenvalue of the initial PCA of matrix X_j. The quantity $\sqrt{\lambda_1^j}$, called *first singular value* in MFA jargon, is basically a matrix equivalent of the standard deviation. This procedure corresponds to a normalization, i.e. the first eigenvalues of the transformed $X_{NEW\,j}$ matrices are all equal to 1 (see also Chapter 9 for additional considerations on the use of MFA to analyse napping data). That prevents the blocks with the largest variance from exerting an overwhelming influence: in napping, this means accounting for individual panellists' differences in the use of the projective space on the paper.

After this step, the data blocks are concatenated in a global data table on which a new PCA is run, i.e. by singular value decomposition of the matrix $X_{NEW} = \left[X_{NEW\,1} \middle| X_{NEW\,2} \middle| \ldots \middle| X_{NEW\,J} \middle| \right]$. The descriptive data from Ultra-Flash Profiles (UFP) are usually treated as supplementary variables to the MFA on the napping coordinates. "Supplementary variables" means that UFP data are not used to construct the MFA model, but correlation coefficients of the UFP sensory descriptors are calculated and can be presented in the product space to aid the interpretation. It is important to remark that this solution provides a sensory configuration that is not necessarily driven by the sensory variables with the strongest structure, but by those that are relatively more important for the panellist[1]. Accordingly, some authors have observed that this method can be thought of as producing both quantitative and qualitative sensory information (Chollet *et al.*, 2011). Although much positive can be said about the approach, it is not easy to use for non-statisticians, and certainly not understandable to people without good statistical command. These considerations are important when considering how to communicate the results to professionals from other walks of life, such as chefs and brewers.

For our data analysis we have kept simplicity and communication to non-sensory professionals as key points.

[1] According to the inventor of the method, this is the main advantage of napping over DA (Pagès, 2005). The latter produces (ultimately) a data matrix crossing products and descriptors. Such data, typically containing mean values over panellists, is then mean-centred column-wise and analysed by principal component analysis (PCA), either by giving identical weight to the same variables after a normalization procedure so that each descriptor gets the same variance (usually dividing the data by the sample standard deviation), or by keeping the weight of each descriptors proportional to its variance (unscaled PCA). Whichever solution one chooses, Pagès (2005) observes, the weights given to the descriptors do not necessarily correspond to the actual importance for the subject.

So for all data analysis we restrict ourselves to PCA on the raw position data, and downweigh the importance of the descriptors for this analysis and presentation to non-specialists. Similar to FactoMineR's analysis, the emphasis of the data analysis is on the positions. We consider them to be the most important because generally non-specialists need to understand the interrelationship between the tested samples. In addition, in our instructions we emphasize the positioning of the samples, and instruct panellists to add descriptors after placing the samples. In respondents' evaluation, it can then occur that samples that are perceived as very different, may share one or a few descriptors. Further, the argumentation for emphasis on positions is that with fewer trained respondents, the variation in descriptors increases. The type of descriptors that respondents use is partly affected by their background – the level of expertise they have with the products being evaluated, their particular cultural and professional background, etc. The focus on communication and thereby also simplicity in the data gives a number of good arguments to select PCA as the data analysis method[2]. For all data analysis we have used full cross validation, leaving one product out at a time. We consider both calibrated and validated explained variance to decide the optimal number of components for the individual data set. For presentation of the data, we restrict ourselves to score plots of validated variance for analysis of interrelationships between products, and use correlation loading plots to elucidate how different descriptors correlate to each other (Martens and Martens, 2001).

17.4 Case study 1: brewers and novices assessing beer

This study was hosted by the Danish craft brewery *Indslev*, which was at that time involved in a collaborative project with the University of Copenhagen, *Danish Microbrew* (see e.g. Giacalone, 2013). The panel consisted of eight brewers and nine other participants who we categorize as novices in terms of describing beer sensory characteristics. The panellists were on that occasion introduced to fast sensory methods, in particular napping. The purpose of this study was two-fold. The first aim was to assess whether napping, performed by relatively knowledgeable subjects but without formal sensory training, would succeed in discriminating between the beers and provide meaningful results for the brewers. The second aim was to compare beer novices and brewers with regards to their performance as napping panellists, with the working hypothesis that the latter group would be more consistent in discriminating and profiling the beers. The latter goal is not treated in depth here. Interested readers may consult Giacalone, Machado, and Frøst (2013). Nine Danish beers – seven commercially available and two experimental brews – were used as test stimuli

[2] At the Department of Food Science at the University of Copenhagen, a number of small animations and lectures with examples of multivariate data analysis concepts and explanations of the principles have been developed. These are broadcast on a YouTube channel ("YouTube channel: Quality And Technology"). This allows presentations of complex computations in a generally understandable form to a broader audience. We have used these videos on many occasions to teach non-statisticians about the background for the analysis and the resulting plots.

Table 17.1 The beer samples tested in case study 1 (see also Giacalone *et al.*, 2013)

Beer name	Brewery	Beer type*	Flavouring
Nutty	Ørbæk Bryggeri	Brown Ale	Walnuts
Fynsk Forår	Ørbæk Bryggeri	Pale Ale	Elderflower
Havre Stout	Bryggeri Skovlyst	Stout	Oat and rye
Classens Lise	Halsnæs Bryghus	Pale Ale	Chamomile and heather honey
Enebær Stout	Grauballe Bryghus	Stout	Juniper berries
Bøgebryg	Bryggeri Skovlyst	Amber Ale	Beech twigs
Oak Aged Cranberry Bastard	Hornbeer	Fruit Beer	Cranberries
Rosehip Beer	Experimental	Pale Lager	Rosehip powder†
Pine Beer	Experimental	Pale Lager	Pine needles extract‡

* Self-reported by the producer.
† "Organic rose hip powder" Coesam SA Laboratorios de Cosmetica. Concentration = 5% w/w.
‡ "Pin Thyrol," Firmenich SA. Concentration = 0.00625% (6.25 μL/100 mL).

(Table 17.1). The selection was made in order to be representative of main trends among Danish craft brewers, and also because each of them contained a specific ingredient of interest (e.g. due to its sensory and/or functional properties).

Experimental set-up and the instructions given to the participants were according to Pagès (2003, 2005) with one exception: in the original napping method the task is completely holistic, whereas in this case panellists were specifically instructed to focus on taste and smell characteristics of the beers. This variant is sometimes referred to as *partial* napping (Dehlholm *et al.*, 2012) and was chosen in part because there were some clear differences between samples with regards to colour (which we were less interested in), and in part because this variant was shown to produce results more similar to those of conventional descriptive analysis (Dehlholm *et al.*, 2012). At the end of the napping task, participants also did a UFP (Perrin *et al.*, 2008) evaluation of the samples: i.e., they added the sensory descriptors they found appropriate to describe the samples, and wrote them down directly on the sheet.

17.5 Results and discussion of partial napping of beer

The 17 respondents generated a total of 325 words or combinations of words to describe the nine beer samples. However, when the words were grouped according to meaning, the number decreased to 136, with 66 of them being unique descriptors used by only one respondent for one beer. The consensus configuration obtained from PCA of the individual respondents' data is showed in Fig. 17.1. It shows product clusters and Fig. 17.2 gives a presentation of the underlying sensory properties. The

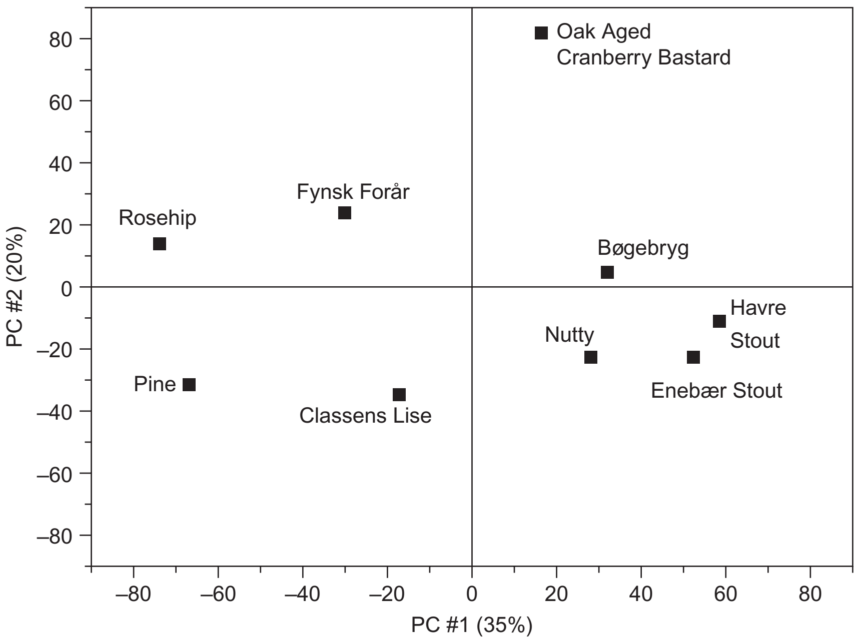

Figure 17.1 Score plot from PCA, Principal Components 1 and 2. Map of nine beers, showing the interrelationship between samples. See Table 17.1 for further information about samples.

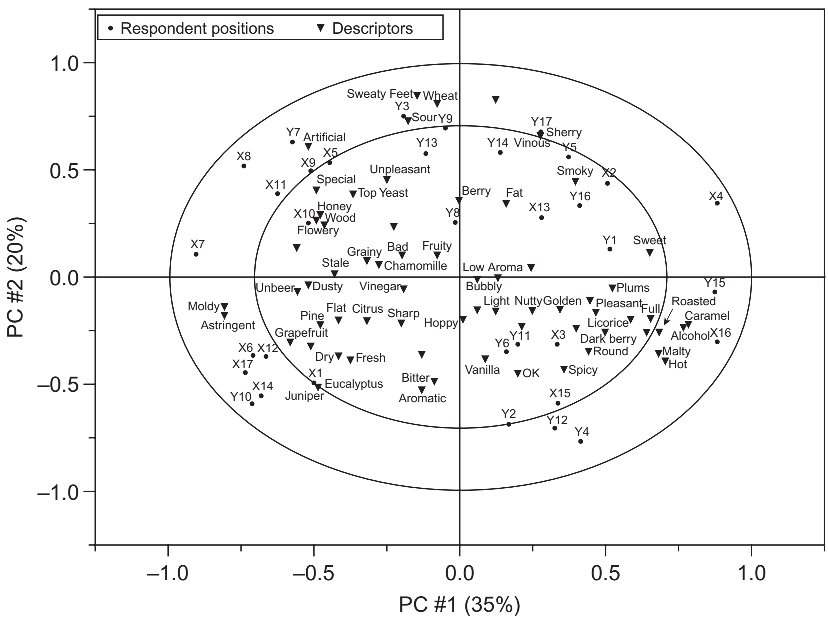

Figure 17.2 Correlation loading plot from PCA, Principal Components 1 and 2. Map of respondents' positioning (X and Y followed by respondent number ●) and descriptors (▼) used by respondents for sensory properties of the beer.

majority of the respondents positioned the beers according to either the style or the specific adjunct flavour addition, and accordingly the first principal component (PC1) separates lagers and pale ales from the four dark ales. The former group included "Bøgebryg", "Havre Stout", "Enebær Stout" and "Nutty". The correlation loading plot (Fig. 17.2) shows that they are primarily characterized by such descriptors as Sweet, Caramel, Alcohol, Roasted, Malty, Hot and Full, and by more specific characteristics such as Licorice, Dark Berries and Plums. All are descriptors which match the general beer style of these four samples. The correlation loading plot (Fig. 17.2) shows that descriptors in the opposite end of PC1 are the following: Astringent, and general woody descriptors, such as Pine, Woody, and citrus fruit characteristics such as Citrus and Grapefruit. The two beers in this group positioned in the most negative part of PC1 were the two experimental brews, Rose Hip and Pine Needle. Other sensory descriptors that were used to describe these two in particular were naturally Rosehip (four occurrences observed in raw data) and Pine, respectively (nine occurrences), but also Astringent and Dry. Fynsk Forår, a pale ale with added Elderflower, is positioned somewhat positive on PC2 and medium negative on PC1. It received descriptors such as Flowery and Elderflower, that are also positioned in that direction in the correlation loading plot. The second component indicates the unique characteristics of one sample (Oak Aged Cranberry Bastard). This is a fruit beer brewed with cranberries, which was often characterized as Sour (nine occurrences) and opposed to Bitter, a descriptor more often used to describe all of the other beers. Further, Oak Aged Cranberry Bastard is produced by spontaneous fermentation (as in some Belgian beer styles): this characteristic was perceived by some panellists, as the descriptors Wild yeast and Sweaty Feet were positively correlated with the second component.

Furthermore, we were interested in looking at the level of agreement of the individual respondents with the general consensus configuration. In line with our expectations, we found that the brewers had configurations more consistent with the consensus profile, suggesting that the degree of product expertise may increase panellists' reliability in a napping task (Giacalone *et al.*, 2013). In general, the product discrimination by napping and the sensory characterization obtained by UFP were clearly interpretable, in the sense that they matched our knowledge of the samples and the characteristics specified by the producers. The method was generally very well received by all panellists, who experienced it as a sort of tasting game. In addition, the brewers and other collaborators in the project understood the results well when they were presented with them. Considering its speed (the whole napping session was conducted within 30 minutes, including time for introducing the method), napping is very advantageous for exploratory purposes in early stages of product development. In a brewery setting, the first issues in a product development project is the design of the brew (e.g. deciding on a specific brewing style), and then the formulation (i.e. deciding on type and quantity of raw materials and processing). At this stage, the pilot plant can be used to develop initial prototypes that may be evaluated by napping, together with existing products or similar in-market alternatives, to obtain an overall description of the product space the experimental beer occupies, and provide a summarized description of the underlying sensory dimensions. Such a test can be used for rapid product screening, to gather feedback on the product and process specifications, and/or for vocabulary generation. In addition, it serves to document the sensory outcome of experimental brews in a systematic manner. If one is sufficiently acquainted with the method, a napping test can be fairly easily arranged, for example with available co-workers: a good solution, since they will be high in beer expertise and will be acquainted with the method, both of which are desirable characteristics for a napping panel. Our results with this particular test showed that the experts (brewers) were more in agreement in their evaluation of the sensory properties than the novices (Giacalone *et al*., 2013). From this we infer that the product expertise they have, and the product language they share, makes them more suitable for fast projective sensory methods than general consumers, mainly because of their expertise in assessing the sensory properties, or more often the quality of the products in their field of expertise.

17.6 Case study 2: exploring the world of spice blends and pastes with chefs and other food experts

Our purpose was to capture the sensory differences in a large set of traditional spice blends and pastes using methods similar to napping® and UFP. Samples were chosen in order to include a unique variety of traditional blends from around the world in addition to several "New Nordic cuisine" samples, such as Juniper Ant Paste and Peaso. Consequently, the samples incompletely represent the very large differences that exist in mixes of different flavourful ingredients from a broad range of cultures. All samples were held frozen before being dispensed and brought to room temperature 45 minutes prior to testing to ensure consistency between trials. Samples are either liquid-based, oil-based, dry-based, dairy-based, or fermented. Samples, sample categories, and ingredients are listed in Table 17.2. A total of 26 subjects, including chefs, students majoring in a food-related field, and other food professionals participated in the study. Due to our large sample size the study would benefit from individuals experienced in tasting food, as they more quickly and accurately are able to identify and name the flavours in the mixes than novices would be. For this reason, we chose to draw from a pool of food knowledgeable persons.

The study included 29 different aromatic blends presented at the same time, which is quite a large number of samples. Thus, to reduce the likelihood of fatigue and inaccurate results, we were prompted to both recruit experienced subjects as well as make subject placement of samples and data quantification easier by increasing the size and including a grid on the napping® sheet, identifying this method as "Big Grid" napping. For this an A0-sized (84.1 by 118.9 cm) plastic-coated sheet was used. A grid of 60 by 90 cm with 2 cm squares was printed on the sheet. For ease of data collection, numbers representing the centimetre position of each line intersection from the lower left corner were added as labels outside the frame of the grid (see Fig. 17.3). The study were conducted at the Nordic Food Lab, located on a houseboat in Copenhagen, Denmark. Due to logistical reasons, respondents completed the study one person at a time. Before the experiment, a quick 5–10 minute instruction session was delivered

Table 17.2 **Spice blends and the ingredients they contain**

Category	Blend	Composition – ingredients
Liquid-based	BBQ Chipotle Blend	Chipotle, panela, apple vinegar
	Jerk paste	Onion, vinegar, scotch bonnet pepper, allspice, black pepper
	Juniper and Ant Paste	Juniper berry, thyme oil, ant, verbena, lemon thyme, woodruff
	Tomato/epazote	Tomato, epazote, piquin chilli
	Pickling blend	Coriander seed, vinegar, juniper berry, bay leaf
	Vihna d'alhos base	White wine, onion, paprika, garlic
Oil-based	Afro Bahian Base	Coconut milk, cassava, green pepper, cilantro
	Aji Panca Adobo	Aji panca, beer, grape seed oil, soy sauce
	Ligurian Pesto	Parmesan, pine nut, French beans, basil, potato, garlic
	Massaman	Shallot, lemongrass, galangal, garlic, red chile, shrimp paste, coriander seed, cumin, peppercorn, clove, cardamom
	Mole Negro	Guajillo chilli, mulato pasilla chilli, chille chipotle mora, sesame seed, peanut, almond, walnut, pecan, raisin, semi-sweet role, cinnamon, black pepper, clove, cumin, thyme, Mexican oregano, bay leaf
	Pipian	Pumpkin seed, tomato, corn, achiote, epazote, Mexican oregano
	Recado	Achiote, masa, cumin, pepper
	Salsa Verde	Capers, flat leaf parsley, olive oil, anchovy, lemon and rind
Dry-based	Berbere Mix	Coriander, clove, fenugreek, black pepper, cayenne, ginger, allspice, cumin, cardamom, cinnamon, nutmeg
	Dukkha	Hazelnut, cumin, sesame, coriander seed, black pepper
	Quatre Epice	Black pepper, cinnamon, clove, ginger, nutmeg
	Za'atar	Oregano, thyme, sumac, sesame seed, cumin
	Shichimi Togarashi	Szechuan peppercorn, buckwheat, koji, orange, garlic, nori, red chilli pepper, ginger, sesame seed
	Chinese Five-Spice	Star anise, Szechuan peppercorn, fennel seed, clove, coriander seed, cinnamon
	Panch Puran	Fenugreek seed, nigella, cumin seed, black mustard seed, fennel seed
	Garam Masala	White pepper, cinnamon, clove, cardamom, nutmeg, fennel seed, coriander seed, bay leaf

Table 17.2 Continued

Category	Blend	Composition – ingredients
Dairy-based	Fresh Dill marinade	Crème fraiche, Dijon mustard, dill, honey, fennel seed
	Kadi	Yogurt (cow's milk), onion, Graham flour, ginger, cumin, mustard seed, turmeric powder
	Aji Escabeche/ Peanuts	Aji Escabeche, huacatay, peanut, milk, crème fraiche, fresh cheese
	Tikka Masala	Yogurt (cow's milk), onion, ginger, garlic, paprika, coriander seed, cumin, turmeric, cayenne, tomato
Fermented	NFL Fermented Bean	Black soy bean inoculated with *Aspergillus oryzae*, icing sugar, food molasses, white wine vinegar, black garlic
	Lacto Blueberry	Blueberry, sea salt
	Peaso	Yellow peas, buckwheat, koji, sea salt

and participants were not provided with any additional details about potential word suggestions to describe samples, but instead were instructed to determine their own criteria for placing and describing samples. Respondents did not discuss their evaluations with others during the assessment. To counteract sensory adaptation, respondents were provided with a small container of roasted coffee beans to sniff when their noses adapted to the aromas of the blended spices/pastes. Sample descriptions from respondents were highly varied, but by grouping descriptors with the same or very similar meaning, a consistent set of descriptive words was formulated to be used for further statistical analysis.

17.7 Results and discussion of spice blends and pastes

A visual representation of the results from the data analysis of the projective mapping of the 29 mixes/pastes is shown in Figs 17.4 and 17.5. From a culinary and sensory viewpoint, all samples are different from each other. For the present purpose, the most interesting part is the degree of agreement between individuals' maps of the differences. Consider the enormous memory load that is used to keep track of the sensory properties of so many samples during the projective mapping. The summed validated explained variance for the first two PCs is 37%. Analysis of the screen plot for both validated and calibrated variance (not shown) indicates that three may be the optimal number of components, but we limit the plots to only PCs 1–2. PC3 accounts for an additional 9% of validated variance, whereas the total calibrated variance is 30% after three PCs. A total of 335 descriptors were used to describe the different samples. Of these 121 were unique descriptors, used by only one panellist to describe one sample; in addition, the total number of descriptors that were used five times or less is 233. So the verbal response to the task varied greatly.

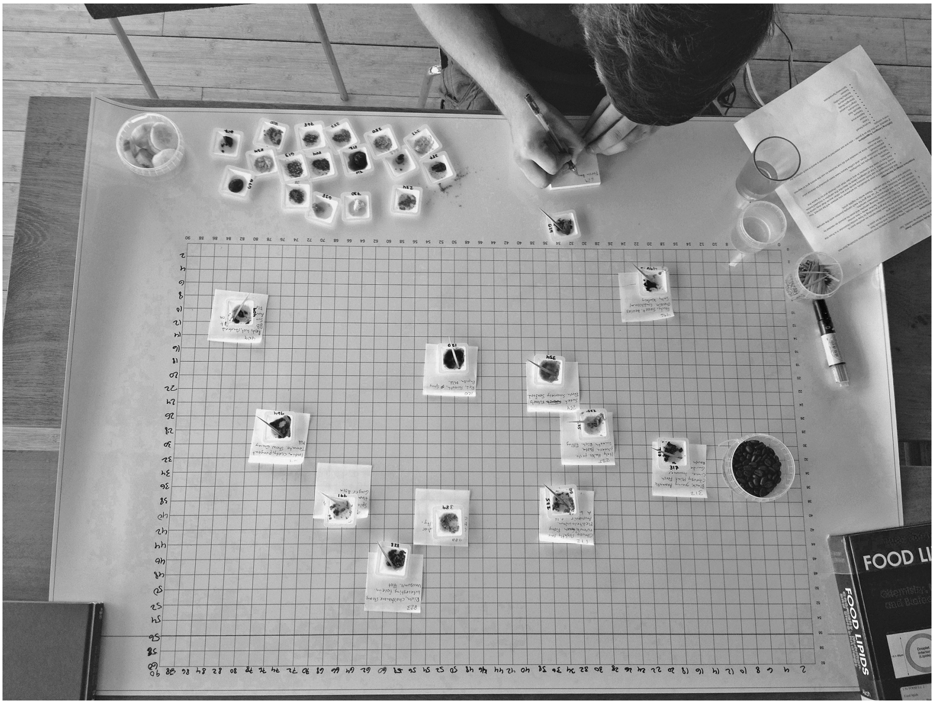

Figure 17.3 Respondent carrying out the task of positioning and describing 29 spice mixes and pastes. Note the size and the grid, identifying this method is "Big Grid" napping.

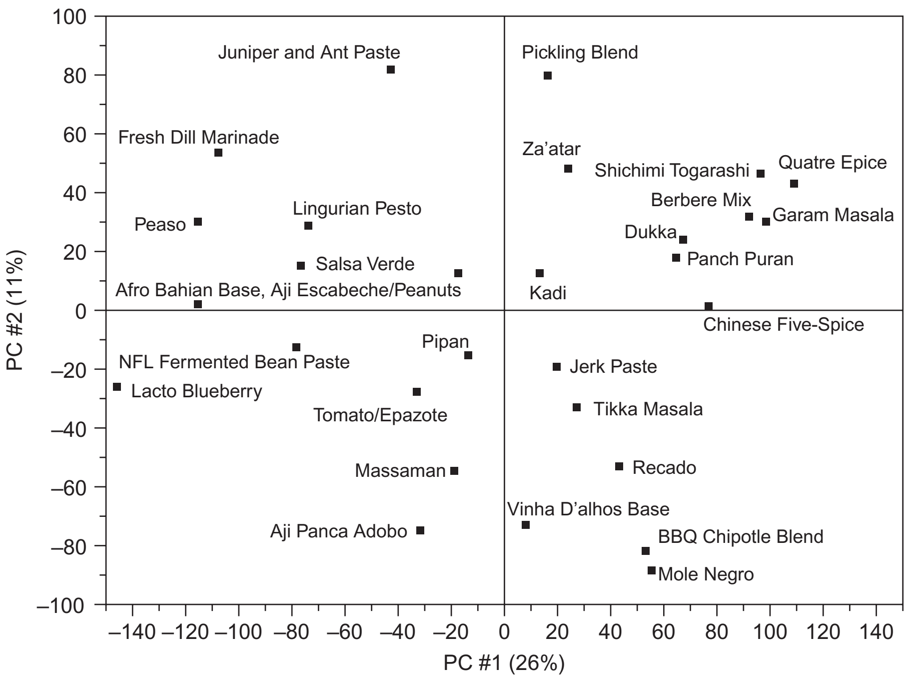

Figure 17.4 Score plot from PCA, Principal components 1 and 2. Map of 29 spice blends, showing the interrelationship between samples. See Table 17.2 for further information about samples.

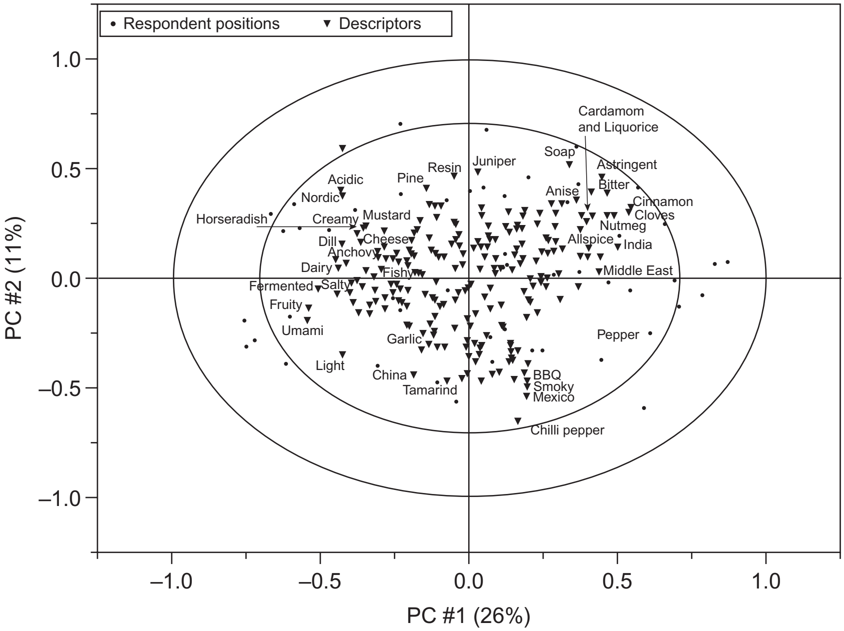

Figure 17.5 Correlation loading plot from PCA, Principal Components 1 and 2. Map of respondents' positioning (●, labels omitted for brevity and clarity of the figure) and descriptors (▼) used by respondents for sensory properties of the spice blends. For clarity only important descriptors are labelled.

Using data from 26 respondents with a large variation in geographical background and an unheard of 29 different potent samples to evaluate, the first question we pose is: are the results from the experiment comparable to other studies? From a range of studies with eight or more samples and many respondents the range of explained variance in the first two dimensions is reported as low as 22% (Torri *et al.*, 2013, 12 wines described by 81 wine consumers) and up to as high as 62% (Reinbach *et al.*, 2014, 8 beers with 55 respondents ranging from novices to brew masters; Ribeiro, 2011). At face value, the present results with 29 spice blend samples evaluated by 26 very diverse respondents from the food and restaurant trade appear comparable to other results. The litmus test is if the results make sense from a culinary and sensory point of view, i.e. can meaningful interpretations be made from the data? The overall observations from the data in terms of the interrelationship between the samples and their descriptions, are given in the following.

Samples positioned in the negative part of PC2 and in the positive part of PC1 (lower right part of Fig. 17.4), are Recado, BBQ Chipotle and Mole Negro, which all emerge from the southern part of North America or Central America. they are characterized with descriptors such as Smoky, Mexico, BBQ, Chilli Pepper and Pepper (Fig. 17.5). The samples positioned in the positive part of PC1 and PC2 (right and upper right part of Fig. 17.4), are Shichimi Togarashi, Quatre Epice, Berbere Mix, Garam Masala, and to some degree the group also encompasses Dukkha, Panch Puran and Chinese Five-Spice. The geographical origin of those samples is well spread. However, they are all mixes of dried spices that are used as a basis for a wide range of dishes in their respective kitchens. The descriptors most often used to describe them are: Cinnamon, Cloves, Nutmeg, Bitter, Astringent, Allspice, Liquorice and Cardamom (Fig. 17.5). Samples positioned in the highest positive part of PC2 (top of Fig. 17.4) are Juniper Ant Paste and Pickling blend, samples that appear to be completely unrelated, but when the ingredients are studied (Table 17.2), they both contain Junipers, which is one of the descriptors characterizing these samples in addition to Resinous and Pine, both have characteristics that Juniper possesses. Samples in the lowest negative part of PC1 (left side of Fig. 17.4) share their origin. Peaso, Black bean paste and Lacto Blueberry originate from the Nordic Food Lab from the Noma restaurant, and are fermented flavour enhancers, with a significant umami taste component to them, which are also the descriptors most associated with them (Fig. 17.5). Afro Bahian Base is grouped with these samples. Bear in mind that the position of each sample is based solely on how the sample is positioned by individuals. The main descriptors for Afro Bahian Base are Coconut, Fresh, Cool and Cucumber (from raw data, not shown), that are also positioned in the direction (Fig. 17.5), albeit closer to the centre than many other descriptors. The downweighting of the descriptors in the analysis is the cause of this observation. In the upper vicinity of this group is Fresh dill marinade, a dairy-based Scandinavian concoction (see Table 17.2), used as a sauce or a marinade. The words associated with it are: Acidic, Nordic, Dill, Creamy, Mustard and Horseradish. These correspond to the ingredients, where the characteristic Horseradish originates from the same compound as mustard – allyl isothiocyanate. Closer to the centre in the same direction are Ligurian Pesto and Salsa Verde, both of them South European oil-based sauces, with a high content of umami-rich ingredients (parmesan and anchovies, respectively), and some pungent characteristics from Garlic – in the Ligurian Pesto, and from lemon with its rind in the Salsa Verde. Naturally the descriptors most often associated with these two samples are strongly related to this: Fishy, Anchovy and Salty for the Salsa and Cheese and Garlic for the Pesto, which are also located in that direction on the loading plots (Fig. 17.5). The samples positioned around zero on PC1 and the most negative part of PC2 are Aji Panca Adobo, Massaman and Vinhas d'Alhos. They originate from three different places: Ecuador/Peru, Thailand and Portugal, respectively. They also have very different compositions (Table 17.2), but by their overall perception in the set of mixes they are relatively similar. There are a few descriptors that they share, such as Salty, Garlic and Light (from raw data, not shown), but they are not located in that direction in the loading plot (Fig. 17.5), as they also characterize a number of other samples. Towards the centre of the plot are samples such as Aji Escabeche/Peanuts and Kadi, where both are dairy-based, and although they share a dairy base, the share only very few characteristics (Nutty and Curry, from raw data). In the lower part of the centre is Pipian, Jerk paste, Tomato/Epazote and Tikka Masala. In general, the samples in the centre of the figure are those that are less extreme with no specific characteristics being very dominant.

All in all, the interrelationship of the samples based on the consensus map from all 26 respondents is meaningful, when aligned with the culinary and gastronomic knowledge regarding those samples. However, as the respondents could freely list as many descriptors as they wanted for each sample, and there were no restrictions on which descriptors to use, the list was immense. Respondents' responses reflected their interest in food, and their experience in verbalizing the sensory information they processed. A majority of the respondents attempted to guess where the individual mixes/pastes came from, by listing countries or regions. A number of them responded with information about their suggested use for the spice mixes/pastes, e.g. "*very nice for cabbage and cake, good for Danish rolled meat sausage and liver pate,*" which was not included in the data analysis. Had we done so, the results from the descriptors would have been much more complex. Of the 335 different descriptors, 126 only occurred once, and a total of 221 were used five times or less. Respondents took between 45 minutes and 2 h to complete the projective map of the samples, and although most were delighted by the sheer variety in sensory properties they were exposed to, it was also an exhausting task to complete. In general, the feedback we collected was that it was a good experience, but there were a lot of samples to assess.

We have not presented the results to all of the participants at the time of the completion of the manuscript, but those to whom we have presented the results responded enthusiastically to the information. To many chefs this is a completely new method to organize their tastings, and the results can be understood by chefs in terms of their culinary organization of knowledge about what different spice blends and pastes can be used for, or as a reminder of what they have tasted on a particular occasion. The variation of the method we introduced – so-called Big Grid napping – was perfectly suited for a large number of samples. The use of a plastic-coated sheet of paper had the additional benefit that it could easily be cleaned with a wet cloth. It has proved very durable and can still be used more than a year later.

17.8 General discussion and recommendations

Initially there were two main questions with taking fast sensory methods out of the sensory laboratory, and into the domains of the professional kitchen or the brewery. One was if chefs and brewers would realize the benefits of the method to them, and the other was if they could understand the results of the data analysis. In general, brewers have a good enough understanding of the benefits of science to their field, so that they see the benefits of organized tasting, and systematic recording of the results of tastings. Chefs in general are less scientifically orientated than brewers, but in recent years the fields of science and gastronomy have benefitted from each other in several connections (see e.g. Risbo *et al.*, 2013). Chefs who have an interest in science appreciate the dual nature of Nordic Food Lab, with both a theoretical and a practical approach to food. Nordic Food Lab seeks to reconcile the two approaches, using modern and traditional methods to combine craft and science for delicious results. Using fast sensory methods with chefs and related professions, we have found that the organized and systematic collection of tasting notes is not overly complicated for the conditions in an experimental kitchen.

As mentioned in the introduction, there have been no systematic tests of the effect of changing the location from a sensory laboratory to different settings, such as a brewery or an experimental kitchen. However, for the practical purposes that we have explored in these case studies, we find that any effect of the location itself may be of a very small magnitude, if the general guidelines that panellists should not discuss their evaluation during sessions are followed. Having said that, it also remained a challenge for chefs and brewers to restrain themselves from voicing their opinions. In the case of the spice blends, panellists would generally do the evaluation alone, and were thus not able to disturb other participants, whereas with the brewers, everybody was seated in the same room and few utterances were made during the session.

The two case studies are very different in their nature. The case study with spice blends shows that it is possible to evaluate a very large pool of samples, and obtain meaningful results from the analysis. However, it is necessary to consider that the variety in the sensory properties in the sample set was very large. It is very likely that had there been only minor sensory differences, the results would not have been so clear. Although we did not systematically compare different variations of the method, we conclude that the new variation of the method that we presented, so-called Big Grid napping, facilitated evaluation of the large number of samples. Comparing the two cases, it is clear that the diverse backgrounds of the respondents for the spice blends/pastes increased both the variety in the descriptors, as well as the number of descriptors. We propose limitations to respondents' use of descriptors, both in terms of the type that they can use, restricting them to sensory descriptors and discouraging more general or holistic terms. However, there may be some applications where e.g. suggesting appropriate uses of a sample, can be beneficial. We also propose to limit the number of descriptors that a respondent can give to a sample. An upper limit of five descriptors appears to be a reasonable balance between restrictions and enough options to give a good description of a sample. An effect of limiting the number could be a more focused process in the selection of which descriptors best characterize a particular sample.

The variety in backgrounds of the respondents in both case studies is likely to have led to increased variety in the descriptors used. One of the differences previously found between different levels of expertise is the type of words used to describe the products. In another experiment with craft style beer, Ribeiro (2011) found that beer experts to a larger extent used specific sensory descriptors (e.g. Malty, Ester, Astringent), whereas less experienced beer drinkers used more abstract and integrated terms (e.g. Summer, Heavy, Youth). Differences in descriptors usage also highlight the apparent benefit of focusing the data analysis on the positions of the samples on the response sheet, and downweighting the importance of the descriptors. Descriptors should be regarding supplemental information that aids in the interpretation of the differences between samples. In an unpublished study of expert chocolatiers' and chefs' perceptions of premium chocolates, Magelund (2013) applied a procedure in which participants tasted the samples, and discussed descriptors that were suitable, prior to carrying out a projective mapping of the samples. The procedure provided more aligned use of descriptors among the respondents.

Successful communication of the results to non-sensory scientists requires careful attention to the knowledge that the receivers have. Multivariate data analysis is a concept that requires thorough explanation, and meticulous attention to the immediate feedback from the receiving audience. PCA can be explained to laymen. The analogy to a geographical map of a region is straightforward. The main purpose of a PCA is to reduce the complexity in data presentation, by extracting the main underlying phenomena and structure of a data set. It is easy to communicate that to laymen, since it is a common feature of much analysis we as humans do in many different activities – we tacitly extract what is important, and eliminate or put less attention to less important features[3].

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[3] At the University of Copenhagen we have implemented a short course aimed at practitioners working with product development in SMEs. The purpose is to teach them how to use fast sensory methods, both similarity-based and verbal-based sensory methods. In the teaching situation we use short animation films to teach PCA at a conceptual level, and the reception from the participants has been very positive. The considerations regarding data analysis have been how to make it operational and simple to use for laymen. The freeware PanelCheck is the most user-friendly free software, with very simple instructions necessary for successful operation of the program (see e.g. Tomic *et al*., 2010). Although the software is designed for data from conventional descriptive analysis, it is possible to analyse data from projective mapping. The challenge is to provide guidelines for evaluation of the quality of the data and results that are both rigid and simple to understand. The experience in the Sensory Science Group at KU is that a necessary precaution when non-sensory scientists analyse the data is a strict focus on the explained variance. Although the range of explained variance in published studies can vary substantially, we recommend that it should be above 30% for the first two PCs. To keep the data analysis simple, we recommend a two-step procedure, with initial analysis of the positions only, and subsequent analysis of the positions and the descriptors (standardized data), and limit the analysis in the latter to plots that give information about which descriptors are attributed to different samples.

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Appendix: Projective mapping versus napping (see also Chapter 9)

Projective mapping and napping are often improperly used as synonyms in the literature. It is more correct to state that napping is a specific case of projective mapping. While napping has a specified protocol (Pagès, 2005) with regards to materials, task instructions and data analysis, projective mapping is a more generic approach to sensory evaluations. Table 17.3 shows an overview of the differences between projective mapping and napping.

Although the issue of terminology may appear trivial, it is useful to bring this up because method users need to be aware that protocol modifications may alter the way panellists face the task and produce slightly different results. For example, as Dehlholm (2012) has shown, the shape and size of the frame affect the projection strategies the panellists adopt (particularly the use of the first and second dimension). Further, data analyses other than MFA on unscaled data may yield results that do not reflect individual panellist's use of the space (Morand and Pagès, 2006).

Table 17.3 A schematic overview of the differences between projective mapping and napping

	Projective mapping	**Napping**
Frame geometry and size	Rectangular (A4 or A3) or square (60 × 60)	Rectangular (60 × 40)
Frame look	Drawn axes, gridline, or blank	Blank
Data analyses	GPA, PCA, MDS-INDSCAL, STATIS	MFA on unscaled data