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A discussion of recent methodologies for combining sensory and extrinsic product properties in consumer studies

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ABSTRACT

Understanding the interaction of sensory and extrinsic product attributes in consumer preferences has been identified as one of the key pillars for raising the likelihood of food products' success in the market. Over the course of the last decade there has been increased attention on research emphasizing a combination of these food-choice driving parameters. This paper discusses progress made in the field focusing on three groups of methods: (i) conjoint hedonic methods (ii) "classic" hedonic testing and (iii) alternative descriptive approaches. For each method a description of the methodology in question, its objectives, advantages, drawbacks and applications are examined. Industrial challenges and future research needs are discussed.

1. Introduction

1.1. Background

New food product development (NFPD) plays a crucial role for modern food industry (Kemp, 2013; Lesschaeve & Bruwer, 2010). Despite this, new food products entering the supermarket shelves every year have a high failure rate (Costa & Jongen, 2006; Grunert, 2007) resulting in substantial costs and missed opportunities for food industries (Kemp, 2013). There are various drivers underlying this high failure rate such as the low rate of investment in research and development (R&D) activities (Winger & Wall, 2006) and the lack of proper incorporation of consumer voices in the new food product development (NFPD) process (Dijksterhuis, 2016; Grunert et al., 2010; Kemp, 2013; Van Kleef & van Trijp, 2007). An important aspect of the latter is that food innovators in general have relied more on experts than on consumers (Olsen, 2015). For example, in the past consumer food scientists have had a tendency to focus more on trained sensory panelists' evaluation than consumer tests. Notwithstanding the above, during the past decades the incorporation of consumer voices in NFPD process through consumer tests and opinions has gained in significance in the food consumer science (Meulenberg, 1997; Moskowitz, 2000; Olsen, 2015; Steenkamp & Van Trijp, 1996). However, even though incorporating the voice of the consumer into the NFPD process is important, previous studies investigating the food quality perception and food choice process conclude that the process is very complicated (Bernués, Olaizola, & Corcoran, 2003; Grunert, 2005; Köster, 2009). A large number of different scientific disciplines (like biology, physiology, psychology, sociology, sensory, consumer and food science, marketing and economics) are involved. Many different factors interact to form consumers' perception and preferences. In this paper, we focus specifically on product related characteristics and how to measure the interaction between them.

1.2. Importance of sensory and extrinsic product attributes and their interaction

Food product characteristics can be separated in two main groups: intrinsic and extrinsic attributes. Intrinsic attributes are product attributes which cannot be changed or experimentally manipulated without also changing the physical characteristics of the product itself (Olson & Jacoby, 1972). Examples of intrinsic attributes are sensory properties (e.g. taste, appearance, texture, etc.), chemical and physical properties of food, such as the product composition (e.g. ingredients) (Grunert, 2002; Olson & Jacoby,

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1972). Sensory attributes are also considered *experience* attributes (Marreiros & Ness, 2009) because consumers have to experience them directly to assess their products' evaluation (i.e. taste a product). Intrinsic attributes play a crucial role in consumers' product appraisal (De Pelsmaeker, Dewettinck, & Gellynck, 2013; Piqueras-Fiszman, 2012; Tuorila & Pangborn, 1988), which again affects consumers' preferences and choices. In this paper we focus on methodology related to sensory attributes.

Extrinsic attributes are product-related attributes which are not a part of the physical product, thus they can be changed without altering the physical product characteristics (Olson & Jacoby, 1972). Examples of extrinsic attributes that can significantly influence consumers in their choices are brand, price, package-layout and health claims (Jaeger, 2006; Lähteenmäki, 2013). Some of these extrinsic attributes (like price, layout, brand) can easily be evaluated during shopping, while others are unobservable (like health/sustainability claims) and must be believed (Fernqvist & Ekelund, 2014; Northen, 2000).

Many studies (De Pelsmaeker et al., 2013; Endrizzi et al., 2015; Grunert, 2015; Hoppert, Mai, Zahn, Hoffmann, & Rohm, 2012; Loebnitz, Schuitema, & Grunert, 2015) show the key role of interactions of intrinsic and extrinsic attributes in affecting consumers' preference. Varela, Ares, Giménez, and Gámbaro (2010) found that the provision of brand and package information has a substantial impact on consumers' hedonic liking for orange-flavoured powdered drinks.

Thus, research that combines both intrinsic (sensory) and extrinsic factors makes it possible to obtain more complete and realistic information about consumer behaviour in real life buying and eating situations (Köster, 2009; Simeone & Marotta, 2010).

1.3. Advantages of methods that combine intrinsic and extrinsic attributes

Both product developers and marketers can benefit from interactive consumer methodologies, but in different ways. First, it is possible to acquire more reliable information about which specific levels of the product attributes are preferred (De Pelsmaeker et al., 2013; Menichelli, Olsen, Meyer, & Næs, 2012). Second, the identification of the main drivers of consumer choice (Næs, Brockhoff, & Tomic, 2010) can be done in a more realistic way. Third, it is possible to speed up the NFPD process by for example including sensory and marketing tests jointly instead of conducting separate consumer tests. Fourth, more accurate information about individual differences can be achieved.

One of the most problematic points that emerges when combining sensory and extrinsic food attributes is the fact that these attributes usually involve different functional areas or departments within the food industry, such as product development, packaging and marketing (De Pelsmaeker et al., 2013; Jacobsen et al., 2014; Piqueras-Fiszman, 2012). One of the key criticisms of sensory tests is that translation into concrete marketing strategies is difficult (De Pelsmaeker et al., 2013; Jacobsen et al., 2014). This is partly due to the general absence of a common language and culture. Thus, it is of crucial importance to improve internal communication among the different functional areas involved in the NFPD process (Jacobsen et al., 2014) as well as to develop a methodological framework that includes the concerns about R&D, packaging, marketing and sensory departments that can be of use to collaborate more efficiently and in turn save time and money.

1.4. Objective and structure of the paper

This paper is a discussion of the latest methodological developments combining sensory and extrinsic food product characteristics in consumer research, and their potential industrial applications, as well as future research needs. The previous discussions and reviews of methodologies on this type of consumer research were published more than five years ago (Simeone & Marotta, 2010; Van Kleef, 2006; Van Kleef & van Trijp, 2007; Van Kleef, Van Trijp, & Luning, 2005). No discussion and review of methodologies that specifically combine intrinsic and extrinsic food attributes were found at the time of writing this paper, the closest being the paper by Varela and Ares (2012) which reviewed some alternative descriptive techniques which can also be used to include the combination of intrinsic and extrinsic attributes. After the introduction section, we will discuss the latest methodological developments combining both sensory and extrinsic attributes, listing each method's objectives, advantages, drawbacks and applications. We will then conclude with a discussion of industrial challenges and future research needs in this area.

2. Latest developments of methodologies combining intrinsic and extrinsic food attributes

We identified three categories of methods which combine intrinsic and extrinsic attributes: conjoint hedonic methods; "classic" hedonic testing; and alternative descriptive approaches (Table 1). However, in some cases overlaps among the different categories were found.

2.1. Conjoint hedonic methods

2.1.1. Traditional conjoint analysis

Conjoint analysis (CA) is a market research method where consumers are presented with a variety of products, each differing from the other on a set of chosen attributes (Green & Srinivasan, 1978) with the main scope of calculating the relative importance of the product attributes (trade-offs) that characterize the food product (De Pelsmaeker et al., 2013). Consumers have to state their preferences either by rating, ranking or choosing among the different options according to their degree of acceptance or probability of purchasing (Enneking, Neumann, & Henneberg, 2007; Jaeger, Wakeling, & MacFie, 2000). In the literature there is a large number of applications of CA within food consumer studies (Almli, Øvrum, Hersleth, Almøy, & Næs, 2015; Ares & Deliza, 2010; Claret et al., 2012; Endrizzi et al., 2015; Font i Furnols et al., 2011; Helgesen, Solheim, & Næs, 1998; Næs, Kubberød, & Sivertsen, 2001). Most frequently, CA data are analysed by ANalysis Of VAriance (ANOVA) based methods; we refer to Næs et al. (2010) and Gustafsson, Herrmann, and Huber (2003) for overviews.

In the special case of combining extrinsic and sensory attributes, the standard way of using CA involves considering the samples as individual levels of a single experimental factor, and then combining these samples with extrinsic attributes in a full factorial design (Johansen, Næs, Øyaas, & Hersleth, 2010). Such an approach is not fully satisfactory because the set of samples is likely to fall short of adequately spanning the important sensory attributes, since these variables are not taken into account in the selection itself (Johansen et al., 2010). Another limitation in CA is that sometimes a full factorial design may be too large, making it difficult in practical terms to perform a test with a large number of products and extrinsic attribute levels. On the other hand, the use of fractional factorial design, which reduces consumer fatigue and brings down costs, is relatively complicated in situations with several factor levels. One of the problems is to obtain exact information about the confounding pattern among the factors, which is important for assessing whether the significance of an estimated effect is only due to the corresponding factor or due to a series of interactions among factors.

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Table 1
Overview of methods combining intrinsic and extrinsic food attributes.

Category	Method
Conjoint hedonic methods	Traditional conjoint analysis Recent rating based conjoint analysis approaches Choice-Based Conjoint Analysis
"Classic" hedonic testing	Combination of blind, expected and informed hedonic-testing
Alternative descriptive approaches	Projective Mapping Check-All-That-Apply (CATA)

2.1.2. Recent rating based conjoint analysis approaches

Johansen et al. (2010) proposed a new approach to experimental design in CA, in which the aim is to investigate the effects of the actual sensory attributes in interaction with product information for the purpose of identifying the most promising (or poor) combinations of the two types. The method is based on selecting a few samples to be tested from descriptive sensory data from a larger set of representative samples for the problem of interest. After performing a sensory profiling session by trained assessors, sensory data are analysed using principal component analysis (PCA), and scores plots and loadings plots are constructed. Then, samples are selected according to a geometric structure resembling (as much as possible) a rectangle in the two-dimensional principal component space. The corners of the rectangle are selected so that the rectangle represents the entire sensory variability space, and with the two rectangular directions corresponding to the two most dominant sensory dimensions. The two dimensions in the rectangle can be thought of as new latent orthogonal variables, called "meta-attributes", while the loadings plot provides additional interpretations. Finally, the two meta-attributes are used as two sensory factors at two levels, each according to the rectangle. These sensory factors are then combined with the related information variables of interest. In Johansen et al. (2010) this was done in a two-level design with the advantage of transparency with respect to the confounding structures.

The new CA approach has several advantages. First, the selected samples span the sensory space, making it possible to explicitly concentrate on the sensory attributes of interest. Second, the selected samples combine easily in an experimental design with extrinsic factors. Third, the method can easily be extended to three or more sensory dimensions and to situations where no specific sensory properties are of particular interest a priori. In these situations one will simply seek to establish a rectangular shape that covers the whole region as fully as possible and interpret the axes accordingly. Fourth, data analysis can be easily performed through the application of ANalysis Of VAriance (ANOVA). The meta-attributes, the extrinsic conjoint factors and their interactions are simply incorporated the standard way making analysis straightforward.

Note that the interactions between the sensory meta-attributes and the extrinsic conjoint factors are of special importance when focus is on combinations of the two types of variables. If the interaction effect is found to be significant, this means that the perception of the sensory properties is changed by the information given. The next step is then to use an interaction plot to visualise how the liking of the sensory properties of the products change with the information given. This type of plot can be used both for identifying good combinations of the intrinsic and extrinsic properties (i.e. those with the highest liking) and also for assessing whether the effect is large enough to be taken into account. For further fine-tuning, one can also use for instance Tukey's method for multiple comparison for assessing differences between the different combinations of levels.

The new CA approach is therefore an appropriate tool for revealing the effects of specific intrinsic and related extrinsic product attributes and their interaction. This approach is recently been used and tested by Endrizzi et al. (2015).

However the new CA approach also has a few drawbacks. For instance, since it only considers the corners of the rectangle in the PCA scores plot, only linear models can be employed (Menichelli et al., 2012). Thus, if one is interested in getting information from the entire sensory space and applying for instance an ideal points model, one must rely on alternative approaches (Menichelli et al., 2012). Another limitation is that as it stands now the method can only be used for situations in which all consumers tests all products.

Menichelli et al. (2012) proposed a different strategy to manage the above-mentioned limitations and tested it on a consumer study of orange juice. This approach is relatively simple and based on standard, well-established principles from experimental design, multivariate analysis and ANOVA. The design uses different products for different consumer groups, in order to ensure that the whole sensory space is covered as thoroughly as possible. Again, the samples are selected from a PCA scores plot of sensory data. The samples for each consumer group are then combined with the extrinsic factors according to a factorial design. For the analysis, two different approaches may be employed. The first is to use ANOVA with a fixed-effects contribution representing the average population effects and a random-effect contribution accounting for individual consumer differences. In the ANOVA, the sensory information is incorporated via the principal components of the axes in the sensory space, in this way joining the different samples through the common principal components. Note that also the interactions between extrinsic attributes and the sensory variables are incorporated via products of the extrinsic variables and the principal components from the sensory data.

As above, one should test for significance of the interactions and study them in for instance interactions plots for assessing good combinations (those with high liking) of the two types of attributes. In Menichelli et al. (2012) it was in this way found that along the positive direction of the first principal component of the sensory PCA space, one of the extrinsic attributes had a significantly larger positive effect than the other. The second approach is based on fuzzy clustering using regression residuals. This method is slightly more complex than the other method, but provides additional information about cluster structures in the data. In addition, it provides the same types of estimates and tests for each segment/cluster as when analysing all data. Again one can analyse interactions in the same way as described above and obtain information about good combinations within each segment. Segments can later on be related to information about consumer attributes as for instance gender and age for improved understanding (Asioli, Næs, Granli, & Lengard Almli, 2014). Note that this approach handles the large number of collinear sensory attributes by using only their principal components.

It should be mentioned that the way that Menichelli et al. (2012) incorporated and combined the extrinsic and sensory attributes (and interactions) through latent variables (i.e. principal components) may resemble a structural equation modelling (SEM) approach. In the ANOVA approach the two sets of variables are added and combined with their products and the different contribution are estimated by least squares. Another possibility could be to consider liking, extrinsic variables, sensory variables and the interactions between the latter two types (i.e. products of the variables in the two sets) as three different blocks of data and then use a SEM approach, either covariance based (see e.g. Kaplan, 2000) or PLS based (see e.g. Tenenhaus, Vinzi, Chatelin, & Lauro, 2005). This type of approach is considered in for instance by Alonso, Gallego, and Mangin (2005) and Martínez-Carrasco,

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Brugarolas, Martínez-Poveda, Ruiz, and García-Martínez (2012) for similar types of data. A possible advantage of the latter could be that it is a one-step approach not requiring calculation of principal components independently, although the same type of information would be the result. A possible drawback could be that it may add slightly to the complexity of the analysis. A comparison between the two approaches has not been conducted yet, but should be done in future studies in the area.

2.1.3. Choice-Based Conjoint Analysis

Choice-Based Conjoint Analysis (CBCA) is a type of CA method used to predict consumer choices; the method combines CA with discrete choice modelling (DCM). Consumers are faced with successive sets of concepts (choice sets) representing goods or services with different combinations of attributes levels. Consumers must choose one alternative within each choice set by simultaneously evaluating the presented product attributes. One of the advantages of CBCA over conventional marketing research surveys is that since product attributes are evaluated simultaneously, consumers will not generally overestimate some attributes over others (Teichert, 2000). CBCA can be applied to reveal the simultaneous interaction among sensory and extrinsic attributes and also allows segment-specific analysis (Enneking et al., 2007). However, one of the main disadvantages of CBCA is that the simultaneous evaluation of extrinsic and intrinsic attributes is quite demanding for consumers since many real samples have to be tested (Enneking et al., 2007). In addition, both the experimental design and the data analysis of CBCA are more complex than traditional CA methods. The first study which applied CBCA for the combination of sensory and extrinsic food attributes was performed by Enneking et al. (2007), who tested consumer preferences for soft drinks for taste, labels and price while (Grunert, Loose, Zhou, & Tinggaard, 2015) investigated intrinsic (colour and fat) and extrinsic (brand, safety certification and origin) attributes of pork ribs with chinese consumers. The latter used the CBCA based on a pairwise comparison task because it is easy to explain and administer to consumers and it is close to real-world choice (Grunert et al., 2015). The different product alternatives were presented to consumers as a combination of pictures (only the visual sensory attributes were used) of the product and accompanying text which varied in the intrinsic and extrinsic attributes previously mentioned. The results showed that the use of CBCA on pairwise comparison of products using image by including both sensory and extrinsic attributes, indicates a clearer and stronger differentiation among products than direct importance ratings.

2.2. "Classic" hedonic testing

2.2.1. Combining blind, expected and informed hedonic tests

A group of methods which combine both sensory and extrinsic food attributes is based on the comparison of blind, expected and informed tests of products (Deliza, MacFie, & Hedderley, 1996). Some of these tests compare blind and informed hedonic tests only, while others also incorporate expected liking. Both cases make it possible to investigate if and how information (informed test) about the product (e.g. different origin, different fat content) potentially influences consumer liking. Thus, it is possible to discuss the effects of sensory and extrinsic properties. For example, in a blind test consumers can taste a product and express their liking on a hedonic scale and then taste the same product with information about for instance the origin of the product, or on the fat content levels, before being given another opportunity to express their liking (informed test-extrinsic factor). This makes it possible to test the effect that information (e.g. different fat content) has on liking and in turn identify promising combinations of the two types of attributes in terms of consumer liking

There are two main advantages to this group of methods. The first is that it provides detailed, accurate and direct measures about intrinsic (sensory) and extrinsic (expected, and informed) attributes and makes it possible to investigate their interactions. Secondly, this method makes it possible to investigate confirmation and disconfirmation mechanisms (Deliza et al., 1996).

In terms of drawbacks, these methods are quite time-consuming and can be demanding for consumers. In addition, consumers might recognize the sample without/with information along the test, potentially affecting results.

Hersleth, Almli, Verbeke, Guerrero, and Næs (2011) combined blind/informed test methods with a conjoint approach by evaluating the effects of information on salt content, aging time and origin on the acceptance of dry-cured ham in Norway. Consumers' acceptance was explored in blind, expected and informed conditions through the use of a conjoint design. In the first session (blind tasting) consumers were asked to rate their hedonic liking of four slices of dry-cured ham. In the second session (expected liking, no tasting), consumers were asked to score their expected liking and their probability of buying for four different dry-cured ham profiles. The profiles were presented on cards displaying information on origin and salt level/aging time. In the final session, consumers rated the dry-cured hams in informed experimental conditions (Informed liking, with tasting). The rating procedure was similar to the first session, but each slice of dry-cured ham was accompanied by a card detailing origin and salt level/aging time information in a similar way to the second session. Data analysis was carried out using descriptive statistical analysis, ANOVA, PCA and cluster analysis in order to reveal the effect at the population, or aggregate, level, as well as providing information on individual differences.

The ANOVA model used was based on using differences between the three responses (blind, informed and expected) as dependent variable (and the design variables as the independent ones) and represented a generalisation of previously used approaches. This type of modelling provides information about for which design variables (and their interactions) there are differences between for instance blind and informed liking. Of special interest in such studies is to see whether special combinations of the design variables have a particularly large influence on the differences in liking between blind and informed. This information can again be used for establishing good combinations of for instance labelling and sensory properties and for providing ideas about further product improvements. The use of PCA on the residuals from the ANOVA model (Endrizzi, Menichelli, Johansen, Olsen, & Næs, 2011) for the purpose of studying individual differences and for segmentation was also new in this context. Each segment can if wanted be studied in the same way as for all the data.

A large number of similar studies have been conducted applying more or less the same type of methodology (see Almli & Hersleth, 2012; Di Monaco, Cavella, Di Marzo, & Masi, 2004; Guinard, Uotani, & Schlich, 2001; MacFie & Deliza, 1996; Mueller & Szolnoki, 2010; Varela et al., 2010).

2.3. Alternative descriptive methods

During the last ten years a new group of consumer research methods, called alternative descriptive methods (also known as rapid methods), have gained popularity within food research. These methodologies are less time-consuming than classic descriptive methods, more flexible, and can be performed with both trained and non-trained assessors (Varela & Ares, 2012). Some of them can also be used to carry out research incorporating both sensory and extrinsic attributes, such as for example Projective Mapping (PM), Check-All-That-Apply (CATA) and Flash Profiling (FP).

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2.3.1. Projective mapping

PM or Napping® involves placing different samples on a two-dimensional perceptual surface, according to the characteristics of the products: similar samples are located close to each other, and less similar samples at some distance from each other (Risvik, McEwan, Colwill, Rogers, & Lyon, 1994; Valentin, Chollet, Lelièvre, & Abdi, 2012). PM is a projective technique that originally derived from psychology and it has been used in qualitative market research to obtain associations among products (Pagès, 2005; Risvik et al., 1994). PM has been applied to studies both on sensory (Ares, Deliza, Barreiro, Giménez, & Gámbaro, 2010; King, Cliff, & Hall, 1998; Risvik et al., 1994) and non-sensory parameters (Carrillo, Varela, & Fiszman, 2012a, 2012b). The main advantage of PM is that consumers assess products from an overall perspective, providing more spontaneous responses than other techniques (Guerrero et al., 2010), more equivalent to what happens at the time of choosing (Varela & Ares, 2012).

An application of the PM method which includes both sensory and non-sensory attributes has been performed by Carrillo et al. (2012a). They studied the relation between on-pack information of enriched and reduced calorie biscuits and their sensory properties, and how extrinsic properties might act as modulator of consumers' perception. Consumers evaluated the biscuits in four scenarios, two sessions without tasting to see how consumers perceived the nutrition information panel and claims, and two further sessions with tasting, with and without information on the nutrition information panel and claims. The results showed that consumers were greatly influenced by the claims (particularly nutritional) highlighted on the front of the package, and the associations generated during the descriptive step were particularly useful to better understand consumers' perception. For example, non-sugar and high-fibre biscuits raised negative expectations about their sensory characteristics, even when looking at the packs without tasting consumers associated them to "insipid", "not very tasty" or "disgusting flavour". When tasting together with the information, negative sensory descriptors ("not very tasty", "disgusting flavour") came up again and were associated to healthiness, however in the blind tasting session those same samples were more frequently associated to positive hedonic terms such as "delicious". The same authors performed further investigations by applying PM to study the effects of food package information and sensory characteristics on the perception of healthiness and the acceptability of enriched biscuits. The participants mapped the samples in PM tests in three different scenarios (blind, informed and expected conditions) and rated overall liking and perceived healthiness. Overall liking was higher for almost all samples in the blind test, whereas seeing only the package showed a trend towards higher perceived healthiness, suggesting that non-sensory factors could influence the first buy and sensory characteristics could determine repeated consumption. PM helped to relate sensory and not sensory drivers, particularly through the analysis of the descriptive step, it was observed that participants were not willing to compromise sensory characteristics for health even though they considered that some food components were beneficial for the diet.

Most frequently, the so-called multiple factor analysis (MFA, see e.g. Pagès (2005)) or the Procrustes analysis (Gower, 1975) are used for PM data in order to establish a consensus configuration to be plotted and interpreted directly or in relation to data obtained by so-called ultra-flash profiling (see e.g. Varela and Ares (2012). The consensus configuration provides information about which samples that are perceived differently or similarly and the ultra-flash data (projected onto the consensus scores) provide information about what are the reasons for the differences. Careful studying of these plots can provide information about whether perceived differences between samples is due to extrinsic or intrinsic properties or combinations of them, which again can lead to improved insight (as in Carrillo et al. (2012a) and products with a higher liking.

2.3.2. Check-All-That-Apply (CATA)

CATA is increasingly applied in sensory research (Dooley, Lee, & Meullenet, 2010; Lado, Vicente, Manzzioni, & Ares, 2010; Plaehn, 2012) and is commonly used in marketing research (Rasinski, Mingay, & Bradburn, 1994). In CATA, respondents should select among a series of words or phrases that they consider applicable to the product they are evaluating from a list of predefined multiple choice questions (words or phrases). Those attributes might include sensory and non-sensory terms, like usage and attitudes, and also hedonic attributes (Varela & Ares, 2012).

Ares, Dauber, Fernández, Giménez, and Varela (2014) proposed a Penalty analysis based on CATA questions to identify drivers of liking and directions for product reformulation. Their proposed Penalty analysis involving the gathering of CATA data, overall liking and the evaluation of an ideal product. The analysis is based on the differences between real and ideal product and the impact on associated liking scores, this can be applied to both sensory and non-sensory attributes. This approach was used and refined by Meyners, Castura, and Carr (2013) to identify (positive and negative) drivers of liking. One of CATA's potential limitations is that it does not provide quantitative information, only frequency data (Varela & Ares, 2012).

Finally, Flash Profiling (FP) is another interesting approach that can be used to combine sensory and extrinsic attributes. FP is based on asking the assessors to use their own descriptive terms in order to rank the evaluated products, through a comparative evaluation (Delarue, 2014; Varela & Ares, 2012). Delarue (2014) has proposed FP as highly suited for assessing perceptual dimensions that go beyond mere sensory perception. The method was tested to assess the sensory expectations driven by the claims and packaging of cosmetic products. This approach could easily be extended to food products by combining intrinsic and extrinsic food attributes.

Further than consumers' perception from a descriptive point of view, all the above mentioned alternative methods can as stated be combined with preference data to better understand the changes in liking due to sensory and extrinsic attributes interaction. Further examples where overall liking data have been gathered together with PM data for concluding on drivers of liking can be found in Ares et al. (2010), Torri et al. (2013) and for understanding the changes in hedonic response in different mapping scenarios (Carrillo et al., 2012b). An example of using CATA for preference mapping or ideal product identification can be found in Ares, Varela, Rado, and Giménez (2011).

Thus, alternative descriptive methods with the use of direct input from consumers appear to be a promising avenue to further improve our understanding of how extrinsic and sensory attributes related to food choice interact. Such methods might include an assessment of an "ideal" product as a procedure to identify product design and optimization opportunities

CATA data are often, also for the type of data considered here, analysed using correspondence analysis on the data matrix of counts with samples representing the rows and the variables the columns (see e.g. Varela and Ares (2012)). In the same way as for PM data, the plots can be used to detect differences and similarities between objects and also whether there are intrinsic or extrinsic attributes (or combinations) that are responsible for the differences.

3. Industry challenges

The development and the adoption of the methodologies discussed here within the food industry should be facilitated by

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taking into account several elements (Dijksterhuis, 2016). First, the conduction of consumer tests can be very expensive, so it is important to keep the costs as low as possible. Second, the employed methodology should be rapid so as to provide results within a short timeframe. This is important for speeding up the introduction of new products in the market, and also for solving day-to-day challenges (related for instance to competition) detected in the market. Third, the employed methodology should be user-friendly for food industry employees that may have diverse backgrounds and positions, e.g. as marketers or product developers. With reference to the latter, the application of these new methodologies can be facilitated by developing user-friendly software packages and concrete guidelines for how to carry out consumer tests within the food industry. For example, the recent development of the open-source software ConsumerCheck[1] (Nofima, Norway and DTU, Denmark) is likely to facilitate the adoption of conjoint analysis (CA) within food industries. Another user-friendly software is XLStat[2] (Addinsoft SARL, France), which can be used to analyse data collected with alternative descriptive methods, as well as a range of other potential applications.

The so-called rapid methods may be especially suited for the needs of the food industry since they are relatively simple to perform, do not request trained assessors with particular skills, are less time-consuming, more flexible and cheaper than classic descriptive sensory methods. Data collection and analysis are not particularly difficult.

Finally, it is worth mentioning that while internal collaboration and communication within the food industry is vital (Jacobsen et al., 2014), external collaboration and communication with for instance other food companies, food research institutes and software companies should be enhanced.

Such cooperation will promote the adoption of these new methodologies and in turn improve the NFPD process.

4. Future research needs and limitations

In this paper a number of different methods for combining sensory and extrinsic attributes have been discussed. It is evident that several of these can be improved and modified to be more finely tuned to meet the needs of the industry, listed above. Jaeger (2006) has observed that due to the different nature of the intrinsic and extrinsic attributes, such developments should be interdisciplinary.

As mentioned above, conjoint hedonic methods have a great potential both in terms of academic research and in the food industry. Recent developments (Enneking et al., 2007; Johansen et al., 2010; Menichelli et al., 2012) have improved this method considerably, but it is clear that more applications and further improvements are required, such as identifying a way of including more attributes and attribute levels, which would be of benefit for the food industry (Hoppert et al., 2012). Since conducting a CA can be quite expensive and challenging due to the need to involve a large number of consumers, future research should try to refine experimental methods and new technologies that can contribute to reducing these costs and to bringing down the number of samples to test, for example. Furthermore, when extrinsic and sensory food attributes are investigated jointly, they need to be balanced against one another in order to avoid any imbalance in favour of some attributes relative to others. Another important aspect linked to CA is the validity of the data provided by this methodology. In most cases simply asking consumers for their preference may not provide the needed practical information, or information that is not always fully representative of consumer behaviour in a real life situation. Possible improvements can be obtained by including price as an attribute (Jaeger, 2006) using non-hypothetical economic experiments (e.g. experimental auction) (Lusk & Shogren, 2007).

As stated above, the fact that the NFPD process involves different industry departments (i.e. product development, packaging, marketing, etc.) may partially account for the high number of failed products. So far this area requires further study in order to improve communication and organizational aspects. Næs and Nyvold (2004) have proposed an approach to boost communication between product developers and marketers during the NFPD process. The method, called "Creative design", is a way of supplementing well-established principles for experimental design with both food knowledge and creative elements. In particular, Næs and Nyvold's method makes it possible to improve communication in the early stage of the product development process, known as the "concept stage". This stage contains a specified description of the principal product characteristics (e.g. sensory properties, packaging and product labelling) that need to be developed. The proposed technique represents a common language or a way of thinking which ensures that all competence elements can be usefully combined (Næs & Nyvold, 2004).

More research should be done on the application of alternative, or rapid, methods, in particular regarding the interaction of extrinsic and sensory parameters driving consumer food choice. Comparison with an ideal sample promises to be a particularly interesting approach. Another interesting field would be the combination of choice experiments and alternative descriptive methods to achieve a better understanding of food choice.

We suggest more in-depth investigation of combined economic and sensory experiments, as these can provide valuable and realistic information for product development and marketing activities in a more realistic setting (Combris, Bazoche, Giraud-Héraud, & Issanchou, 2009).

Finally, further research should consider the interactions between intrinsic and extrinsic attributes from first shelf exposure to post ingestion, so for example investigate their interactions during the preparation and meal consumption as well as after the consumption using the so-called micro lifecycle concept proposed by Grunert (2015).

A major limitation of this discussion paper is that, due to the space restriction, we considered only food products characteristics without considering the other factors that affect food choice, such as psychological, situational, socio-cultural, biological and physiological factors and their interplay which affect food choice. More research is thus encouraged to be performed in a wider multidisciplinary framework, to combine also these other factors which can support a better and more realistic understanding of the food choice process. This in turn can contribute to provide more realistic information in the NFPD process to reduce product failures on the market.

Most of the methodologies used in the area rely on rather standard ANOVA-based models and multivariate analysis based on PCA and clustering. An important challenge for future research is to refine these methodologies for the purpose of simplicity and improved interpretation. Another challenge is to look in a wider context on the potential of incorporating SEM based methods in an even stronger way than is the case today.

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[1] www.consumercheck.co.
[2] www.xlstat.com.

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