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Testing SensoGraph, a geometric approach for fast sensory evaluation☆

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ABSTRACT

This paper introduces SensoGraph, a novel approach for fast sensory evaluation using two-dimensional geometric techniques. In the tasting sessions, the assessors follow their own criteria to place samples on a tablecloth, according to the similarity between samples. In order to analyse the data collected, first a geometric clustering is performed to each tablecloth, extracting connections between the samples. Then, these connections are used to construct a global similarity matrix. Finally, a graph drawing algorithm is used to obtain a 2D consensus graphic, which reflects the global opinion of the panel by (1) positioning closer those samples that have been globally perceived as similar and (2) showing the strength of the connections between samples. The proposal is validated by performing four tasting sessions, with three types of panels tasting different wines, and by developing a new software to implement the proposed techniques. The results obtained show that the graphics provide similar positionings of the samples as the consensus maps obtained by multiple factor analysis (MFA), further providing extra information about connections between samples, not present in any previous method. The main conclusion is that the use of geometric techniques provides information complementary to MFA, and of a different type. Finally, the method proposed is computationally able to manage a significantly larger number of assessors than MFA, which can be useful for the comparison of pictures by a huge number of consumers, via the Internet.

1. Introduction and related work

The aim of this work is to introduce and evaluate SensoGraph, a novel approach for the analysis of sensory data using geometric techniques which deal with basic objects in 2D, like points, circles, and segments (Gabriel & Sokal, 1969; Kamada & Kawai, 1989). A data collection following the methodology introduced by Risvik, McEwan, Colwill, Rogers, and Lyon (1994) for Projective Mapping is combined with a data analysis using geometric Multidimensional Scaling. A consensus graphic is obtained, showing not only a positioning of the samples, but also connections between samples and the force (strength) of these connections. This aims to be helpful in order to calibrate the significance of the positions on the graphic and to reflect the relations between groups. Moreover, the use of geometric techniques aims to help avoiding possible misuses of statistical techniques. The proposed method is validated by performing four sessions with three types of panels tasting different wines.

Sensory profiling is among the most important and widely used tools in sensory and consumer science (Lawless & Heymann, 2010), both in academia and industries (Varela & Ares, 2012). In these two fields, descriptive analysis has usefully linked product characteristics and consumer perception (Varela & Ares, 2012; Vidal et al., 2014). Descriptive panels allow, due to their expertise, to obtain very detailed, robust, consistent, and reproducible results (Moussaoui & Varela, 2010). However, creating and maintaining a well-trained, calibrated, sensory panel can become too long and costly: For academic research, because of dealing with occasional projects or scarce funding (Lawless & Heymann, 2010; Murray, Delahunty, & Baxter, 2001; Varela & Ares, 2012). For companies, because of reasons like funding limits or difficulty to enrol assessors in a panel during a long time.

Thus, several alternative methods have arisen in the last years (Varela & Ares, 2012), aiming to provide a fast sensory positioning of a set of products by assessors who are not necessarily trained. Skipping the need to train the panellists allows to elude the need of waiting a

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long time before obtaining results, as well as the need of agreeing on particular attributes, which may become difficult when working with experts like wine professionals or chefs (Hopfer & Heymann, 2013). Introduced by Risvik et al., 1994; Risvik, McEwan, and Rødbotten, 1997, Projective Mapping asks the assessors to position the presented samples on a two-dimensional space, usually a blank sheet of paper as tablecloth, following their own criteria: The more similar they perceive two samples, the closer they should position them, and vice versa (Perrin et al., 2008). In those seminal works, the data were analysed by generalized procrustes analysis (GPA) (Gower, 1975) and principal component analysis (PCA) (Gabriel, 1971), using the RV coefficient (Escoufier & Robert, 1979) to compare the method with conventional profiling.

More recently, Pagès (2003, 2005) proposed the use of multiple factor analysis (MFA) (Escofier & Pagès, 1994) for data analysis, coining the name Napping®. Typically, a two-dimensional graphic is obtained, where proximity of two samples indicates that the panel has globally perceived them to be similar.

The goal of these statistical methods is always to get an average configuration of products called consensus graphic, so it is crucial to assess its stability. Thus, in order to know whether two products are perceived as significantly different from a sensory point of view, the positions on the map given by these statistical methods should include a confidence area, e.g., confidence ellipses (Cadoret & Husson, 2013).

Projective Mapping has been successfully used with many different kinds of products, among which the application to wine stands out (Ballester, Dacremont, Le Fur, & Etiévant, 2005; Bécue-Bertaut & Lê, 2011; Hopfer & Heymann, 2013; Pagès, 2005; Piombino, Nicklaus, Le Fur, Moio, & Le Quéré, 2004; Perrin & Pagès, 2009; Perrin et al., 2008; Ross, Weller, & Alldredge, 2012; Torri et al., 2013; Vidal et al., 2014). Other examples of beverages analysed by these methods are beers (Abdi, Valentin, Chollet, & Chrea, 2007; Chollet & Valentin, 2001; Lelièvre, Chollet, Abdi, & Valentin, 2008; Lelièvre, Chollet, Abdi, & Valentin, 2009; Reinbach, Giacalone, Ribeiro, Bredie, & Frøst, 2014), citrus juices (Nestrud & Lawless, 2008), drinking waters (Falahee & MacRae, 1995; Falahee & MacRae, 1997; Teillet, Schlich, Urbano, Cordelle, & Guichard, 2010) high alcohol products (Louw et al., 2013), hot beverages (Moussaoui & Varela, 2010), lemon iced teas (Veinand, Godefroy, Adam, & Delarue, 2011), powdered juices (Ares, Varela, Rado, & Giménez, 2011), or smoothies (Pagès, Cadoret, & Lê, 2010). The book by Varela and Ares, 2014 details more products to which consumer-based descriptive methodologies have been applied.

Until now, all the methodologies proposed for fast sensory evaluation have used statistical techniques to perform the data analysis. This paper introduces and evaluates a novel approach, a combination of geometric techniques to obtain a different kind of consensus graphic, here named SensoGraph. The outcome is a graph representation which combines a positioning of the samples together with connections representing the strength of the relations between them. Such a kind of representation is becoming more and more usual nowadays, among other reasons because of allowing dynamic data visualization (Beck, Burch, Diehl, & Weiskopf, 2017), being helpful for big data visualization (Baumann, Fabian, Lessmann, & Holzberg, 2016; Conover, Gonçalves, Ratkiewicz, Flammini, & Menczer, 2011; Junghanns, Petermann, Gómez, & Rahm, 2015), and providing apparent graphics suitable for mass media (The Electome & The Laboratory for Social Machines at the MIT Media Lab, 2016) and the analysis of sports (Buldu et al., 2018).

2. Material and methods

2.1. Data collection

In order to validate this proposal, a total of four tasting sessions using Projective Mapping (Risvik et al., 1994; Pagès, 2005) have been performed, with three types of panels tasting different wines.

(A) Panel trained in Quantitative Descriptive Analysis (QDA): A panel trained in QDA of wine, composed of eleven assessors, tasted eight different red wines in one session, all of them elaborated at the winery of the School of Agricultural Engineering of the University of Valladolid in Palencia (Spain). Four of the wines were from cv. Cabernet Sauvignon and the other four from cv. Tempranillo, all of them from the same vintage. This panel was selected and trained using (ISO 8586, 2012).

(B) Panel receiving one training session in Projective Mapping: Another panel, composed of twelve assessors with experience in wine tasting, performed two sessions of Projective Mapping; a first session without any experience in the method and a repetition. The same eight red wines were used both for the training and for the final test, all of them elaborated at the winery of the School of Agricultural Engineering of the University of Valladolid in Palencia (Spain) using cv. Tempranillo from Toro appellation (Spain) and the same vintage. These eight wines were different from those tasted by the previous panel. This panel was composed by students of the Enology degree at the University of Valladolid, who had studied three academic years of Enology including a course in Sensory Analysis.

(C) Panel of habitual wine consumers tasting commercial wines: A final panel, composed of twenty-four habitual consumers of wine, performed one session of Projective Mapping. They tasted nine commercial wines, one of them duplicated. Seven of the wines used only one variety: Three of them were cv. Mencía, three more were cv. Tempranillo (one of them from Toro appellation, Spain), and another one was cv. Monastrell. The other two wines were a blend of varieties: The duplicated wine used mainly cv. Cabernet Franc, together with cv. Merlot, Garnacha, and Monastrell. The other wine was mainly cv. Tempranillo, blended with cv. Garnacha and Graciano.

For all the sessions, the number of samples followed the recommendations of Valentin, Cholet, Nestrud, and Abdi (2016). The samples were simultaneously presented to each assessor. The panellists were requested to position the wine samples on an A2 paper (60×40 cm), in such a way that two wine samples were to be placed close to each other if they seemed sensorially similar, and that two wines were to be distant from one another if they seemed sensorially different. All of this according to the assessor's own criteria for what close or far mean.

In all the sessions, the samples were served as 25 mL aliquots in standardised wineglasses (ISO 3591, 1977), which were coded with 3-digit numbers, and all the samples were presented simultaneously using a randomized complete block design. The serving temperature was 14 ± 1°C. All these sensory evaluations were carried out at the Sensory Science Laboratory of the School of Agricultural Engineering, at the University of Valladolid, Palencia (Spain), in individual booths designed in accordance with ISO 8589 (2007).

2.2. Data analysis

The x- and y-coordinates of each sample on the paper were measured from the left-bottom corner of the sheet. These data were then stored in a table with S rows, one for each sample, and $2A$ columns, with A being the number of assessors.

2.2.1. Statistical techniques

On one hand, these data were analysed by statistical techniques with MFA, as proposed by Pagès (2005), using the `R` language (R Development Core Team, 2007) and the `FactoMineR` package (Lê, Josse, & Husson, 2008). MFA has become a common choice for the analysis of Projective Mapping data (Varela & Ares, 2014), and it has been proved to be equal or better than other models like individual differences scaling (INDSCAL) for estimating the consensus configuration (Næs, Berget, Liland, Ares, & Varela, 2017). Finally, confidence ellipses were constructed using truncated total bootstrapping (Cadoret & Husson, 2013) with `SensoMineR` package (Lê & Husson, 2008).