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Advances in representation and analysis of mono and multi-intake Temporal Dominance of Sensations data

M.V. Galmarini [a,b,c,*], M. Visalli [a], P. Schlich [a]

[a] INRA, UMR1324 Centre des Sciences du Goût et de l'Alimentation, Dijon, France
[b] Consejo Nacional de Investigaciones Científicas y Técnicas, Buenos Aires, Argentina
[c] Facultad de Ciencias Agrarias, Pontificia Universidad Católica Argentina, Buenos Aires, Argentina

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ABSTRACT

Using the concept of dominance, other than intensity, Temporal Dominance of Sensations (TDS) has become a highly used temporal descriptive technique providing information on sequentiality and duration time of dominant sensations. In the present work we propose: (i) a new graphical tool for representing the sequentiality of (multi-intake) TDS data and (ii) an inferential approach to data analysis based on duration of dominance. TDS data are generally presented as TDS curves. However, visual inspection and curve comparison among intakes of a same product, several products or both, can be a cumbersome task. To better show sequentiality of dominant attributes, we propose different TDS band-plots. These representations show whether attributes are dominant or not (at panel level) allowing the follow-up of each descriptor and improving visual comparison of products. Nonetheless, visual assessment is not enough to determine significant differences. Using the total duration of dominance of each attribute, three-way ANOVA's including subject, product and intake as factors, together with their two-way interactions, with subject as random effect can be performed. This test reveals if a certain attribute is dominant for a significantly longer or shorter period of time in some products, as well as its changes over intakes. Interaction between product and intake becomes highly important to see if evolution over intakes is the same for all the products. Further, multidimensional differences can be summarized over attributes by a MANOVA and represented by a Canonical Variate Analysis (CVA), allowing the comparison of different intakes of a same product, or different products, or altogether.

1. Introduction

Temporal Dominance of Sensations (TDS) is a temporal multidimensional sensory method (Pineau, Cordelle, & Schlich, 2003). It consists in presenting to the assessors a list of descriptors from which they are asked to choose at every moment of consumption the one which they consider dominant (the most striking perception at a given time, not necessarily the most intense one (Pineau et al., 2009)). Without the need of quantification, this qualitative, temporal technique provides an intuitive response which needs less training since no scaling is used. This somewhat playful approach is one of the reasons which facilitated extending this technique to working with consumers (Brachet et al., 2014; Schlich, 2013; Thomas, Visalli, Cordelle, & Schlich, 2015) and also to the evaluation of successive intakes such as multi-bite (Schlich, Pineau, Urbano, & Visalli, 2013) or multi-sip (Zorn, Alcaire, Vidal, Giménez, & Ares, 2014). This multi-intake approach could be key towards better interpreting the sensory perception of a whole food portion. However, it also means that more information is obtained therefore needing different ways of representation and analysis.

TDS data is generally represented by curves (Pineau et al., 2009) of rate of dominance at panel level of each attribute against time (standardized or not). These curves are rich in information and their visual inspection is the base for product description (Marcano, Varela, Cunha, & Fiszman, 2015; Zorn et al., 2014). However, when working with multiple products and also multiple intakes, the amount of curves multiply quickly and visual comparison becomes a cumbersome task. Working with multiple sips of sweet solutions, Zorn et al. (2014) attempted to simplify the representation by plotting TDS curves which included all products but represented only one attribute (e.g. description of the dominance rate of sweetness with the different lines represent the evaluated products). This is a somewhat practical approach, but by reducing

* Corresponding author at: Facultad de Ciencias Agrarias, Pontificia Universidad Católica Argentina, Cap Gral. Ramon Freire 183, 1426 Buenos Aires, Argentina.
E-mail address: mgalmarini@gmail.com (M.V. Galmarini).

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the presented information the global image of all products and sips comparison was lost. Another way of graphical comparison used for TDS data includes difference curves (Pineau & Schlich, 2014) which allow the comparison of two different products. But this is a one-on-one comparison which implies that with as little as 4 products evaluated over 3 sips, the amount of difference curves of interest could amount to 18. In this way, being the visual representation of sequentiality of dominant sensations so important in TDS data, new graphical tools are needed for better summarize the obtained information. Taking this into account, in the present paper a different way of representing the sequentiality of TDS data is proposed aiming to facilitate the observation of the evolution of the descriptors over time as well as product differences. It is to be noted that it is not the aim of the present paper to present a statistical tool to analyze the succession of cited sensations as could be found in Castura and Li (2016).

Also based on TDS curves, different authors have suggested statistical tests using parameters which characterize the curves as in Time–Intensity (T–I) data analysis (Bruzzone, Ares, & Giménez, 2013; Cadena, Vidal, Ares, & Varela, 2014; Pineau & Schlich, 2014; Rodrigues, Condino, Pinheiro, & Nunes, 2016). Nonetheless, it should be kept in mind that dominance rate represents the agreement on dominance at panel level at a given moment of tasting (Lenfant, Loret, Pineau, Hartmann, & Martin, 2009) which is different from intensity as in T–I curves. Moreover, when using the parameter of the area under the curve the temporal aspect of the data is removed (Di Monaco, Su, Masi, & Cavella, 2014).

Another approach to TDS data analysis has been proposed by Meyners and Pineau (2010) who introduced a randomization test based on distances between matrices. For this purpose, TDS sequences were unfolded to data matrices with a single non-zero entry per time point (column) proposing pair-wise comparisons and inference by attribute or time point. Unfortunately, this test needs long computing times and is dependent on the randomization used limiting its practical application.

More recently, several authors have proposed a univariate approach to analyze TDS data based on different ways of splitting the time of the evaluation into time intervals (Devezeaux De Lavergne, Van Delft, Van De Velde, Van Boekel, & Stieger, 2015; Hutchings, Foster, Grigor, Bronlund, & Morgenstern, 2014; Hutchings, Foster, Hedderley, & Morgenstern, 2014; Lepage et al., 2014). Using time intervals allows applying the concept of sensory trajectory to TDS data which has already been well documented (Devezeaux De Lavergne et al., 2015; Lenfant et al., 2009). However, determining time periods as a pre-treatment for ANOVA tests can be tricky since there is no *rule of thumb* to decide the number of time periods. Moreover, it is very likely that the attribute chosen at time $t+1$ will be the same as the one chosen at time t, which makes time points data auto correlated as well, i.e. not independent and this dependency is less strong on pre-processed data (Lepage et al., 2014). Taking all this into consideration, and looking for a simpler tool for data analysis, in the present paper we propose an inferential approach based on individual total duration of dominant attributes, including also the multiple intakes as factors. For an illustrative purpose, the different forms of analysis will be presented using a data set from a multi-sip TDS on wine. It should be kept in mind that the characterization of these products is not the main interest of the present paper and that, given the product used as an example, the word sip will be generally used when talking about intake.

2. Acquisition of the data set used as example

The data set used for an illustrative purpose was acquired by a multi-sip TDS evaluation of four different wines, as part of a wine sensory characterization project. A brief description of the wine samples used is presented in Table 1.

Product evaluation was carried out by a total of 31 frequent wine consumers from the city of Dijon (Burgundy region), France. They were recruited by means of an on-line questionnaire based on their frequency of consumption of red, dry white and rosé wines. Other conditions included their availability and willingness to participate as well as having no food allergies. The final group was composed of 15 males and 16 women, aged between 27 and 67 years-old (mean of 52) and they were economically gratified for their participation in the study. They attended a total of three tasting sessions. The first one was for the purpose of familiarizing them with the method and the proposed descriptors. References for sour (0.08% citric acid solution), bitter (0.05% caffeine solution), sweet (2% sucrose solution) and astringent (concentrated green tea) were presented coded with a three-digit number and consumers were asked to try them and state the sensation perceived while drinking each solution. Afterwards they were presented the olfactory references and they were explained that they represented the different aromatic families, e.g.: for floral they were presented a violet scent but they were instructed that any aroma in relation to other flowers such as roses, gardenias, etc., could be considered as floral. Over the other two sessions (one-hour long each) consumers described the four wine samples (having evaluated them in duplicate by the end of the study) by multi-sip TDS.

The tasting protocol for each sample was the same. Consumers were instructed to click on the "START" button as soon as they had the wine sample in their mouth. They could then successively select the attribute that most triggered their attention from a list of 11 descriptors (Fig. 1). Only one attribute could be selected at each time, but they were free to select an attribute several times and they could continue to describe their perception until no sensation was dominant. At this point, they clicked on the "STOP" button to indicate the end of the TDS evaluation of this sip. There was no time limit for each sample evaluation, which is important for data evaluation since each sip could have a different duration. After this, consumers performed the same task for the second and third sip. In this way three TDS profiles were obtained for each wine and each consumer. The same list of descriptors was used for all samples.

For each sample 3 cl of wine were presented in coded (three-digit random numbers) black wine glasses, in a monadic way following a Williams presentation. Consumers were instructed to pay special attention to the amount consumed in each sip in order to take approximately the same quantity of wine each time (≈1 cl). Nonetheless, the volume of the sip was not further controlled in order to have a more natural consumption. The 31 consumers evaluated all four samples per session (total of 12 cl of wine) and sample evaluation by this protocol was done in duplicate obtaining a total of 62 observations. All data was acquired in controlled sensory laboratory conditions by means of the software TimeSens© (www.timesens.com).

All TDS data is characterized by a sequentiality of dominant attributes which also have a given duration. For the purpose of clarity in the presentation of the proposed data analysis, an example of the type of data which can be obtained by panellist is shown in Fig. 2.

Table 1
Wine samples evaluated for data acquisition.

Code	Type of grape	Type of wine	Wine region	Year
V1	Chardonnay	White, dry	Bourgogne, France	2012
V2	Pinot Noir	*Rosé*, dry	Champagne, France	2012
V3	Pinot Noir	Red	Bourgogne, France	2012
V4	Gamay	Red	Beaujolais, France	2014

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