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Short Communication

A methodological proposal based on Signal Detection Theory for the study of dissociation between sensory and decision processes in the context of olive oil tasting

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ABSTRACT

An experiment evaluated a Signal Detection Theory (SDT) approach to olive oil tasting research within laboratory conditions akin to ecological tasting situations. Participants confronted a tasting situation in which olive oil concentration (0.4%, 0.8% or 1.6%) and instructions (lenient or conservative) were manipulated in a full factorial between-subjects design. Results were analyzed using a variety of measures of sensitivity and bias, both parametric and non-parametric, as well as robust statistics. Olive oil concentration only affected sensory processes while instructions only affected decision processes. Non-parametric indices of sensitivity A' and bias B'_D, and robust analysis of variance were, both conceptually and methodologically, the most suitable for separately measuring sensory and decision processes in the context of olive oil tasting.

1. Introduction

The olive oil tasting process constitutes a good example of interface between the fields of sensorial analysis and psychology. From a practical point of view tasting may be more simply viewed as a process of sensory evaluation in which tasters' senses are used as a measurement tool to give a sensory characterization of the food (see Rousseau, 2004). Sensorial evaluation analyzes how food products are perceived, involving perceptual processes such as the ability to discriminate between complex compounds (i.e., similar foods of different quality), and among the elements within the compound. Psychophysics enables us to characterize those processes related to perception of food attributes (Lawless & Heymann, 2010). These two disciplines, sensorial evaluation and psychophysics can benefit from each other. Olive oil evaluation imposes practical limitations with respect to the number of samples participants may taste in a session and this constriction should be considered in the laboratory so that basic perceptual results are not affected by these restrictions. Similarly, experimental research could provide training panels with methods that allow gaining experimental control of the tasting situation.

The olive oil sensorial analysis procedure is defined by the International Olive Council (COI/T.20/Doc. No 14/Rev.3, 2011), mainly based on Classical Psychophysical Threshold Theory. The first step after candidates screening is the determination of their detection threshold for olive oil attributes. Sensory threshold is defined in psychophysics as the smaller amount of stimulus energy necessary to produce a sensation or a just noticeable difference. This approach involves methodological limitations as it confounds sensory precision with fluctuations associated to response biases related to tasters' interests, motivation or mood. Response biases attributable to cognitive strategies have not been mentioned in the IOC document. An alternative psychophysical model, the Signal Detection Theory (SDT), allows overcoming these limitations, as it separates the two possible cognitive processes, detection and decision (Wichchukit & O'Mahony, 2010).

Our main goal within this line of research was to evaluate an approach for the study of olive oil tasting within the laboratory that allows a separate evaluation of detection and decision processes in a situation that may be subsequently implemented within olive oil tasting panels. Paredes-Olay, Moreno-Fernández, Rosas, and Ramos-Álvarez (2010) used SDT within the context of olive oil tasting, focusing their attention in evaluating participants' performance within a situation in which no response biases were expected. In the current experiment we simultaneously manipulated two independent factors, olive oil concentration and instructions, in a complete factorial design. Concentration should

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affect only the detection process (SDT d′ type indexes), while instructions should affect only the decision process (SDT Beta type indexes). The absence of interaction would point to the independence between those psychological processes associated to each factor. This Double Dissociation Additive test based on Sternberg (1998) additive factors method allows assessing the interaction or independence of the sensory and criterion indexes within a single experimental situation, avoiding confusions generated by indirect inferences (i.e., Stillman, Brown, & Troscianko, 2000). Usually, tasters' training improves exclusively the process of sensorial discrimination (COI/T.20/Doc. No 14/Rev.3, 2011). However, if the instructions affect sensory evaluations, reaching professional skills could also depend on strategic training about decision-making. The tasting task designed in this work could serve as a basis in training programs for preventing trainees to be overly conservative or lenient (Macmillan & Creelman, 2005).

Searching for the best dissociation between sensory and criterion processes, over thirty computation formulas have been proposed (e.g., Balakrishnan, 1998; Snodgrass & Corwin, 1988). As the choice of the appropriate indexes should depend on the specific field of application (Balakrishnan, 1998), an additional goal was to compare, conceptually and methodologically, the use of different types of sensory and decision indexes and statistical analyses within the field of olive oil tasting. Here, sensory evaluation necessarily involves a small number of tasting trials to avoid saturating the senses, making it difficult to fulfill parametric requirements such as normality of data and equivalent variances (e.g., Wickens, 2002). This can be solved by using a nonparametric alternative to compute sensory and criterion indexes (see Paredes-Olay et al., 2010). However, given the novelty of the SDT application to olive oil tasting and that finding dissociation between processes may depend on the chosen indexes (Snodgrass & Corwin, 1988), we will compare the results of parametric and nonparametric indexes in this research. Similarly, the use of standard analyses of variance may not be acceptable for dealing with the small amount of data provided by the olive oil tasting situation. Accordingly, we used robust statistical techniques (Wilcox, 2005). Thus, our methodological proposal is intended to measure in an optimal way the tasters' sensitivity, without contamination of possible response biases.

2. Method

2.1. Participants

Seventy-two undergraduate volunteers of the University of Jaén, 66 females and 6 males, participated in the study. They were between 18 and 27 years old (*Mdn* = 20.5). They were regular consumers of olive oil, though none had previous experience with the task, neither had formal training in sensory evaluation. Participants received either course credit or a 3-Euro copy-card for participating in the experiment. They signed an informed consent before starting the experiment.

Participants were instructed to come to the laboratory in the appropriate conditions to conduct a taste experiment, avoiding smoking, or taking tasty foods or drinks within the 30 min before their arrival. Participants were appointed in sets of eight and randomly assigned to each of the 6 experimental conditions involved in the experiment ($n = 12$). Age and gender distribution was uniform across groups.

2.2. Materials and apparatus

2.2.1. Oil samples

A mixture of Carrefour S.A. sunflower oil and Merck food-grade liquid paraffin was the base for all the samples. Olive oil was elaborated from *picual* and *hojiblanca* olives (Hermejor de la Reina S. L., Andújar, Spain).

A constant amount of sunflower oil (85%) was a common element in all mixtures. The salience of the olive oil concentration was manipulated starting at 1.6% and decreasing it by the method of successive dilutions 1:2 (1.6%, 0.8%, and 0.4% concentrations were used). The amount of paraffin in each sample depended on the olive oil concentration, going from 15% in the noise trials (without any olive oil) to 13.4% in samples containing 1.6% olive oil. Samples were stored in dark glass bottles.

As recommended by the IOC (COI/T.20/Doc. No 5/Rev.1, 2007), samples were presented in standardized olive oil tasting blue glasses covered with watch-glasses and placed in numbered grids within stainless steel industrial water baths (*Eurast Mod. 501, 408x610x320 cm, 1000 W 230/1 v; Cod. 50100G08*) similar to those recommended by the IOC but allowing to present up to 24 samples simultaneously. They were calibrated to ensure an olive oil temperature of 28 ± 2 °C (at lower temperatures the peculiar aromatic compounds of oil volatilize poorly, while higher temperatures lead to the formation of volatile compounds of heated oils).

2.2.2. Tasting laboratory

Eight individual cubicles inspired by the IOC guide for the installation of a test room (COI/T.20/Doc. No 6/Rev.1, 2007) were used (see Fig. 1). Each cubicle was equipped with a desk and a chair (Workstation), a Water bath, and a computer to control the task. On the table there was a trial sample, a glass of water, a plate full of green apple chunks to wash the palate between trials, and a numbered plastic sheet to leave the samples after tasting them.

Session was automatically controlled by *LearnOlive*, a Visual Basic (Microsoft Co.) based computer software specifically developed to design and conduct olive oil tasting experiments. The program generates different ASCII files allowing for the psychophysical and statistical analysis of the data.

2.3. Procedure

Once participants sat in front of the computer and signed the written consent, the experiment started. After filling a socio-demographic questionnaire, participants received general instructions on the screen about how to taste olive oil samples ("Turn-Smell-Taste-Clean" procedure, see Paredes-Olay et al. (2010) for details).

2.3.1. Tasting task

Each water-bath contained 24 samples, in which Signal + Noise samples (with olive oil) and Noise samples (without olive oil) were equiprobable (12 S+N & 12N). Fig. 2 presents an example of the screen participants received before tasting each sample. Instructions about how to deal with the current sample are at the top of the screen. Tasting sample appeared highlighted and blinking within the water-bath picture. The question "Do you think the sample contains olive oil?" was presented just below. Participants had to select buttons (Yes or No). Confidence question was below. Participants had to drag a button to indicate the confidence they had in their response (from 0, null, to 10, complete). Confidence judgments were concentrated in a few values of the scale, precluding obtaining the minimum number of points necessary to estimate the ROC curve. So, they are not reported here.

Sensory process was manipulated using three levels of olive oil concentration: Low (0.4%), Medium (0.8%) or High (1.6%). Decision process was manipulated by instructions inducing a conservative (positive bias) or lenient strategy (negative bias):

Conservative instructions (C). "In real situations one of the most valued aspects in olive oil tasters is their ability for being concentrated in samples which do not contain the relevant attribute for tasting. The task you are about to perform may be the first step