

Product's sensory characterization and study of preference using paired comparison approach

Lucile Riaboff, Thibault Schneider

Student at Oniris, Ecole Nationale Vétérinaire, Agroalimentaire et de l'Alimentation Nantes-Atlantique, Rue de la Géraudière, 44322 Nantes, France
E-mail: lucile.riaboff@oniris-nantes.fr

Student at Oniris, Ecole Nationale Vétérinaire, Agroalimentaire et de l'Alimentation Nantes-Atlantique, Rue de la Géraudière, 44322 Nantes, France
E-mail : thibault.schneider@oniris-nantes.fr

Abstract

Usually, the products' sensory characterization is performed by a trained panel of judges. However, we suggest to establish the sensory profile of products using a panel of consumers and also to study their preferences, using paired comparison experiments. The application concerns 6 apple juices evaluated by 90 consumers in paired comparison for sensory profile and preferences. All the results are obtained in the framework of Bradley-Terry-Luce model. Using a latent class approach for preference data, it's possible to segment the consumers' panel in two homogeneous classes. The relations between preferences and sensory profiles are also presented.

Keywords: Sensory characterization, paired comparison experiments, Bradley-Terry-Luce model, Preference studies, latent class approach.

Résumé en Français

Habituellement, la caractérisation sensorielle de produits s'effectue à partir d'un jury entraîné. Néanmoins, nous suggérons ici d'établir le profil sensoriel de produits à partir d'un panel de consommateurs et d'étudier leurs préférences, sur la base de comparaison par paires dans les deux cas. L'application portera sur 6 jus de pommes évalués par 90 consommateurs pour le profil sensoriel et pour les préférences à l'aide d'épreuves de comparaison par paires. Tous les résultats seront obtenus sur la base du modèle de Bradley-Terry-Luce. Une approche en classes latentes pour les données de préférences permettra de segmenter le panel de consommateurs en deux classes homogènes. Une mise en relation des données sensorielles et de préférence sera présentée.

Mots-clés: Caractérisation sensorielle, Comparaison par paires, Modèle de Bradley-Terry-Luce, Préférence, Approche classes latentes.

1. Introduction

Usually, sensory profiling is mainly conducted by a panel of trained judges. They have to note each product following different descriptors which allows obtaining the products' profile. However it seems wise to get product's profile using a panel of consumers directly. Their preferences could be linked with the sensory perception that they have expressed.

To deal with this problem, it is possible to use a paired comparison approach, which has already been used on such panel. In fact, even if this method is mostly applied on hedonic tests, it can resort to discrimination test (ISO Standard 5495, 2005). In that case, the panel is asked to point, for a given criteria, which sample is the most intense.

As a part of this study, a sensory analysis in pair-wise comparison is conducted on 6 apple juices from the market by a panel of ninety consumers. A product profile is obtained. Meanwhile, a hedonic test in paired comparison too is achieved on the same products. Using a latent class approach with Bradley-Terry-Luce model (COURCOUX, SEMENOU, 1997), a consumer's segmentation is proposed.

2. Material and method

2.1 Sensory characterization

2.1.1 Setting up of a sensory analysis by paired comparisons.

2.1.1.1 Selection of products and descriptors

Six apple juices were considered during this study, precisely two nectars, two clarified pure juices and two un-clarified ones. For each type of juices, one organic and one non-organic juice were chosen. This selection was made so as to check if an untrained panel is able to settle profiles for different products. Moreover, to test products which differentiated from each other by either their process (nectars, pure juice clarified or un-clarified) or the origin of their ingredients (organic or not) allowed to better target consumer's preferences.

In order to have a better scan of the product environment while staying within range of an average consumer, the selected descriptors are as follows: dark, cloudy, apple smell, astringent, apple taste, sour and sweet.

2.1.1.2 Design of presentation

The design of presentation is built according a design suggested by Kraitchik (DAVID, 1988). By using a balanced incomplete block, the judges tested only three pairs on the fifteen possible ones, but each judge rated the six products. First one block was created, based on all the combinations possible with three pairs, leading to a table of fifteen judges and three pairs. By shifting each pair's from a column to the next one and swapping product's order in each pair, the initial block ended up in six blocks of fifteen judges each. This operation deleted the order effect of the product presentation and the report effect. For this reason, the plan was built on a ninety judges' basis.

2.1.1.3 Sensory profile experiment

The ninety judges tasted the products in separated boxes, under artificial lightning. Each sample was encoded with a three digit number.

Pairs were presented one at a time. For each pair, judges had to note down the sample's number, respecting the presentation order. Then they were asked to write for each criterion which juice was the most intense. The judges had to follow precisely the order in which descriptors were given to avoid a potential order effect.

2.1.2 Sensory data analysis by the Bradley-Terry-Luce Model (BRADLEY, 1952)

Suppose that n , the number of products, and H , the number of individuals who did the test. Each individual h must choose for each pair between two stimuli (first or second product). The response for the pair (i, j) is noted:

$$y_{ij,h} = \begin{cases} 0 & \text{if } j \text{ was chosen against } i \\ 1 & \text{if } i \text{ was chosen against } j \end{cases}$$

Since $y_{ij,h}$ can only have two values: 0 or 1, it is an observation of a Bernoulli variable $Y_{ij,h}$.

The probability of stimulus i to be chosen to the stimulus j by the consumer h , is noted $p_{ij,h}$. Therefore the Bradley-Terry-Luce model (BRADLEY, 1952) states that:

$$p_{ij,h} = \frac{\pi_i}{\pi_i + \pi_j}$$

Where π_i is the Bradley's score for the product i , under the constraints: $\pi_i \in]0 ; 1[$ for $i = 1, \dots, n$ and $\sum_{i=1}^n \pi_i = 1$

With this notation of $p_{ij,h}$, the odds ratio could be written in the following way:

$$\frac{p_{ij,h}}{1 - p_{ij,h}} = \frac{\pi_i}{\pi_j}$$

Moreover, supposing the independence between the variables $Y_{ij,h}$, the likelihood associated with the whole of observations $y = (y_1, \dots, y_H)$, where $y_H = (y_{ij,h} / 1 \leq i < j \leq n)$ is the observations' vector for the individual h , is:

$$L(y, \pi) = \prod_{h=1}^H \prod_{i=1}^{n-1} \prod_{j=i+1}^n \left(\frac{\pi_i}{\pi_j} \right)^{y_{ij,h}} \left(\frac{\pi_j}{\pi_i + \pi_j} \right)$$

The estimation of π is obtained by solving the maximum likelihood equation (DYKSTRA, 1956)

2.2 Study of preference

2.2.1 Realization of the hedonic test using paired comparison

In order to target the consumer's preferences, a hedonic test in paired comparison is achieved. Products are the same as at the previous experiment, and the previous design of presentation was kept. Ninety consumers tested the products again, in the same conditions as at the sensory analysis. The instructions were the same but each consumer had to select the product that he preferred, for each of the three pairs.

2.2.2 Hedonic data analysis by the model of segmentation in latent class (COURCOUX, SEMENOU, 1997)

The previous approach supposes a homogeneous panel, which is not obvious when the preferences are studied.

Suppose the existence of T segments of consumers. We call $\alpha(t)$ the probability that an ordinary individual belongs to the group t, with $\alpha(t) \in]0 ; 1[$ and $\sum_{t=1}^T \alpha(t)=1$.

We note $p_{ij,t}$ the probability that the stimulus i to be preferred to the stimulus j for the segment t. As previously, for each class t, the probability can be written following the Bradley model:

$$p_{ij,t} = \frac{\pi_{i,t}}{\pi_{i,t} + \pi_{j,t}}$$

Under the constraints $\pi_{i,t} \in]0 ; 1[$ and $\sum_{i=1}^n \pi_{i,t} = 1$

Parameters $\alpha(t)$ and $\pi(t)$ will be estimated for any $t = 1 : T$ by maximum likelihood, using an algorithm type EM. (DEMPSTER et al., 1977). The selection of the number of classes can be achieved with a likelihood ratio test by Monte Carlo simulations.

3. Results

3.1 Products' profile obtained by the sensory analysis

The juices were coded in the following way: BCPJ for the biologic cloudy pure juice, CPJ for the cloudy pure juice, BN for the biologic nectar, N for the nectar, BPJ for the biologic pure juice and PJ for the pure juice.

A non standardized PCA was made on the Bradley's scores related to each product and each descriptor. The representation of the products and descriptors on the first two dimensions is presented below.

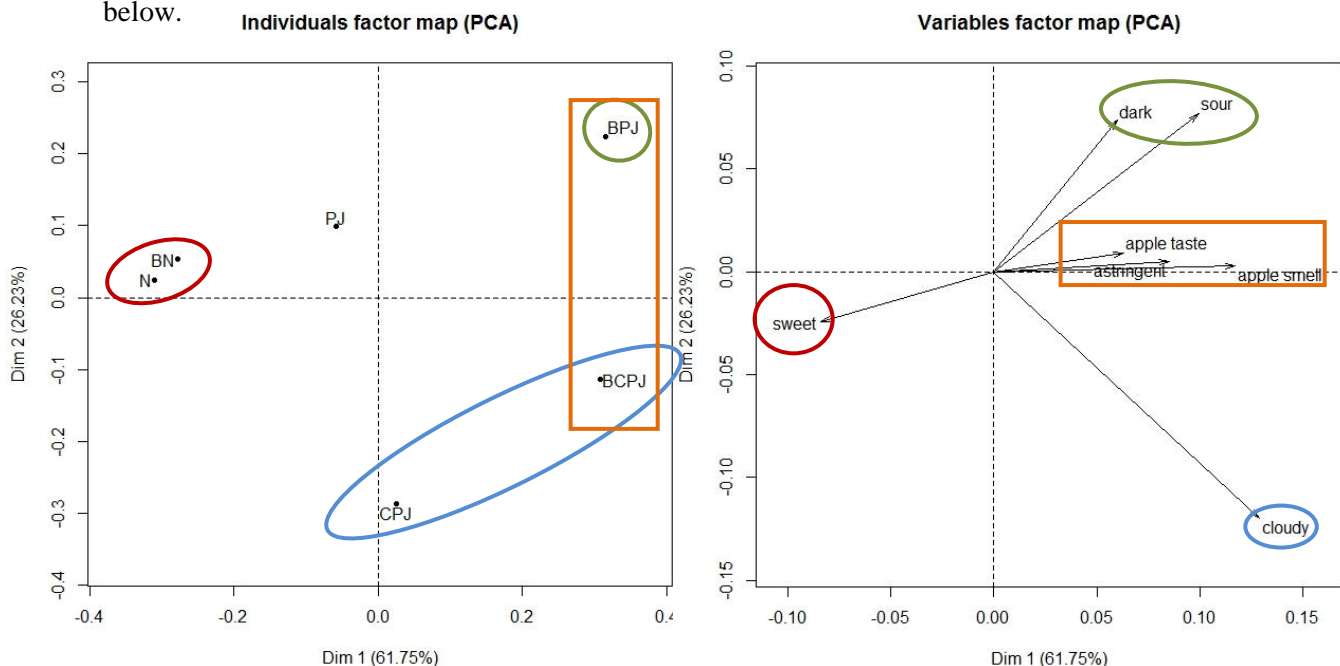


Figure 1 : Representation of the products and descriptors obtained by non-normed PCA on the Bradley's scores

From these results, two types of profiles are identified, opposing the nectars to the pure juices. Actually, the nectars are perceived sweeter, less sour, with a smell and a taste of apple less pronounced than the biologic pure juice and the cloudy pure juices. On the contrary, these last juices are felt less sweet and more acidic, with a smell and a taste of apple more intense. Only the pure juice has an intermediate profile.

3.2 Segmentation of consumer in homogeneous classes

From the segmentation model, the panel could be split according to their preferences in two homogeneous classes. Configurations of the products and weights of the two classes are given in Table 1

| | Class 1 | Class 2 |
|--------|----------|----------|
| Weight | 49% | 51% |
| BCPJ | 0.032966 | 0.180410 |
| CPJ | 0.110084 | 0.215203 |
| BN | 0.111734 | 0.069915 |
| N | 0.547013 | 0.000007 |
| BPJ | 0.072532 | 0.212221 |
| PJ | 0.125671 | 0.322476 |

Table 1 : Product's Bradley's score in each Class and class's weight

A different appreciation of the nectar is the main difference between the two classes. Indeed, the first class seems to like this product a lot, whereas the second class tends to reject this one.

3.3 Study of the link between the preference and the sensory characterization

Bradley's scores of each class were projected in the sensory space previously obtained.

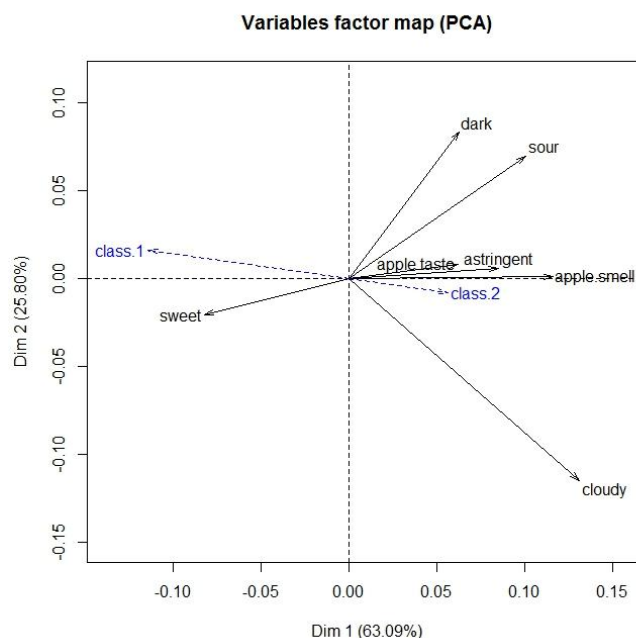


Figure 2 : Representation of descriptors with the preferences by class as supplementary variables

Consumers from the first class prefer the juices which are sweeter, less sour, with a weak taste of apple, whereas the consumers from the second class prefer the products which are less sweet, more acidic and cloudier, with a more intense apple taste.

All the calculation for paired comparison data were done by using the R package CompR (SEMENOU (2015)).

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