IN SEARCH OF THE TASTE OF TERROIR: A CHALLENGE SENSORY SCIENCE

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Abstract

The definition of terroir has evolved throughout history, from something clearly negative in the XVIth-XVIIIth century to a complex multi-parametric construct with positive connotations but also with many scientific unknowns. Terroir has always been linked more or less explicitly to the sensory properties of the resulting products.

Wine consumers have little access to objective terroir information and even if they had, it would be very difficult for them to interpret in terms of wine quality. In Europe, the proxy for terroir is the Protected Designations of Origin (PDO) system, which is what consumers have come to know. According to INAO "It is the notion of soil (terroir) that is the basis of the concept of Appellations d'origine" and results in a product with original and typical features.

From a cognitive point of view, terroir-based and other wine sensory categories have been approached from prototype categorization theory, according to which categories are stored in long-term memory as prototypes. The prototype would be abstracted from the instances of the category during previous tastings and shared between experts. The prototype is highly typical of the category and serves as reference to categorize new items. Such categories are based on family resemblance (instances from the same category share more features then instances from different categories) and are organized according to a typicality gradient.

The main sensory methods used to explore the structure of wine sensory categories are typically ratings and sorting tasks combined with descriptive analysis. The sensory studies dealing with PDO-based categories are scarce. Globally, the results suggest that PDO-based categories are quite difficult to distinguish sensorially. A possible explanation is that high within-category variability makes it difficult to pinpoint a prototype and yields quite fuzzy borders.

Keywords: Terroir, PDO, typicality, expert panel, sensory concept

Introduction

According to the French Institute of Appellations of Origin (INAO), the idea of terroir underlines French Appellations, or if we consider the European extended concept, the Protected Designations of Origin (PDO). A product from a given PDO takes its authenticity and typicality from its geographical origin. As a corollary, it is not possible to reproduce this very product outside the considered PDO or terroir.

The definition of terroir has evolved throughout history, from something clearly negative in the XVIth-XVIIIth century to a complex multi-parametric construct. While some authors (Johnson and Robinson, 2002) focus the definition of terroir to a set of physical environment parameters (soil, sub-soil, climate, microclimate…) and a more recent definition includes human factors. For instance, Casabianca *et al.* (2006) define terroir as a delimited space where a human community builds throughout History a collective production know-how. In other words, terroir is based on a system of interactions between a physical and biological environment and a number of human factors. According to the authors the impact of the physical environment combined with local production methods gives the resulting products their originality, typicality and reputation. The idea of terroir or "sense of place" is the one of the most important communication vectors in the European wine industry (most notably, France, Italy, Germany, Spain and Portugal) while this idea is still in development in some new wine-producing countries.

The notion of sensory qualification by an expert jury to guarantee that a product has the typical sensory features expected for a given PDO existed a long time ago (Capus, 1947). In 2008, the INAO established regulations in order to implement tasting panels aiming to check both the quality and the typicality of the samples.

However, the existence of a unique typicality for each PDO is far from proven. As Deloire *et al.* (2008) state "What does the product taste like, is its taste related to terroir and is this relationship identifiable?"

Sensory Typicality Assessments on PDO Wine Categories

As said before, French PDOs are based on the presence of a specific terroir. In other words, each PDO is supposed to have a unique combination of physical and human factors that result in a unique and recognizable sensory style. However, this does not mean products standardization within a PDO. In many traditional PDOs, variability is allowed and even encouraged within the limits of a reasonable sensory typicality (Casabianca *et al.,* 2006). The main methodology to explore the existence of a sensory identity associated to wine categories is the typicality assessments. This method has been first used to study the typicality of varietal wines (Candelon et al. 2004; Ballester *et al.,* 2005; Ballester *et al.,* 2008) and subsequently transposed to PDO categories. Additionally, categorization tasks (free or directed sorting tasks) have also been used to explore varietal categories (Lobodanin *et al.,* 2014, Honore-Chedozeau *et al.,* 2019) and also PDO categories.

The theoretical framework of this approach are the categorization models proposed in cognitive psychology. In terms of category structure and category membership we can consider two interesting options. First the classical view proposes a set of defining features singly necessary and jointly sufficient for category membership (Katz and Postal, 1964). According to this view, categorization always has a binary outcome; either an instance is a member of the category or it is not. Transposed to wine, we could imagine a PDO category like Vosne-Romané for which it exists a set of rules and specifications singly necessary and jointly sufficient for a wine to be a member of this category.

The second point of view is the probabilistic view. In this case the category is constructed according to the principle of family resemblance, in other words, based on typical features, and organized on a typicality gradient (Rosch, 1975). For instance, a study has shown that a robin or a sparrow were more typical of the Bird category than a penguin or an ostrich. Transposed to wine, we can consider the PDO Vosne-Romané this time from a sensory point of view (rather than as a "legal" category). A typical instance of this category will display the most typical features of the category, but not necessarily all of them. The instances of the category are then organized along a typicality gradient. Ballester et al. 2012 showed that a sample set of 20 Vosne-Romané wines assessed in terms of typicality by a panel of 20 wine experts (all producers of Vosne-Romané wines) were indeed organized along a typicality gradient from the less typical to the most typical (Figure 1).
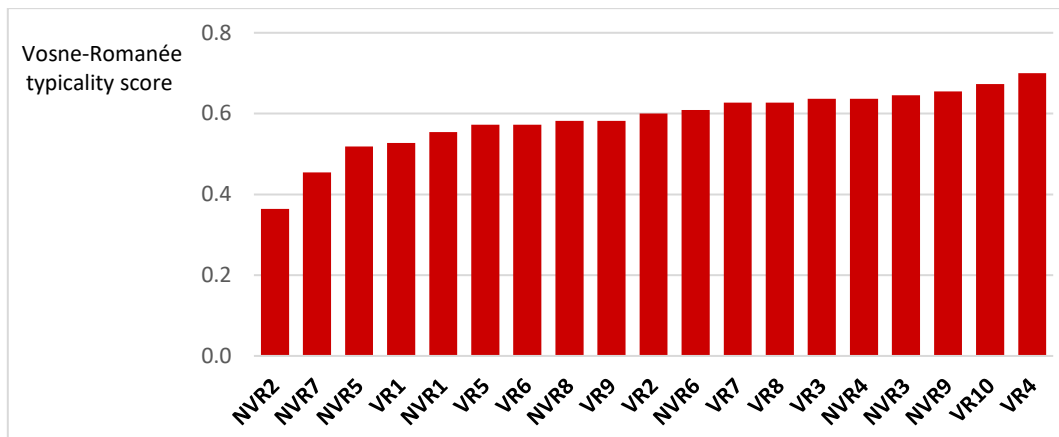
Figure 1: Typicality gradient within the Vosne-Romanée wine category (Ballester *et al.,* 2012).

However, in order to properly show the existence of the sensory typicality of a wine category, there is no choice but to include in the sample set instances from a contrast category, which must be comparable to the target category, allowing for a more "apples-to-apples" comparison.

The first typicality studies on PDO categories concerned Fleurie and Duché d'Uzès. Both studies used a large sample set (101 and 60 respectively) with 50% targets and 50% outsiders, and large expert panels (see Table 1 for details). Both studies hypothesized that the wines from the target category were significantly more typical of the category than the outsiders. Concerning the Fleurie PDO study no significant differences were found between targets and outsiders. Therefore, the results did not support the existence of a Fleurie sensory typicality. The results concerning Duché-Uzès were more surprising; the outsiders were judged more typical of Duché d'Uzès than the wines that were actually from Duché d'Uzès (Table 1). Moreover, the experts showed a reasonable consensus in their typicality judgements (Jaffré, 2009).

Using a similar methodology Perrin (2008) carried out two small studies on the typicality of two PDOs from Loire valley: Savennières and Anjou Villages Brissac. The Savennières study did not show a significant sample effect on Savennières typicality scores. In other words, Savennières wines were not more typical of their appellation than the outsiders (see Table 1 for more details). However, the study on Anjou Villages Brissac PDO showed than the targets were slightly more typical of the Anjou Villages Brissac Appellation than the outsiders (Figure 2).
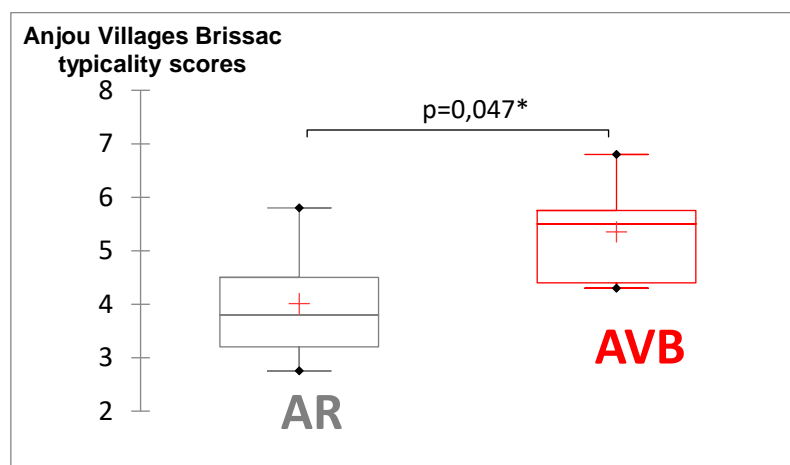

Figure 2: Box-plot of the Anjou Villages Brissac typicality scores for targets (AVB) and outsiders (AR) (carried out using the data provided in Perrin, 2008).

Based on these encouraging results, a second study on the same PDO combined typicality assessments was undertaken using the Just About Right analysis (Cadot *et al.,* 2010). In this case the samples set and the panels were larger than in Perrin's study. However, the results showed that the perceptual Anjou Villages Brissac concept was not consensual among expert tasters. Moreover, despite the fact that the 6 most typical samples were targets,

Chi-square tests showed that globally, the targets were not scored as significantly better examples of Anjou Villages Brissac wines than the outsiders. In addition, neither JAR analysis nor QDA showed the expected discrimination between Anjou Villages Brissac and the outsiders (Cadot *et al.,* 2010).

A very recent study on the typicality of six Languedoc terroirs was carried out by Leriche *et al.* (2020). A specific expert panel was used for each terroir. The proportions of outsiders were lower than in previous studies (see Table 1 for details). As in Cadot *et al.* (2010), typicality assessments were completed by Just About Right descriptions. Four out of six terroirs did not show a significant sample effect on the typicality scores. For the sake of simplicity, Student tests were performed for this review from the typicality data provided in Table 6 of Leriche *et al.*'s article. Only the results of PDOs A and F showed significantly higher typicality for the targets, supporting the existence of a sensory signature for these two PDOs (Figure 3A and 3B).
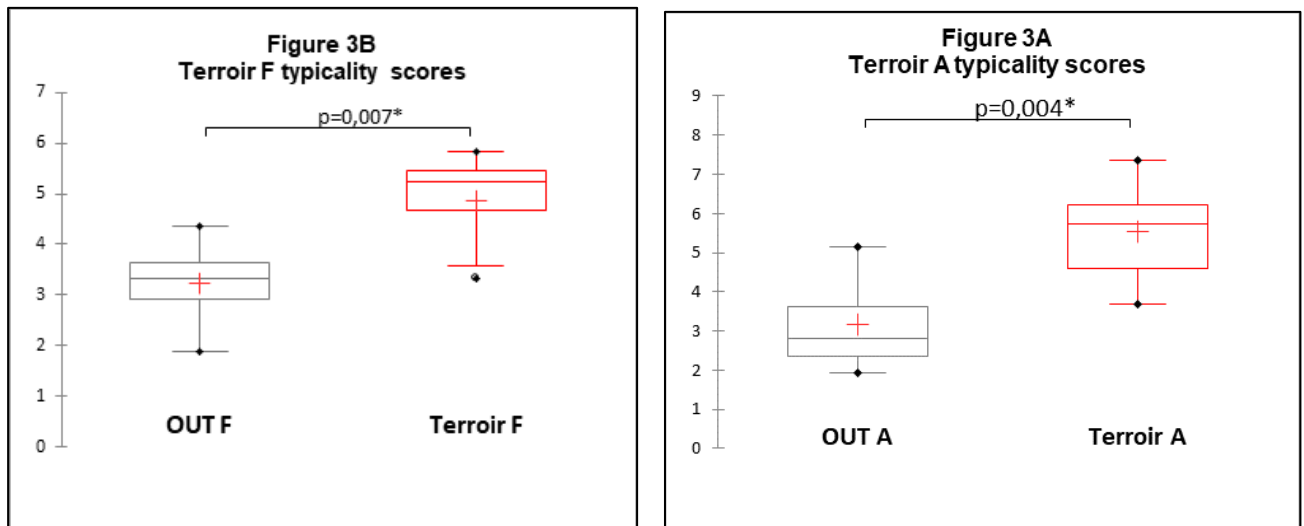
Figures 3: Box-plot of the typicality scores for (A) Terroir A (left) and (B) Terroir F (right) (carried out using the data provided in Leriche *et al.* (2020).

Leriche et al. (2020) made a focus on Terroir F and presented the corresponding JAR analysis. The JAR results showed that untypical samples were either too ripe or too black fruits and not enough spicy, tannins, fresh, red fruits or sour. Some of the untypical samples lacked also ripeness or black fruit. Targets clustered fairly well and showed optimal levels for most of the attributes.

Sensory Categorization Tasks on PDO Wine Categories

Free sorting tasks have also been used to explore family resemblance within PDO categories. Honoré-Chedozeau *et al.* (2020) explored the sensory similarity of two Beaujolais PDOs: Morgon and Regnié. The free sorting results were analyzed using Distatis (Abdi and Valentin, 2007). The authors hypothesized that if Regnié and Morgon wines had distinctive sensory styles the two categories should be properly discriminated in the Distatis compromise map (Figure 4). The results showed that the samples were not clustered by PDO but following a seemingly random pattern. A similar approach was used to explore family resemblance within Pouilly-Fuissé and Saint Véran PDOs (Honoré-Chedozeau *et al.,* 2012, unpublished data). The MDS plot resulting from the co-occurrence matrix is shown in Figure 5. The results showed that the samples segmentation was not based on their PDO.

When performing a directed sorting task panelists activate in memory their own sensory representation of the target categories before the task begins. Ballester and Jacquet (2014) used a binary directed sorting task to explore the sensory signatures of Chambolle-Musigny and Gevrey-Chambertin PDO categories. In this case, the authors verified before the tasting that participants (wine connoisseurs) had very distinct mental representations of these two categories, being Chambolle-Musigny mostly associated to "feminine" sensory characteristics and
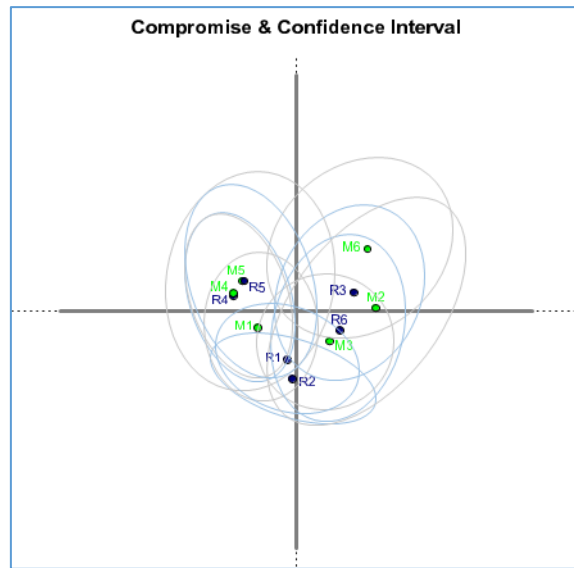
Figure 4: Distatis compromise map carried out on a free sorting task with Regnié and Morgon wines (Honoré-Chedozeau *et al.* (2020).
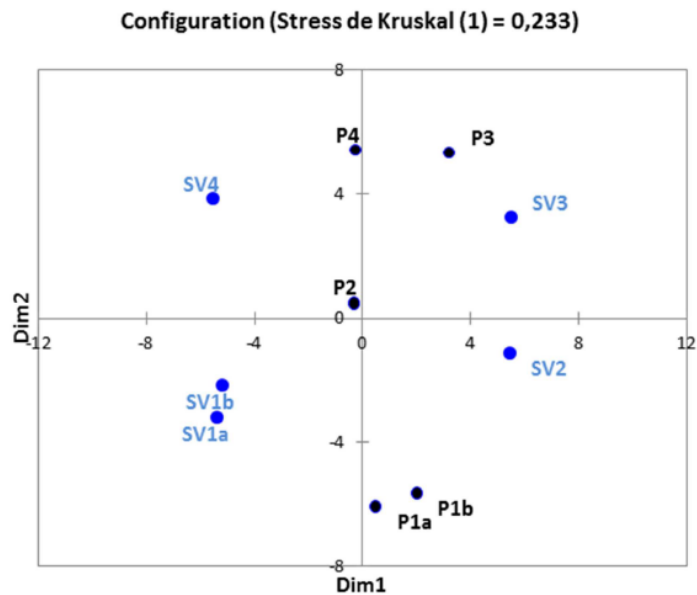

Figure 5: Two dimensional plot of the MDS carried out on a free sorting task with Pouilly-Fuissé and Saint Véran PDOs wines. (Honoré-Chedozeau *et al.*, 2012, unpublished data).

Gevrey-Chambertin to "masculine" ones. The authors hypothesize that the strong alleged sensory differences expected from the wines of both categories should enable an easy sensory recognition of the origin of the samples when tasted blind. Chi-square tests showed that only one sample out of 16 was significantly categorized in the correct category (Figures 6A and 6B).
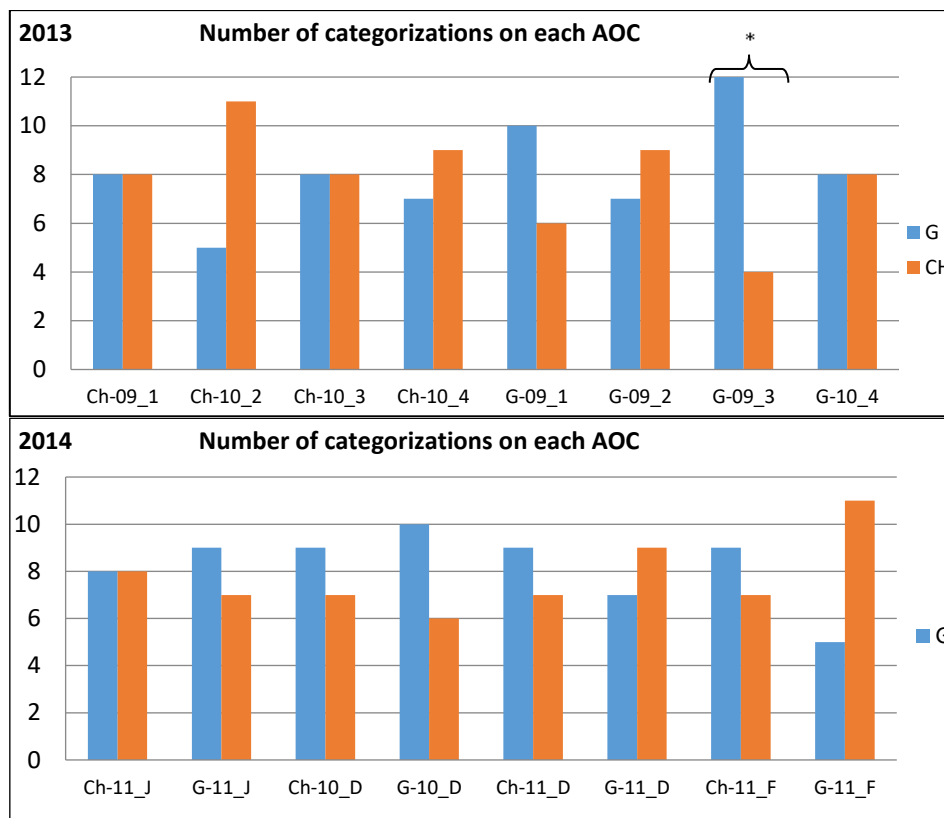
Figure 6: Number of categorizations for each sample on each AOC in the (A) 2013 (top plot) and (B) 2014 (bottom plot) tasting sessions. G= Gevrey-Chambertin; Ch= Chambolle-Musigny. *= significant Chi-square test (α=0.05). From Ballester and Jacquet (2014).

Table 1: Summary of the different studies using typicality assessments. In bold studies that support PDO typicality.

Target PDO category	Panel size	Number of Targets	Number of Outsiders	Results	Reference
Fleurie	29	51	50	Not significant typicality differences between targets and outsiders	Jaffré (2009)
Duché d'Uzès	33	30	30	Outsiders significantly more typical than targets	Jaffré (2009)
Savennières	20	4	8	Not significant typicality differences between targets and outsiders	Perrin (2008)
Anjou Villages Brissac	**14**	**5**	**5**	**Targets significantly more typical than outsiders**	**Perrin (2008)**
Anjou Villages Brissac	12	16	8	Not significant typicality differences between targets and outsiders	Cadot et al. (2010)
Terroir A	**9**	**10**	**4**	**Targets significantly more typical than outsiders**	**Leriche et al. (2020)**
Terroir B	8	9	4	Not significant typicality differences between targets and outsiders	Leriche et al. (2020)
Terroir C	7	10	4	Not significant typicality differences between targets and outsiders	Leriche et al. (2020)
Terroir D	9	8	4	Not significant typicality differences between targets and outsiders	Leriche et al. (2020)
Terroir E	7	8	4	Not significant typicality differences between targets and outsiders	Leriche et al. (2020)
Terroir F	**15**	**9**	**4**	**Targets significantly more typical than outsiders**	**Leriche et al. (2020)**

Conclusions

Only a small proportions of the studies presented in this review succeeded in supporting PDO typicality. It is plausible that high within-category variability combined with lack of consensus among experts make it difficult to pinpoint a consistent sensory signature and produce a significant overlapping with neighboring categories. Based on these results, future studies on the sensory impact of terroir should bypass the existing PDO system and rather build their experimental design based on objective measurable terroir parameters.

Acknowledgments

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