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Taste-aroma interaction in model wines: Effect of training and expertise

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ABSTRACT

The effects of training and expertise on aroma enhancement by taste were investigated in model wine matrices, containing the same aroma compounds in the same quantity, but varying in sugar and acid composition. Three groups of panelists, untrained, trained and experts, scored the odor and aroma of the matrices, in conditions encouraging a synthetic strategy (a single rating scale for aroma) or an analytical strategy (several rating scales, for both aroma and taste).

The enhancement of aroma by acid and sweet tastes depended on both the number of scales (only the aroma scale vs. aroma and taste scales) and the panelist group (untrained, trained or experts):

- Untrained panelists reported the intensity of taste on the aroma score when provided with a single rating scale, but not when they were provided with multiple rating scales.
- When presented with a single scale, all three groups experienced the same level of aroma enhancement by sweetness. However, when several scales were provided, trained panelists and wine experts showed a significantly lower enhancement than untrained panelists.

These results indicate that when tasters' attention is guided towards taste perception, trained and expert tasters can take advantage of their ability to adopt an analytical strategy, which enables them to separate better (but not perfectly) the different components of wine flavor, while untrained tasters cannot. This suggests that in the case of wine, training and expertise lead equally to an improvement in analytical abilities. Several explanations are proposed for the effects of attention and training in order to improve the ability to distinguish aroma and taste.

1. Introduction

The sensory character of a food results from the integrated perception of the multiple stimuli elicited by its chemical and physical properties. It would be inappropriate to try to understand each single perception separately as the perception of each stimulus can be affected by the presence in the food of other stimuli, assessed by other senses. Food chemists, sensory analysts and psychophysicists have tried for decades to understand the origin and mechanism of the multisensory perception of flavor (Auvray & Spence, 2008; Booth, 1994; Delwiche, 2004; Plug & Haring, 1994; Poinot, Arvisenet, Ledauphin, Gaillard, & Prost, 2013; Stampanoni, 1993). In particular, retronasal aroma perception can be modulated by the presence of sapid compounds although these do not stimulate olfactory receptors. How the perception of aroma interacts with the perception of sweet taste has notably been the subject of many studies. Different aroma compounds have been found to enhance sweetness perception, for example in model systems (Hort & Hollowood, 2004; Stevenson, Prescott, & Boakes, 1999) beverages (Clark & Lawless, 1994) and custard desserts (Tournier, Sulmont-Rosse, Semon, Issanchou, & Guichard, 2009). A recent study showed that in French ciders with a medium level of sugar, those with fruity notes were perceived sweeter (Symoneaux, Guichard, Le Quere, Baron, & Chollet, 2015). However, the quantity and release of the aroma compounds in the different ciders was not controlled.

Reciprocally, the addition of sucrose has also been found to increase perceived aroma intensity in model solutions (Dalton, Doolittle, Nagata, & Breslin, 2000; Hort & Hollowood, 2004; Pfeiffer, Hollowood, Hort, & Taylor, 2005) and dairy desserts (Lethuaut et al., 2005; Tournier et al., 2009). Working on the enhancing effect of sucrose on mint aroma, Davidson, Linforth, Hollowood, and Taylor (1999) showed that panelists' perception of mint aroma in a chewing gum matrix followed the same pattern

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as in-mouth sucrose release rather than menthone release (Davidson et al., 1999). In other studies, aroma enhancement by sucrose was shown to occur only at low aroma concentration (Fujimaru & Lim, 2013; Green, Nachtigal, Hammond, & Lim, 2012).

The mechanisms proposed to explain the mutual influence of aroma and taste when perceived together can occur at physico-chemical, physiological or psychological levels.

1. *Physico-chemical interactions:* can occur between aroma and taste compounds in the matrix, changing the concentration of the stimulus before it activates the receptors. Such interactions between sweet compounds and odorant volatile compounds can induce either the retention or the release of the volatile compounds, depending on the nature of the volatile and saccharide molecules (Delarue & Giampaoli, 2006). Mono- or disaccharides usually induce a "salting out" effect of aroma compounds due to the hydration of the sucrose molecules by water, which decreases the water activity of the matrix mainly for polar molecules, such as alcohols, pyrazines, furans (Piccone, Lonzarich, Navarini, Fusella, & Pittia, 2012), menthone and isoamyl acetate (Ebeler, Pangborn, & Jennings, 1988), acetone and 1-octanol (Voilley, Simatos, & Loncin, 1977) but also for esters and terpenes (Hansson, Andersson, & Leufven, 2001). However, a retention effect can also be observed when sucrose is added to water, explained by an increase in viscosity (Siefarth et al., 2011). To ensure the absence of physico-chemical interactions, some sensory studies have been performed by delivering the olfactory stimulus orthonasally and the gustatory stimulus directly in the mouth (Charles et al., 2013; Fujimaru & Lim, 2013; Lim, Fujimaru, & Linscott, 2014).
2. *Neurophysiological level:* Unlike taste-taste and odor-odor interactions, it seems utterly improbable that taste-aroma interactions would occur at the level of the olfactory or gustative receptors (Noble, 1996). However, the olfactory and gustatory signals have been shown to converge in the same areas of the orbitofrontal cortex (de Araujo, Rolls, Kringelbach, McGlone, & Phillips, 2003; Eldeghaidy et al., 2011; Rolls & Baylis, 1994; Verhagen & Engelen, 2006). Small (2008) showed that the neural activation observed when the subjects received a taste-odor mixture was greater than the summed neural activation produced by separate stimulations with taste and odor. It was proposed that the experience of co-activated unimodal inputs shapes multimodal cells and bimodal cells encode for the perception of flavor (Small, 2008). In fact, some neurons in the orbitofrontal cortex of macaque were shown to have bimodal responses to both taste and olfactory stimuli with congruent characteristics (Rolls & Baylis, 1994). de Araujo et al. (2003) described these bimodal and unimodal gustatory and olfactory neurons as being spatially "intermingled". These authors showed that activation of certain brain areas by an odor-taste pair was correlated with the congruence of the two stimuli.
3. *Psychological interactions:* Some authors consider flavor as a "distinct sense" cognitively constructed from separate sensory systems, primarily olfaction and gustation. A prior experience of the co-occurrence of a gustative and an olfactory stimulus in the mouth results in the acquisition of a flavor memory, which can later be reactivated when one of its components is experienced alone (Stevenson et al., 1999). According to Stevenson, a global encoding of the multimodal inputs from the oral cavity occurs via configural learning, in which taste and smell are treated as a single global flavor percept (Stevenson, Boakes, & Wilson, 2000). The attention of the subjects to the elements in the flavor mixture during the initial co-exposure is important. The adoption of a synthetic perceptual strategy by subjects during the co-exposure was shown to be necessary to produce enhancement of sucrose sweetness by an odorant (Prescott, Johnstone, & Francis, 2004) and an increase in the sweetness-paired odor of this odorant (Prescott & Murphy, 2009). In these studies, when the subjects' attention was directed towards individual stimulus elements in the flavor mixture during the conditioning exposure, there were no changes in sweetness ratings between the pre- and post-exposure sessions. On the contrary, other studies showed that odor–taste associative learning could still occur when an analytical strategy was adopted during the conditioning (Stevenson & Mahmut, 2011). Attentional strategies during the post-exposure session also seem to be determinant for the observed multisensory interactions. This was first observed by the "dumping" phenomenon (Clark & Lawless, 1994), which is the enhancement of odor perception by congruent tastants or the enhancement of taste perception by congruent odors, apparently provoked by attributes either insufficient or inadequate to describe the product (Frank, 2002; Frank & Byram, 1988; Frank, Van Der Klaauw, & Schifferstein, 1993; Frank, Wessel, & Shaffer, 1990; Nguyen, 2000). In these studies, when provided with only a scale to score sweetness, panelists included the intensity of other stimulus components in their scoring of sweetness. However, when scales to rate both odor and taste were provided, the enhancement of taste by odor was sometimes no longer observed (Frank et al., 1993, 1990; Nguyen, 2000). The same effect was reported for aroma enhancement by taste (Davidson et al., 1999; Hort & Hollowood, 2004). These studies suggest that congruent stimulus attributes are combined when response alternatives are restricted. This apparent effect of the number of attributes on odor/taste interactions may result from the impact of these scales on how attention is directed towards odor and taste (Prescott, 2012; van der Klaauw & Frank, 1996). Thus, by directing subjects' attention to the appropriate attributes in a taste–odor mixture, taste enhancement was suppressed even though a single attribute (sweetness) was scored (van der Klaauw & Frank, 1996).

To date, in studies in which an analytical strategy was encouraged, aroma enhancement by taste has mostly been evidenced at low aroma concentrations, either perceivable but weak (Fujimaru & Lim, 2013; Green et al., 2012; Lim et al., 2014) or at subthreshold concentration (Dalton et al., 2000). Only a few studies have shown an enhancement of aroma by taste, at clearly perceivable aroma concentrations and not provoked by a synthetic strategy induced by a single scale (Lethuaut et al., 2005; Tournier et al., 2009).

This question of attentional strategy seems to be crucial in understanding the mechanisms that underlie cross-modal interactions. There is a need to understand whether the failure to disentangle individual flavor components, experienced by most people, comes from an inability to direct their attention to a specific attribute when other sensory properties are perceived, or whether a "fusion" of the signals makes them impossible to distinguish. One way to make sensory panelists adopt an analytical strategy is by training, a common practice in sensory descriptive analysis. If the confusion between taste and aroma merely reflects the inability to direct attention to an attribute, then asking assessors to adopt an analytical strategy should produce inhibitory effects on odor-taste interactions. Differences should thus be observed between the results obtained by trained and untrained panels in the same scoring task.

How would product experts, like wine or beer experts, behave in the same task? Because of their extended experience of specific products and their ability to compare, describe and detect defaults in these products, they have developed a perceptual expertise that enables them to detect and scale single flavor dimensions better than untrained panelists can (Stevenson, 2009). In the particular case of wine experts, a number of researchers suggest that they