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Influence of odor function and color symbolism in odor–color associations: A French–Lebanese–Taiwanese cross-cultural study ☆

Léa Nehmé [a], Reine Barbar [b,*], Yelena Maric [c], Muriel Jacquot [d]

[a] LIBio (Laboratoire d'Ingénierie des Biomolécules), Université de Lorraine, 2 avenue de la Forêtde Haye, BP 172, 54505 Vandoeuvre-lès-Nancy, France
[b] Department of Food Science, Faculty of Agricultural and Food Sciences, Holy Spirit University of Kaslik (USEK), Lebanon, P.O. BOX 446, Jounieh, Lebanon
[c] Myrissi, 24-30 rue Lionnois, BP 60120, 54003 Nancy Cedex, France
[d] Innovative Crossmodal Interactions Modeling (InnoCIM), ENSAIA, Université de Lorraine, 2 av. de la Forêt de Haye, 54500 Vandoeuvre-lès-Nancy, France

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ABSTRACT

The olfactory and visual sensory systems appear to share robust and consistent associations. It is well known that culture specific experiences with odors may influence different aspects of odor perception such as intensity, pleasantness or edibility. Differences in terms of odor–color association might therefore be culturally specific. In order to determine the role of culture in odor–color associations, the responses of 155 French, 96 Lebanese and 110 Taiwanese subjects to the same 16 odorants were compared. The results highlight the role of culture and culinary habits on edibility ratings and color associations of some odors. Both perceptual and semantic factors seem to play a role in the odor–color associations in each country. Odor–color associations could indeed be affected by the function of odors in different countries. Culture-induced experiences influence the perception of odors familiarity, which will affect the prevalence of either perceptive (intensity, irritancy and hedonics) or semantic (nameability, familiarity) processing of these associations. Further studies should be conducted in order to understand the mechanisms underlying these cross-modal correspondences and the influence of cultural background and experience on them.

1. Introduction

In everyday life, we constantly have to combine information from different sensory modalities to better understand and predict the world around us. A large body of research has shown that people exhibit consistent crossmodal correspondences between many stimulus features in different sensory modalities.

Crossmodal correspondences have been defined as the tendency for a sensory feature, or attribute, in one modality, either physically present or merely imagined to be matched (or associated) with a sensory feature in another modality (Parise & Spence, 2013). An earlier definition was given in 1983 by Marks, according to his definition, sensory experience in one modality can often evoke parallels with sensory experience in another modality which can lead to crossmodal correspondences. In addition, Spector and Maurer (2012) underlined the fact, that traditionally, senses have been considered as separate modalities that become integrated only at higher level of the cortex but, they challenged this view by showing that recent research demonstrated that sensory modalities influence one another from the earliest stages of cortical processing. Early multisensory interactions may contribute to the ease and consistency with which we make cross-modal associations.

Psychologists have known about the existence of crossmodal correspondences for many years. For example, more than 80 years ago, Edward Sapir (1929) highlighted the existence of a crossmodal association between the speech sounds /a/ and /i/ and object size. He observed that most people associate the nonsense words "mal" and "mil" with large and small objects, respectively.

Eating is another example in which cross-modal interactions are common. How the food looks (Spence, Levitan, Shankar, & Zampini, 2010), its texture and smell (Bult, De Wijk, & Hummel, 2007), the temperature of it (Cruz & Green, 2000), the interactions of sweet, sour, umami, etc., and even the sound while chewing (Zampini & Spence, 2010) affect our taste-experience.

Many researchers have highlighted crossmodal associations between colors and odors (Gilbert, Martin, & Kemp, 1996), tastes (O'Mahony, 1983), and flavors (Spence et al., 2010). Elsewhere, crossmodal associations have been documented between auditory

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* Corresponding author.
E-mail address: reinebarbar@hotmail.com (R. Barbar).

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pitch and smell (Belkin, Martin, Kemp, & Gilbert, 1997), smells and shapes (Seo et al., 2010), and even shapes and tastes/flavors (Gal, Wheeler, & Shiv, 2011). It therefore appears likely that crossmodal correspondences exist among almost all possible pairings of sensory modalities.

Whereas the relationship between audition and vision has been well documented, a cross-modal linkage between the olfactory and visual senses is seldom mentioned in the literature. In one of the oldest studies available, Martin (1909) found that olfactory impressions were among the sensory experiences reported by subjects when shown reproductions of paintings.

Of all sensory systems, chemical sensors (smell and taste) are the most common. From the beginning they are the systems used by man and animals to defend themselves against predators and find food and ensure its edibility. Combined with the sense of taste, smell allows the individual to recognize food and detect potentially harmful substances in its environment. The nature of functionalities which involve the olfactory system gives it a great importance in the perceptual system (Ferrier et al., 2009).

According to Gibson (1966) and Marks (1991), the integration of afferent, from different sensory modalities, is a general property of the mammalian nervous systems. However, in terms of intersensory influence, it's usually the visual modality that predominates our daily interactions (Stein & Meredith, 1993). Zellner and Kautz (1990) reported that the intensity of olfactory stimuli is overvalued when presented with a compatible color (e.g., smell of strawberry/red color). This increase in perceived odor intensity does not seem to be due to learning since the performance also increases when introducing new pairs of colors/scents. The authors conclude that color induces a faint odor percept that combines more or less, depending on the degrees of compatibility, with percepts directly induced by olfaction.

Several reports of strong associations between certain odors and colors imply that such color–smell associations are most likely acquired and may be the subject to variation between cultures (Dematte, Sanabria, & Spence, 2006; Gilbert et al., 1996; Kemp & Gilbert, 1997; Maric, Barbar, & Jacquot, 2012; Schifferstein & Tanudjaja, 2004; Spector & Maurer, 2012). Interestingly, these associations were shown to be consistent over individuals (at least within the same culture) and to remain stable over time when retested as much as 2 years later (Gilbert et al., 1996). Results such as these suggest that a reliable multisensory interaction between olfaction and vision can take place even when the visual information consists of only simple stimulus features. Several color–smell associations are so compelling that an odor percept can change with color, e.g., subjects may perceive a cherry-flavored drink as orange-flavored if it is colored orange (DuBose, Cardello, & Maller, 1980). Furthermore, color not only facilitates odor identification but can also influence judgments of odor intensity, pleasantness and edibility (Zellner, Bartoli, & Eckard, 1991).

Spence (2011) distinguished between three kinds of correspondences: structural, statistical, and semantically mediated. Structural correspondences can occur due to neural connections (e.g., if stimuli in different senses share a feature such as intensity). Statistical correspondences are learned, and occur when two stimulus dimensions are routinely correlated in the environment. Semantically mediated correspondences arise due to language (e.g., "low" for elevation and pitch).

According to Stevenson, Rich, and Russell (2012), to determine whether the crossmodal correspondence arise as a consequence of the semantic and/or perceptual mechanisms, one must first examine which odor characteristics (intensity, irritancy, hedonics, familiarity, nameability) co-varies with which crossmodal match; if crossmodal correspondences seem to rely on odor characteristics that relate more to semantic processes (nameability, familiarity), one may infer that semantic processes may be involved in mediating that correspondence. Similarly if a crossmodal match was associated with a perceptual (intensity, irritating and hedonics) odor characteristic this would suggest that some form of perceptual communality might have mediated that match. Taking into consideration the ultimate question: whether affective match (hedonics) would be considered as a semantic or perceptual mechanism. Hedonic has been long considered a key factor in the semantic differential, since affective reactions are usually learned. However, there may be substantive similarity in neural representations of positive or negative affective states across sense modalities allowing it to be classed recently as a perceptual mechanism (Herz & von Clef, 2001). For color–odor associations, both perceptual and semantic factors seem to play a role; color brightness correlates with perceptual attributes of odors (odors that are more irritating, intense, and unpleasant are associated with brighter colors) and semantic attributes (more familiar and identifiable odors are associated with more saturated colors) (Stevenson et al., 2012).

Culture specific experiences exert a profound influence on various basic aspects of odor perception (Ayabe-Kanamura et al., 1998; Ferdenzi et al., 2011). A study carried out by Chrea et al. (2004) to evaluate the effect of culture on the relationship between physiological dimensions underlying odor perception and odor categorization, showed that American, French and Vietnamese participants differed in their responses for several perceptual dimensions. Nevertheless a common general odor representation was shared by populations, structured in categories. Participants used the same perceptual dimensions to categorize odors, namely pleasantness, edibility and cosmetic acceptability. It was thus concluded that some universal cognitive mechanisms might interfere in the perception of odors. Consistency in odor representation was found for two of the three groups of participants: the American and the French. The function of odor could explain this result given that, as industrial cultures, French and American people are exposed to similar standardized odors from international trades, while Vietnamese people are more familiar with local aromas (Aubaile Sallenave, 2000). As a consequence, differences in odor–color associations might be expected as a function of the culture in which people live or have grown up, especially when the functions of odors and the symbolism of colors are different between countries (Levitan et al., 2014; Maric & Jacquot, 2013).

In the present study, we aimed to explore possible cultural differences in odor–color associations between 3 widely different cultures. To address this, we carried out a cross-cultural experiment with European (France), Middle-Eastern (Lebanon) and Asian (Taiwan) participants.

These populations were chosen because they were likely to reflect diversity in:

- Food and culinary habits, but also environment and climate which could affect population references. According to Wan et al. (2014), in addition to cultural difference, differences in other domains, such as geographic locations, climates, agriculture, may also play an important role in the formation of crossmodal associations between taste/flavors and visual features.
- Color symbolism in each country. For instance, yellow color in Europe symbolizes lemons, whereas in Colombia normally dark green symbolizes lemons (Dematte et al., 2006).

The objective of the present work was to identify the nature of crossmodal correspondences and whether odor–color associations are made upon perceptual or semantic factors. Consistent associations within a culture but differences across cultures would demonstrate that color–odor associations are not only structural, but that they are mediated by statistical or semantic experiences.