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Olfactory attributes and colors associated with naturalness

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Highlights

- Specific olfactory properties like freshness and lightness were founded to be associated with natural odor
- Green, white and yellow were reliably associated with natural products
- Culture and product categories appeared to modulate associations between colors and natural products and expected intensity of natural products' odor and color

Abstract

In developed countries, naturalness is an important food attribute for the majority of consumers. However, the relation between natural products and their sensory properties are still poorly understood, and only few studies explored the olfactory attributes and colors associated with naturalness. In the present study, American and French participants were asked to associate attributes with natural and unnatural odors, and colors with natural products. Results showed that freshness was more often associated with natural odors, while green, white and yellow were the colors associated with natural products. However, our results also underlines disparities between countries and categories of products, as American participants expected higher intensity of natural products' color and odor, and choose less often white than French respondents. Brown, green, and orange were more associated with food, while blue and white were chosen more often for non-foods products. Taken together, these findings bring new insights on consumers' expectations and consumers' associations between olfactory properties, colors and natural products.

Keywords: Naturalness, sensory properties, odors, colors

1. Introduction

There is a growing demand for natural products, in food and non-food domain. Despite socio-demographic variability, naturalness features today among main expectations of a majority of consumers. Women, old consumers, and consumers with high income give greater importance to food naturalness (Bäckström et al., 2004; Olbrich et al., 2015; Roininen et al., 1999; Steptoe et al., 1995). Natural products are expected to have positive attributes: to be fresh, to be tasty, to be environmentally friendly, and to be healthy (Román et al., 2017). Moreover, preferences for “natural” exceed instrumental motivations (i.e. material or functional superiority), and is also based on ideational motivations, which means “the desirability of natural per se (for moral or ideational/aesthetic reasons)” (Rozin et al., 2004). To answer this demand, more and more products are presented with “natural” labels. However, no legal definition of a “natural product” exists in France, nor in the US, and these labels cover a variety of realities. As naturalness remains a vague concept, there is a need to better understand consumers’ definition and expectations of natural products.

What is a natural product? There is no clear consensus to answer this complex question. “Natural kinds”, which are the “naturally occurring objects”, are often opposed to “artifacts” which are made by humans. These categories have different specificities. The “naturally occurring objects” imply a particular internal structure (genetic or chemical), whereas artifacts imply a particular function (Gelman, 1988). In light of this definition, we might postulate that transformations changing the particular internal structure alter the most the naturalness of a natural object. In the food domain, Paul Rozin (2004) has defined natural food as “one that had not been changed in any significant way by contact with humans. It could have been picked or transported, but it was chemically identical to the same item in its natural place”. He opposed natural food to processed food, defined as “one that had been grown with fertilizers or pesticides and that might contain additives or preservatives to enhance its taste” (Rozin et al., 2004, p. 148). The neuropsychologist Raffaella Rumiati introduced a subdivision in the food category into “natural (i.e., fruit/vegetables) and manufactured (i.e., “food that underwent some kind of organoleptic transformation”) (Rumiati & Foroni, 2016,p.104). Roman and colleagues reviewed the studies conducted to measure how naturalness is important for consumers in their food choices. They observed that a majority of studies relied on three criteria when it comes to assess products naturalness: “how the food is grown” (organic or local), “how the food is produced” (for example without additives or artificial colors, produced with traditional methods), and the properties often attributed to natural foods (e.g. ecofriendly, healthy, tasty or fresh) (Román et al., 2017).

However, it has been argued that none of the above mentioned criteria might be used as a clear cut-off point between natural kind and artifact, and several authors raised the issue of the relativity of naturalness (Gelman, 1988; Lepiller, 2016). For example, Susan Gelman highlighted that, domesticate animals or cultivated plants like wheat or corn, are borderline cases, as they do not belong to the artefacts, but they have been modified by human selection. Considering these borderline cases, the author proposed that “there is probably a continuum rather than a strict dichotomy between natural kinds and artifacts” (Gelman, 1988, p.69). The degree of naturalness for a product would then be its particular place on this continuum, and represents its distance from its naturally occurring state. The more the product has been changed in its essence by human interventions, the lower its naturalness would be.

Moreover, human actions do not all have the same effect on naturalness. Indeed, Rozin and his colleagues (2005) showed that, for consumers, chemical transformations, like adding fat, affect

naturalness more than physical ones, like freezing (Rozin, 2005). Their results also underlined that 1) the contagion by unnatural entities (e.g. synthesized purified minerals) strongly affects the naturalness of a product, 2) the history of an entity's manufacturing process has a higher effect than its actual content to determine its naturalness, as significant changes in genotype and phenotype due to generations of domestication are perceived as less destructive of naturalness than adding a single gene by genetic engineering and 3) mixing natural entities (e.g. mixing spring water) marginally affects naturalness. In line with Rozin's study, Evans and colleagues (2010) suggested that the more the food was processed (i.e. "physical or chemical changes to the food or ingredients") the less it was perceived as natural (Evans et al., 2010). Abouab and Gomez (2015) showed that the production mode (hand-made vs. machine-made) played a role in the naturalness evaluation. The name of the ingredients is also of interest in the evaluation of naturalness. Indeed, E-numbers or chemical names, like E100 for curcumin, were evaluated as less natural than their equivalents with common names (Chambers et al., 2018; Evans et al., 2010; Murley & Chambers, 2019; Siegrist & Sütterlin, 2017).

Sensory characteristics of packaging also influence the perception of products' naturalness. Indeed, beyond the functions of protection and transportation, the graphic and structural properties (color, pictures, shape, type of materials) of the packaging can have an impact on the consumers' expectation about the product inside (Ampuero & Vila, 2006). For example, the color of the package (orange vs white) influences the expected freshness and naturalness of fruit juice, as white background on the bottle is perceived as more natural, purer, fresher, and is more appreciated than the orange one (Deliza et al., 2003). In a study conducted in 2013, Labbe and his colleagues observed a positive correlation between roughness and suppleness of packaging with expected naturalness of the product, and a negative correlation between noise intensity (i.e. "loudness of the noise when the fingertips slide on the material's surface") and expected naturalness (Labbe et al., 2013). However, the literature on sensory properties of natural products is small, and does not cover olfactory attributes.

The first objective of the present study was to explore which olfactory attributes and which colors were associated with natural products. These two modalities are linked with flavor evaluation, odor being one component of flavor, and color being a relevant cue about the flavor of a product (Garber et al., 2000; Spence, 2016). Moreover, as they both are sensory cues which can be experienced before product consumption, they can have a great influence on consumers' expectations prior to consumption. To achieve this aim, we investigated the semantics association between odors and naturalness, and colors associations with natural products. As some studies highlighted the role of intensity in naturalness' perception and cross-modal associations (Spence, 2011; D. A. Zellner, 2013; D. A. Zellner et al., 1991) we also raised the question of the expected intensity for color and odor of natural products.

The second objective of the present study was to explore how these associations were modulated by culture and product category. Indeed, culture is a prominent factor in odors' perception and cross-modal association (Ferdenzi et al., 2016; Levitan et al., 2014). Moreover, effect of context on perception, seen as effect of variables like physical, social and temporal environments, or also effect of intrinsic properties of the product, or effect of individual characteristics have been extensively documented, especially for food (see (Dacremont & Sester, 2019) for a review). In the case of naturalness, Lunardo and Saintives (2013) showed that the point of purchase affect the perception of naturalness, as the same chocolate cookie picture was perceived as more natural when presented with traditional market context rather than supermarket context (Lunardo & Saintives, 2013).

Moreover, results from Michel et al. (2019) underline that importance given to food naturalness varies according to the product category. Participants' preferences for organic food was higher for unprocessed foods than for processed foods. However, impact of the category of product on perception and expectation of naturalness has been little studied, even though they are subject to very different regulations and standards of production.

2. Method

2.1 Participants

The study consisted in a survey conducted via an online panel of French and North-American participants. These countries were chosen for a cultural comparison, as they are closed in terms of organization of consumer goods markets (production with manufacturers, supermarket as purchase point, etc.) and classification of consumer goods products (Food, personal care products and household products represent different categories with different functions). Definition of naturalness and attitude toward naturalness are also close between these countries (Rozin et al., 2012). Cultural differences have however been highlighted between these countries about attitude toward some products, like GMO (Rozin et al., 2012). Moreover, consumer goods and food market differ to some extent between these countries, and cultural differences have been underlined on the associations between colors and odors for example (Levitan et al., 2014). The questionnaire was developed in French, and then translated into English. French participants were recruited via Mane online Proprietary Panel, and American participants were recruited via a global consumer panel company named Toluna. Questionnaire was sent to both panels in January 2020. Our final sample consisted of 838 French participants and 505 Americans. For the French sample, 62% were women, 13% were in the 18-34 age group, 34% in the 35-49 age group, and 53% were in the 50 years old and over age group. For the American sample, 51% were women, and 35% were in the 18-34 age group, 30% were in the 35-49 age group, and 35% were in the 50 years old and over age group. To adjust these samples to the target population structure, we applied a population weighting adjustment based on age and gender (see data analysis part for more details).

2.2 Questionnaire and data collection

The questionnaire was divided into four sections. The first part was dedicated to standard demographics (age, gender and region). Then, in a second part, in order to better understand the consumers' definition and perception of natural odors, participants were asked to give, at least one and up to three adjectives associated with a natural odor. The same question was asked for unnatural odors. In the third part of the questionnaire, participants rated the expected intensity of natural products' odors and colors on an 8-points visual analog scale, from 1-Very weak to 8-Very intense for odors and from 1-Very pale to 8-Very vibrant for colors. Since we also aimed at investigating the effect of the product category on expected intensity, participants were asked to rate the expected intensity of natural products' colors for three categories of products: natural food, natural personal care products, and natural household products. For odors, they rated the expected intensity of natural odors for these categories and for natural strawberry as well. Natural food category gathers a wide diversity of products, so we investigated if an unprocessed food - a fruit - would be perceived differently from the general food category.

The goal of the fourth part was to explore the associations between natural products and colors. Here, participants had to choose on a color palette with different hues (white, yellow, orange, pink-red, purple, blue, green, brown, grey and black) all the colors that best matched natural foods, natural personal care products, and natural household products. General categories of products, like food, cover a large amount of different products and thus does not allow to dissociate associations mediated by naturalness from those mediated by typicality. Indeed, literature on cross-modal associations, between odors and colors for example, underlined the importance of typicality in mediating associations (Spence, 2020). To tackle this issue, participants had then to choose the color they considered to be natural for a strawberry (“Among the following colors, which ones do you consider NATURAL for a STRAWBERRY (as opposed to ARTIFICIAL)?”), and the color they considered to be artificial for a strawberry. We chose these four categories for two reasons: i) to investigate if participants would be able to associate colors with very general categories (food, personal care products, and household products), ii) to explore if typicality would become a more salient dimension in the association between colors and natural products as the specificity of the category increases. As hue and lightness have been shown to be salient dimensions in the cross-modals associations with colors (Kemp & Gilbert, 1997; Spence, 2011), we offered them a 2D color palette varying in terms of hue (Yellow, Orange, Red, Pink, Green, Purple) and lightness (light, bright and dark for each hue) leading to 18 different possible choices.

Data were collected anonymously, and collection and storage of data respected rules and regulations of GDPR and CNIL. The study conformed to the Declaration of Helsinki.

2.3 Data analysis

Text corpus from semantic associations between naturalness and odors was analyzed with Sphinx software. To study semantic associations rather than inflectional forms, lemmatization was conducted on the corpus (Gries, 2011). We studied which words had the most occurrences, and analyzed associations between naturalness and odors following three thematic dimensions: emotional valence, sensory attributes, and synonym of “being natural” or “being artificial” for odor. For questions about intensity, associations with colors, analyses were performed in R and significance level was set at $\alpha = 0.05$. Our samples did not have the same demographic structure as original populations (French and American population). Thus, we applied a population weighting adjustment, to adjust our sample to original population by a multiplying factor based on age and gender (Kalton & Flores-Cervantes, 2003). We analyzed adjusted sample data. Participants rated expected intensity of odors and colors of each product category. To look for differences between product categories within each participant, we analyzed data from intensity ratings with an ANOVA including product category as a within factor, and country, age and gender as between factors. Then we conducted a post hoc test corrected for multiple comparisons (Bonferroni). For questions on associations between colors and natural products or strawberry, we used χ^2 test and post hoc Bonferroni corrected χ^2 to test particular associations between colors and products, and also effect of culture and categories of products on these associations.

3. Results

3.1 Associations between colors and natural products

We tested whether the observed associations between colors and natural products were nonrandom with a χ^2 test between the participants' choices of colors (number of times each color was chosen for a given product category and a given country) and the random equal distribution (i.e. 10% of choices for each color), for each categories of products and both countries. Results show that for all product categories and in both countries, distributions of choices were nonrandom (all $p < .05$, see Table 1, column Randomness Test for details), which means that particular colors were associated with natural products. To capture particular associations between colors and natural products, we conducted post hoc χ^2 comparisons with Bonferroni correction ($\alpha = .005$) to compare theoretical random choices with participants choices of colors, for each color in each condition (3 product categories X 2 countries). For both countries, post hoc χ^2 with Bonferroni correction showed that the two non-food natural product categories, personal care products and household products, were matched with green, yellow and white. Food was matched with green, yellow and orange in the American sample, and with green, yellow, white and orange in the French sample (all $p < .005$) (see Table 1, column matched color for details).

Table 1: Matches between colors and natural products, according to the category of product and the country

Category of product	Country	Randomness test	Matched color	Un-matched color
Food	US	$\chi^2(9)=263.88$, $p < .001$	Green (22%), Orange (16%), Yellow (16%)	Black (2%), Blue (6%), Grey (2%), Purple (7%)
	France	$\chi^2(9)=572.87$, $p < .001$	Green (20%), Yellow (19%), White (19%), Orange (15%)	Black (1%), Blue (4%), Grey (2%), Purple (4%)
Personal Care	US	$\chi^2(9)=188.7$, $p < .001$	White (20%), Green (17%), Yellow (15%)	Black (2%), Grey (5%), Pink-Red (5%), Purple (5%)
	France	$\chi^2(9)=496.86$, $p < .001$	White (25%), Yellow (20%), Green (14%)	Black (1%), Brown (4%), Grey (2%), Pink-Red (7%), Purple (5%)
Household Product	US	$\chi^2(9)=200.33$, $p < .001$	Green (18%), Yellow (18%), White (16%)	Black (2%), Brown (6%), Grey (4%), Pink-Red (6%), Purple (6%)
	France	$\chi^2(9)=477.32$, $p < .001$	White (23%), Yellow (19%), Green (17%)	Black (1%), Brown (3%), Grey (3%), Pink-Red (7%), Purple (6%)

Results of χ^2 analysis to test the non-randomness of choices of colors for each product category and each country are displayed in column "Randomness Test". A significant p ($p < .05$) implies that the distribution of participants' color choices were not homogeneous with equal distribution, i.e. choices were not equal between colors. Matched colors are those that were significantly selected more than 10% of the time (post hoc comparisons with Bonferroni correction $\alpha = .005$), while un-matched colors are those that were significantly selected less than 10% of the time (post hoc comparisons with Bonferroni correction $\alpha = .005$).

Moreover, for the three categories of products, χ^2 test showed a non-homogeneity in the distribution of participants' color choices between countries: food ($\chi^2(9)= 110.33$, $p < .001$), Personal Care products ($\chi^2(9)= 69.952$, $p < .001$), Household Products ($\chi^2(9)= 54.157$, $p < .001$). Indeed, for food, American respondents selected brown and purple more often than French respondents (all $p < .005$) and we observed a trend for blue ($p = .0052$ before correction), while French respondents selected more often white than American respondents did ($p < .005$), and we observed a trend for yellow ($p = .01$ before correction). For Personal care products, American respondents chose more often blue, brown, grey (all $p < .005$) and less often yellow and white ($p = .002$) than French respondents. For household products, American respondents selected more often brown ($p < .005$), and less often white ($p < .005$) than the French respondents (see figure 1 for details).

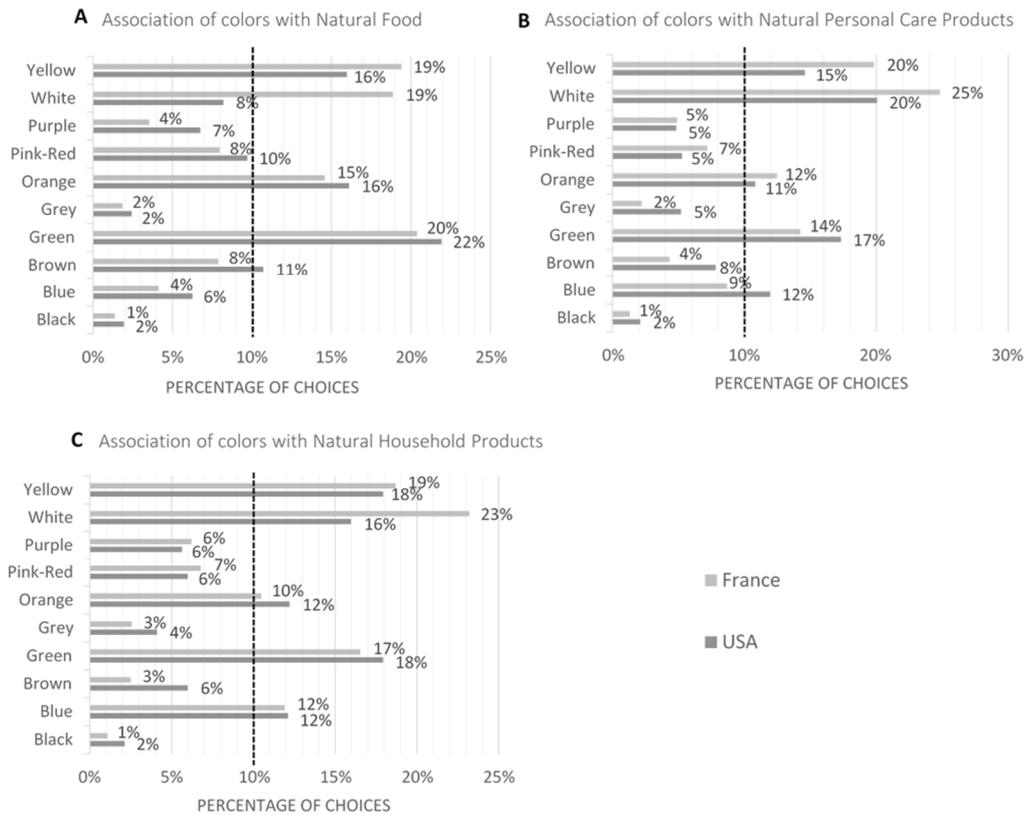


Figure 1: Association between colors and natural food (A), natural personal care products (B), and natural household products (C) depending on the country of the panel. Horizontal bars represent the percentage of choices of each colors for each panel, i.e. the number of time each color was associated with a natural product, and the black dotted line represent the chance level.

Results also showed disparities between categories of product. Indeed, distributions of participants' choices of colors were not homogenous between the three categories of products for American participants ($\chi^2(18) = 176.4, p < .05$) and French participants ($\chi^2(18) = 198.14, p < .05$). However, post hoc χ^2 test with Bonferroni correction ($\alpha = .0045$) showed that this non-homogeneity was only due to the food distribution in American panel, as post hoc χ^2 did not revealed significant difference in the distribution of choices for Personal Care product and Household product ($\chi^2(9) = 15.942, p = .068$). For the American panel, brown, orange, and pink-red were more often associated with food, while blue and white were more often associated with natural personal care products and household products (all $p < .0045$). In the French panel, brown was more chosen for food than for the other categories, and for personal care than for household product, green was more chosen for food than for non-food products, while orange and purple were more associated to natural food than to natural household product (all $p < .0045$). Blue was more chosen for household product than for the two other categories, and more chosen for personal care than for food, while white was less chosen for food than for non-food products (all $p < .0045$).

3.2 Natural and artificial colors for strawberry

Regarding natural or artificial colors associated with strawberry, we conducted χ^2 tests between distribution of choices of colors and equal distribution to determine whether particular colors were perceived as natural or artificial for strawberry. For both natural and artificial associations with strawberry and both countries, χ^2 test revealed that choices of colors were non-random (natural colors for strawberry: France $\chi^2(17) = 785.63, p < .001$ and US $\chi^2(17) = 484.12, p < .001$, artificial colors

for strawberry: France $\chi^2(17) = 104.23, p < .001$, and US $\chi^2(17) = 104.23, p < .001$). For both countries, post hoc χ^2 with Bonferroni correction ($\alpha = .003$) showed that dark red and bright red were chosen significantly more often than 5.5 % of the time for the question about natural colors for strawberry (France: bright red (34%), dark red (24%), US: bright red (29%), dark red (28%), all $p < .001$). For colors perceived as artificial for strawberry, only bright pink (8.2%) was chosen significantly more often than 5.5% of time in the French panel ($\chi^2(1) = 20.708, p < .001$). Surprisingly, bright pink (10%) and bright red (11%) were chosen significantly more often than 5.5% of time in the American panel (respectively $\chi^2(1) = 23.58, p < .001$ and $\chi^2(1) = 35.491, p < .001$), whereas bright red was also perceived as natural for strawberry.

3.3 Intensity

Participants expected medium intensity- between 4 and 5 on a scale from 1 to 8 - for both odors and colors and all categories of products: odors for natural food (4.27 ± 1.66), odors for personal care products (4.31 ± 1.73), odors for household products (4.36 ± 1.72), odors for strawberry (5.04 ± 1.63), colors for food (4.44 ± 1.66), colors for personal care products (3.93 ± 1.69), colors for household products (4.12 ± 1.79).

To examine how the categories of products or the demographic factors measured (country, age and gender) influence expectation of intensity, we performed two mixed (with between and within factors) analysis of variance (ANOVA). As meaning of "intensity" could differ between visual and olfactory modalities, we conducted one ANOVA for expected intensity of odors and another for expected intensity for colors. We then conducted post-hoc comparisons with Bonferroni-corrected t-tests ($p < .05$ prior to correction).

For odors, results revealed a significant main effect of Category of Product ($F_{3,1337} = 113.6, p < .001$), due to significant higher expected intensity for the Strawberry odor (5.04 ± 1.63) than for Food (4.27 ± 1.66), Personal Care products (4.31 ± 1.73) or Household products (4.36 ± 1.72), but we found no significant differences between the three latter. We also found an effect of age ($F_{2,1339} = 5.9, p = .003$), and post-hoc t-test showed that the younger the participant the higher the expected intensity was, as 18-34 years old (4.77 ± 1.76) expected higher intensity than 35-49 y/o (4.57 ± 1.68) and than 50 y/o and over (4.31 ± 1.69), and that 35-49 y/o expected higher intensity than 50 y/o and over. Results showed an effect of gender ($F_{1,1339} = 45.5, p < .001$), reflected by the fact that men (4.80 ± 1.72) expected higher intensity than women (4.26 ± 1.68); and an effect of country ($F_{1,1339} = 18.7, p < .001$) as American (4.76 ± 1.81) expected higher intensity than French (4.34 ± 1.63). Results also showed a significant interaction between age and category of product ($F_{6,2676} = 5.1, p < .001$), and between gender and category of product ($F_{3,1336} = 3.9, p = .009$). Mean scores are represented in figure 2.

The statistical analysis performed on expected intensity for colors showed a main effect of Category of product ($F_{2,1337} = 68.8, p < .001$), as expected intensity was higher for food (4.35 ± 1.65) than for personal care products (3.93 ± 1.69) and for household products (4.12 ± 1.79), and it was higher for household products than for personal care products. Effect of age on expected intensity was also significant ($F_{3,1338} = 2.9, p = .035$), with the 18-34 years old (4.59 ± 1.85) expecting higher intensity than 35-49 years old (4.16 ± 1.74), and than 50 years old and over (3.96 ± 1.62), and 35-49 years old expecting higher intensity than 50 years old and over. Results also showed an effect of gender ($F_{1,1338} = 66.1, p < .001$), as men (4.58 ± 1.70) expected higher intensity than women (3.86 ± 1.68) and an effect of country ($F_{1,1338} = 47.0, p < .001$), as American (4.58 ± 1.87) expected higher intensity than French participants (3.91 ± 1.58). Interactions between country and Product Category ($F_{2,1337} = 10.2, p <$

.001) and between gender and product Category ($F_{2,1337}=8.4, p < .001$) also reached significant level. Mean scores are represented in figure 3.

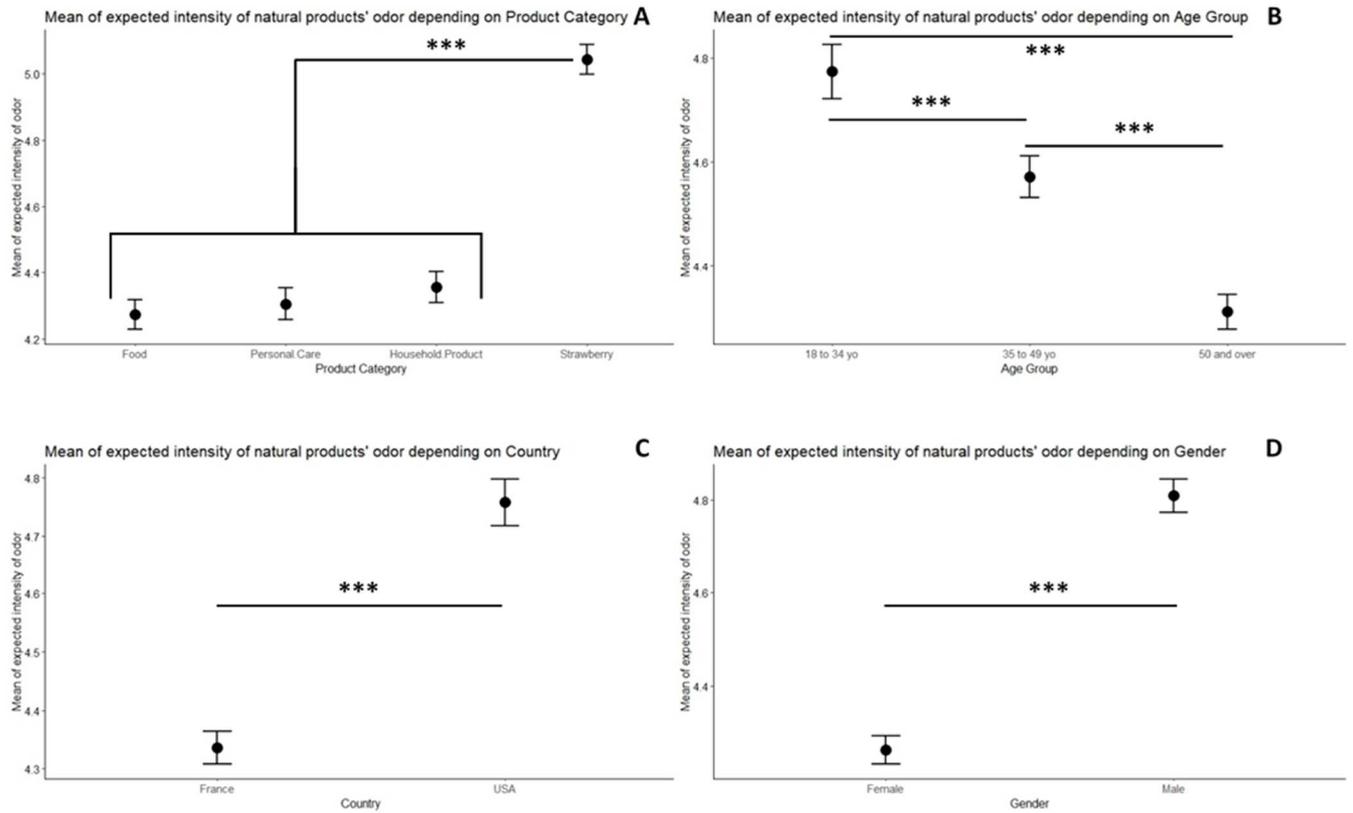


Figure 2: Mean of expected intensity of natural products' odor depending on the Product Category (A), the Age Group (B), the Country (C) or the Gender of the participant (D). Bonferroni corrected post-hoc test *** $p < .001$, ** $p < .01$, * $p < .05$, # $p > .05$

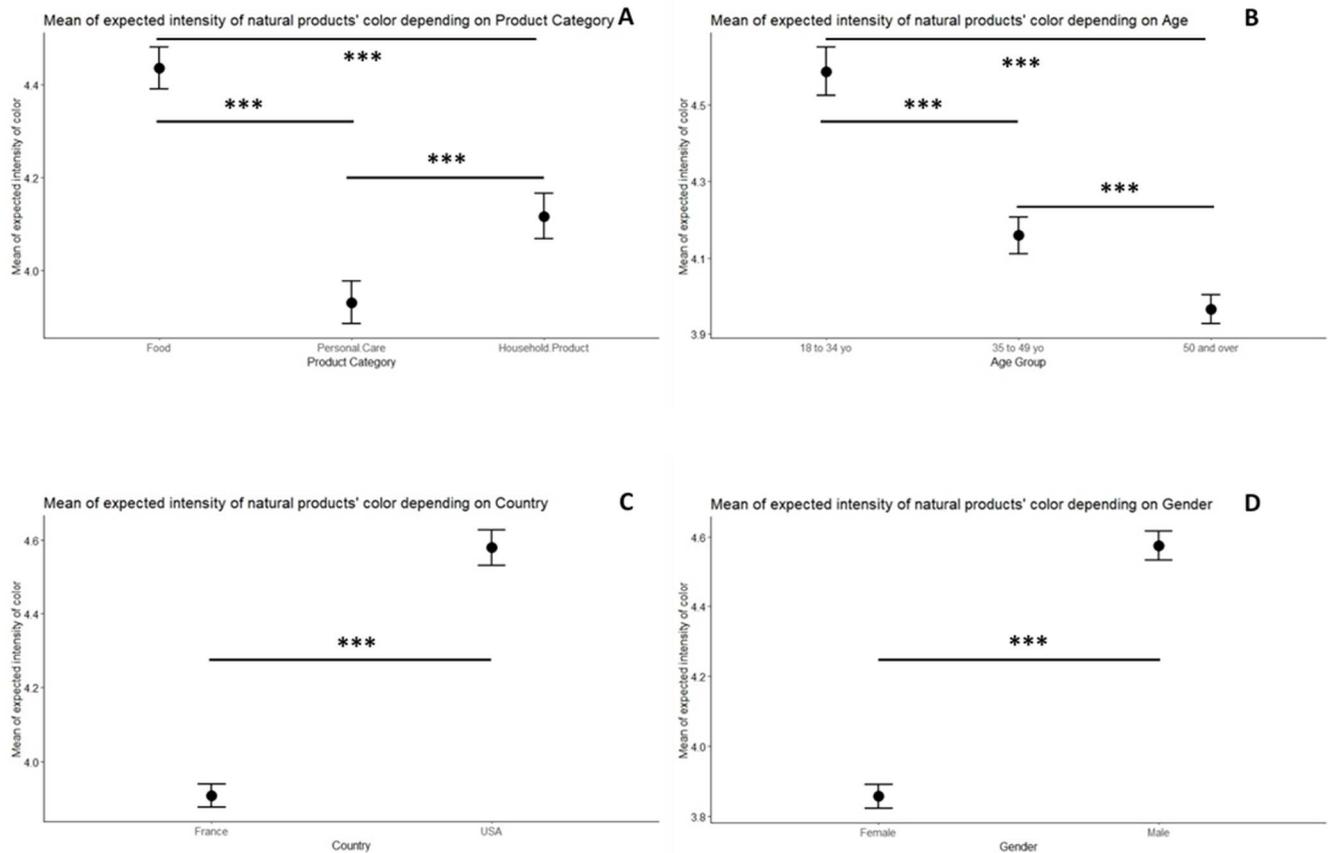


Figure 3: Mean of expected intensity of natural products' color depending on the Product Category (A), the Age Group (B), the Country (C), or the Gender (D). Bonferroni corrected post-hoc test *** $p < .001$, ** $p < .01$, * $p < .05$, # $p > .05$

3.4 Semantic association with odors

In a fourth analysis, we examined which words were the most associated with a natural odor, and which ones were associated with an unnatural odor. In France and in the US, “freshness” (7.9% for both countries) and references to flowers (respectively 6.3% and 2.8% of the corpus) were in the top three words associated with natural odors. For an unnatural odor, the word with most occurrences was chemical in both countries (18% of the corpus for the French sample, and 4.8% for the American sample).

Looking into the data, we also observed an emotional content associated with a natural or unnatural odor. For both countries, an unnatural odor was associated with adjectives of negative valence (15% of the corpus for the French sample, 28% for the American sample), like “bad”, “stinky” or “unpleasant”, but also with example of a somewhat unpleasant odor (3.3% for the French corpus and 9.1% for the American corpus), like “hydrocarbons” or “rotten” object. On the other hand, a natural odor was associated with positive adjectives (10% of the French corpus and 8.1% of the American corpus), like “good” or “pleasant”, and with example of odors like flowers and plants.

We also observed associations with some specific sensory attributes. A natural odor was first associated with freshness (13% in French sample and 7.9% in the US sample). For the French sample, it was also associated with lightness and simplicity (respectively 6.8% and 4.1% of occurrences in the French corpus), and with cleanliness for American respondents (5.7% of occurrences). Unnatural

odor was associated with strength (12% for French corpus, and 3.5% of occurrences for American one), pungency (3.9% for French corpus and 1.5% for American corpus) and with complexity for the French respondents (1.7% for French corpus, and 1% for American one).

This corpus of text brought us some elements of definition of natural or unnatural odors. An unnatural odor was first associated with “chemical”, in both countries. An unnatural odor was also associated with adjectives like “fake”, “artificial”, “human-made”, etc. while a natural odor was associated with “organic”, or “without additives”. Looking at the example of odors associated with naturalness, we observed that natural odors were associated with flowers, and more generally plants and natural kinds, while unnatural odors were associated with examples of manufactured object, like hydrocarbons, consumer goods, or fragrances. These elements suggest that a natural odor is both the odors of a natural object, like a flower, and an odor that was obtained naturally, like essential oil.

4. Discussion

4.1 Sensory attributes of naturalness

Previous studies highlighted effects of colors or tactile properties of packaging on perception of product’s naturalness (Ampuero & Vila, 2006; Labbe et al., 2013). However, few studies explored which sensory attributes are associated with naturalness. The first objective of our study was to investigate whether specific olfactory attributes and colors were associated with natural products.

For olfactory attributes, our findings revealed that freshness was the word most often associated with naturalness. This result is in accordance with the review of Roman and colleagues (2017), who found that freshness was one of the expected attributes of natural products. However, freshness is a polysemic and ambiguous term, as it refers to a trigeminal sensation close to coldness, or also to a “level of closeness to the original product, in terms of distance, time and treatment” (Péneau et al., 2006, p.6; see also Fenko et al., 2009 for a discussion on freshness definition). Freshness, in the review of Romàn and colleagues, refers to this second meaning, and freshness in our corpus could refer to the freshness of an odorous object. However, associations with words like “smooth” for a natural odor or “pungent” for an unnatural odor also raise the issue of the trigeminal properties of natural odors. Additional results are needed to better understand which meaning of freshness participants referred to.

In a smaller but reliable extend, lightness was related to naturalness, as a natural odor was associated to adjectives like “light”, “subtle” while an unnatural odor was associated with adjectives like “overpowering” and “strong”. On the other hand, results from questions on expected intensity point out that participants expected medium intensity for odors of natural products. These elements suggest that consumers would expect artificial products to be more flavored or scented and thus to have stronger odor than natural products, rather than the fact that natural products have a weak odor.

The issue of complexity is also of interest, as natural odor was associated with “simple” and unnatural odor with “complex”. Most odors are complex mixture of molecules, but they are perceived and recognized as unitary discrete objects (Stevenson & Wilson, 2007). However, the ability of participants to discriminate odors mixed with three odors or more (e.g. mixture of strawberry, chocolate and rose) is low, even for familiar odors. Results also suggested that humans could only discriminate four components in odors mixture (Livermore & Laing, 1998). Thus, the meaning of complexity diverges between the chemical and perceptual level, as very complex mixtures could lead to very simple percept. Odors coming from natural objects are usually more

complex at the chemical level than artificial ones. For example, a strawberry emits hundreds of aromatic molecules, while a strawberry flavoring does not exceed a few dozen different molecules. The association between naturalness and complexity would then occur at the perceptual level, a natural odor being a complex mixture of molecules leading to a simple percept, while an artificial one could be a more simple mixture of molecules but difficult to recognize as one object.

Moreover, in line with Apaolaza and colleagues (2014), our semantic corpus showed a distinction in terms of emotional valence, as words with positive valence were associated with natural odor, while words with negative valence were associated with unnatural odor. These results are in line with previous studies who underlined the positive attitude of the majority of consumers toward naturalness, and the prevalence of positive words in the free association with naturalness (Rozin et al., 2012). Moreover, if claims on naturalness are likely to trigger a halo effect on pleasantness and purchase intention (Apaolaza et al., 2014), blind tasting showed that natural food are not always those preferred by consumers (Hemmerling et al., 2016). Thus, tests with real odors would bring valuable results on the link between perception of odors' naturalness and hedonic judgment of odors.

For results from the part on associations between colors and natural products, three colors were reliably paired with natural products whatever the category of products or the country: green, white and yellow. As green is very often semantically associated with the natural kind (green vegetables, green space, etc...) this result is not surprising. Results of free associations with "natural" from Rozin and colleagues (2012), highlighted that plants and vegetables were more often cited than animals. Green, the color associated with plants, as noticed by the authors, was the color occurring most often in their corpus. The prevalence of green in participants' choices could be related to the fact that participants thought of natural products as plant-based products. Moreover, a previous study showed that a white background was perceived as more natural than an orange one for a fruit juice bottle (Ampuero & Vila, 2006). A possible explanation of this link could be found in the symbolic value of purity of white, as it is also an attribute associated with naturalness (Rozin et al., 2004). The association with yellow is more surprising, as no clear statistical or symbolic association links yellow with natural kinds.

However, results from the question about natural or artificial associations of colors with strawberry, outline the issue of typicality as mediating associations between colors and natural products. Indeed, red was considered as natural for the strawberry rather than green, white or yellow. A color would then be natural when it corresponds to the typical color of the natural object to which it is associated. This result is in line with findings on the effect of colors on smell perception. Indeed, the effect of colors on odor pleasantness ratings and identification was modulated by appropriateness of the association, i.e. if colors and odors were connected to the same source (like red for a strawberry odor)(DuBOSE et al., 1980; D. A. Zellner, 2013; D. A. Zellner et al., 1991). Thus, it is interesting to notice that three colors are associated to natural products at the superordinate level (e.g. food, personal care products, or household products), but that by increasing the specificity of the category considered, the typicality becomes a more salient dimension. It is also of interest to notice that colors of the packaging convey information, and colors of the product itself convey other ones. Indeed, results from Zellner and colleagues (2018) suggest that color of the stimulus (e.g. a candy) is more important than the color of its packaging (e.g. its wrapper) for the consistency of the association with stimulus flavor. Thus, if green, yellow and white seem interesting to convey information about product's naturalness on the packaging, typicality would head manufacturers' choices on product's color.

4.2 Cultural disparities and disparities between product categories

The questions about intensity and choices of colors also highlights the issue of cultural disparities and of disparities between product categories in the perception of natural products' sensory attributes. Indeed, results showed that the American respondents expected higher intensity than the French respondents did. It could be explained by general higher intensity of odors and colors of products on American markets than on French markets, or also by a general cultural difference in the use of scales as cultural different pattern of response might occur (Lee et al., 2002). Cultural differences were also observed in the associations between colors and natural products, as green was more often chosen by Americans and white by the French participants. Once again, an unsolved question is: is this result explained by different co-occurrences of pairs of colors and natural products between the American and French markets, or else by cultural differences in the symbolic values assigned to these colors? Slight disparities were also observed in the semantic association with a natural odor. The most noticeable is that Americans, although they mainly associated positive adjectives with natural odors, also associated some negative adjectives with it (4.4% of the corpus), while French respondents associated almost no negative adjectives with natural odors (0.5% of the corpus). More than a question of attitude toward natural products, these results raise the issue of the cultural disparities in the attitude toward nature and wilderness. Indeed, verbatim words like "dangerous", "dirty", "stinky", "musty" in the text corpus from the American panel evoke an attitude of fear and disgust toward wilderness, which are one of the attitudes of humans toward nature (Kellert, 1995).

Results from question on associations between colors and natural products also provide evidence that perception of naturalness depends on the product category. Indeed, blue and white were more associated to non-food products than to food, while orange for example was more associated to food. Moreover, as noted above, typicality also can trigger associations between colors and products. Thus, the underlying factors explaining these disparities are still unclear. They can rely on differences of statistical occurrences of colors for some product categories (e.g. few food are blue), differences in the perception of sensorial characteristics of products and thus matched colors (e.g. blue for freshness), or different symbolic representations of colors depending on the product categories (e.g. white for cleanness in household products) (see Spence, 2020 for a review on cross-modal associations between odors and colors). Results from questions on expected intensity provide less evidence for this point. For colors, expected intensity differed between product categories. These observed differences could arise from statistical reasons (i.e. statistically in consumer goods market, foods have more intense colors than the others products categories), or from structural reasons (e.g. as food are more arousing than non-food products, consumers expect more intense colors because they are also more arousing). Additional results are needed to further explore the underlying mechanism behind these differences of expectations. For odors, only the strawberry odor was expected to be stronger than the ones of the three other product categories. "Strawberry", as being an example of fruit, could have been perceived as more natural than the other products categories, which regrouped objects that underwent some transformations. However, in this case, looking at the corpus results, the intensity for "strawberry" could have been expected to be lower than for other product categories as natural odors were expected to be light. To our knowledge, no other study explored the differences between categories of product in terms of naturalness perception and representation. Thus, these findings have to be considered as preliminary results on this question, and further studies are needed to supplement it.

Moreover, effect of age and gender on expected intensity were also founded, as the younger group of participants and men expected higher intensity for natural products' color and odors than the older group of participants or women. Studies on influence of age on olfactory sensitivity brought evidence of deterioration of the sense of smell with age, and a decrease in smell sensitivity (Venstrom & Amoore, 1968). Moreover, gender differences on smell sensitivity are less consensual,

some results suggesting that women have a more sensitive sense of smell, while others failed to find gender differences (Öberg et al., 2002). Thus, it seems unlikely that these differences of expected intensity arise from sensorial sensitivity differences between gender or age group. On another perspective, women and older consumers are also usually those with the most positive attitude towards naturalness (Román et al., 2017). Study of the relation between attitude toward naturalness and expectations in terms of sensory attributes could be a fruitful avenue to better understand these results.

Last, but not least, results from semantics associations with natural or unnatural odors brought some interesting elements on what a natural odor is. Indeed, words associated with a natural odor like “without additives”, “unprocessed”, or also “extracted from a flower” suggest that naturalness of an odor depends on the production process of an odor, and the less transformed, the more natural. Moreover, the mention of objects like “flower”, “rose”, “grass” for natural odors, and like “gas”, “plastic”, “air freshener” for artificial odors, let us to think that a natural odor is the odor of a naturally occurring object, like a flower. Thus, these results raise an ambiguity on the definition of a natural smell.

4.3 Limitations and suggestions for future research

Some limitations have to be mentioned, and findings and conclusions should be taken with caution. A first limitation is in the nature itself of this study, which is an online survey. Indeed, these results come from declarative data, and are based on reported expectations and representations of natural products’ odors and colors. Further studies with olfactory testing are needed to test the strength of these findings. Such experiences would provide complementary results about the link between naturalness and intensity as well, and comparison between odors’ and colors’ intensity for natural and unnatural products would also be informative.

Another limitation concerns the association between colors and natural products, especially when dealing with the natural and artificial associations with strawberry. Indeed, the choice of colors was restricted to 18 colors, and thus the space of typical colors for strawberry was restrained. This element could explain why the same color was perceived as natural and artificial for strawberry for American participants. Indeed, as the question was formulated specifically for strawberry, it is possible that green, yellow or white hues were rarely chosen not because they were natural or artificial, but because they were perceived as unrelated to strawberry. The same question with a wider palette of colors could then lead to finer grain results, as slight differences in terms of hue or lightness could differentiate artificial from natural colors for strawberry. A replication with another object (lemon, grass, etc.) would also provide further elements to understand the association between color typicality and natural products. Moreover, food, personal care products and household products are very general categories. If results provide new insights in the consumers’ perception of natural products, caution is needed for the extrapolation of these results to more specific categories. In particular, saliency of typicality of colors of the product could vary depending on the specificity level of the category. Moreover, as American and French markets are different, the objects considered typical for these categories could also differ between countries. Thus, seeing the name of the categories, the participants may have imagined different objects depending on their country. Observed differences between countries could come from differences of object’s characteristics that participants had in mind when they filled the questionnaire, rather than differences of representation of product categories at the general level.

5. Conclusion

Taken together, our results highlight that naturalness is linked with a range of sensory and semantic attributes. Specific olfactory attributes, like freshness or lightness, were found to be associated with natural odors, while green, white and yellow were the three colors associated with natural products. Moreover, slight disparities in these associations were observed depending on the country or product category considered. Indeed, American participants had a preference for green and French participants for white, and American participants expected higher intensity of natural products' colors and odors. On the other hand, blue and yellow (and white for American respondents) were more associated with natural non-foods products, while brown, green, and orange (and pink-red and purple for American respondents) were more associated with natural food. Results on question about strawberry also raise the issue of color typicality in mediating associations. Such results could be insightful to better understand consumers' expectations towards natural products, and open new avenues of research for further studies. Sensory testing would bring important complementary results to our findings. Last, but not least, this study brings preliminary elements to consider the definition of a "natural odor". Results revealed an ambiguity on this issue, as a natural odor was both, 1) an odor produced naturally (e.g. essential oil), and 2) an odor that smells like a naturally occurring object (e.g. an odor of rose). New results are needed to disentangle this ambiguity on the definition of a "natural odor".

6. Declaration of conflict of interest

The author(s) declared no potential conflicts of interests with respect to the authorship and/or publication of this article.

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