Contents

ABSTRACT

Improved population nutrition is one of the key factors underlying increased health and longevity (Chernoff, 2001) and vegetables are often identified as the most important part of a diet recognized as beneficial for health (Appleton et al., 2016). The adoption of diets rich in vegetables resulted in positive effects not only for human health but also for planetary health. (Whitmee et al., 2015). Dietary change through an increase of plant-based foods to the detriment of animal-based foods has been suggested to be necessary to reduce the environmental impact of the food system (Notarnicola et al., 2017). Despite the recommendation, studies show that a large proportion of consumers consume fewer vegetables than recommended. Therefore, for improved health and diet sustainability, an increased intake of vegetables is required. These interventions should be based on in-depth understanding of the underlying determinants of the preference for vegetables and methodologies aimed to assess consumer preferences and perception in an effective and reliable way.

An aspect that links many of the new methodological approaches in sensory and consumer science is the process of categorization. Categorization is a natural cognitive process where objects with common characteristics are grouped and inference is made about their properties, in order to obtain considerable information with minimum cognitive effort (Rosch & Lloyd, 1978). Among the methods based on categorization is the Free sorting task (Lawless et al., 1995), a procedure that can be used with consumers to study similarities among food products. There are a number of methodologies of implicit measure related to categorization, such as the Implicit association test (Greenwald et al., 1998), that find in the process of categorization the operative task carried out by subjects during the implicit test. Considering the relevance of categorization among the approaches to overcome the current limits in sensory and consumer research is therefore of interest in studying issues strongly related to the preference for vegetables with the contribution of the process of categorization.

Many issues related to the study of preference for vegetables need attention. For instance, beside the suggestion to consume a specific number of portions of vegetable, of particular importance is the comprehension of which items consumers include in the category "vegetable", highlighting possible mismatches between guidelines and consumers. Considering these aspects, a deeper comprehension of how consumers represent the vegetable category may be useful to improve the

effectiveness of dietary guidelines and increase the consumption of recognized vegetables. This research question was explored in Study I recurring to the prototype theory of categorization, in order to investigate the relationships between the typicality of the dishes and of the dish features with expected liking among consumers.

Taking into consideration the increasing interest of interventions targeted at older adults and children to increase vegetable consumption (Appleton et al., 2016), the use of investigative tools that allow evaluation of the perceptions and preferences in an effective and reliable way is needed. In healthy older adults most sensory and consumer methods can be applied (Methven et al., 2016). However the use of consumer tests with this segment of population should be evaluated carefully, due to the possible presence of difficulties related to the comprehension and use of rating scales (Dermiki et al., 2013) and cognitive and perceptive fatigue with long and complex methodologies. A methodology with big potential, yet to be fully explored with older adults is the Free sorting task. Considering these aspects, the study of usability of Free sorting task among healthy older adults would be of interest. This issue was explored in Study II, where older adults from Italy and France were involved in a Free sorting task with peas and sweetcorn samples.

Among the different approaches to investigate eating behaviour, the use of interviews and questionnaires may be considered as the most common one, thanks to their relative low cost and ease of submission. However, explicitly measured concepts may suffer from limitations such as voluntary self-presentation strategies (e.g. social desirability), resulting in a discrepancy between declared and actual behavior (Maass et al., 2000). Implicit measurements (De Houwer & Moors, 2010) may overcome some of the problematic elements of traditional self-report measures of attitudes. The use of both explicit and implicit measurements, such as the Implicit Association Test, may therefore be an effective approach to classify with higher reliability consumers' attitudes toward the vegetable category. This issue was explored in Study III, where vegetarians, flexitarians and omnivores were involved in an Implicit association test intended to assess their attitudes toward plant-based and animal-based dishes and the physiological and psychological variables that may influence these attitudes.

Study I concluded that specific dishes, such as salads and boiled vegetables, were more typical of the plant-based dish category than others, such as soups and fried vegetables. Typicality affected expected liking for dishes depending on the consumers' level of familiarity toward vegetables. Among consumers with a low level of familiarity toward vegetables, the less a dish is typical the higher the expected liking is. No similar relation was found among consumers with a high level of familiarity. Expected sensory attributes were found to influence the typicality of a dish. The attributes Bitter, Green and Bland positively influenced typicality, while Brown, White and Creamy negatively influenced it. The promotion of consumption of vegetables targeted at vegetables dislikers should therefore consider their representation of the category, in order to limit the exposure to features with a negative hedonic value.

Study II concluded that the Free sorting task was a suitable method to use with healthy older adults, as it allowed the detection of differences in the categorization of stimuli even among the more aged representatives of the elderly population. Familiarity with the product was the main factor affecting the categorization maps of the tasted vegetables. Categorization maps from the familiar vegetables were found to be reliable to obtain information on sensory and hedonic dimensions, while maps obtained from the unfamiliar vegetables mainly depicted sensory variability.

Study III concluded that the Implicit association test is an effective method to study attitudes toward the plant-based dish category. Vegetarians and Flexitarians were more inclined to implicitly associate positive emotions to meat-free dishes than omnivores, with vegetarians showing a stronger association than Flexitarians. Our findings showed that positive attitudes toward meat-free dishes were positively related to the empathic sensitivity toward humans and animals and positive attitudes toward healthy and natural products, whilst being negatively related to bitter responsiveness and sensitivity toward pathogen disgust. Conversely food pleasure emerged as equally important among the considered groups, highlighting a higher importance of food consciousness in determining the eating habits considered.

In conclusion, all the methodological approaches considered in this research proved able to satisfy the different research questions related to the study of the preference for vegetables, therefore confirming the effectiveness and reliability of categorization in consumers’ studies.

LIST OF ORIGINAL PUBLICATIONS

The study is based on the following original publications:

Study I. Cliceri, D., Spinelli, S., Dinnella, C., Ares, G., & Monteleone, E. Categorization of plant-based dishes and its implications for consumer preferences. In preparation for submission to *Food Research International.*

Study II. Cliceri, D., Dinnella, C., Depezay, L., Morizet D., Giboreau, A., Appleton, K., Hartwell, H., & Monteleone, E. (2017). Exploring salient dimensions in a free sorting task: a cross-country study on elderly populations. *Food Quality and Preference, 60,* 19-30.

Study III. Cliceri, D., Spinelli, S., Dinnella, C., Prescott, J., & Monteleone, E. The influence of psychological traits, beliefs and sensory responsiveness on implicit attitudes toward plant- and animal-based dishes among vegetarians, flexitarians and omnivores. *Food Quality and Preference* (Under review).

1. INTRODUCTION

1.1 The consumption of vegetables

1.1.1 The importance of eating vegetables

Improved population nutrition is one of the key factors underlying increased health and longevity (Chernoff, 2001) and vegetables are often identified as the most important part of a diet recognized as beneficial for health (Appleton et al., 2016; Atkins & Mitchie, 2013). In fact a considerable body of data suggest that eating vegetables leads to life-long health benefits. Antioxidant compounds present in vegetables act as clean up free radicals before they cause detrimental health effects (Kaur & Kapoor, 2001). The high content of fibers in vegetables has been shown to reduce intestinal passage rates, leading to a more gradual nutrient absorption (Anderson et al., 2010). Fibers can be fermented in the colon, increasing the concentration of short chain fatty acids having anticarcinogenic properties (Lattimer & Haub, 2010) and maintaining gut health. Various studies demonstrate the beneficial effect of the presented properties on health. Observational studies have demonstrated reduced risk of cardio-vascular disease (Oyebode et al., 2014), type II diabetes (Villegas et al., 2008), acute pancreatitis (Oskarsson et al., 2013), cancer (Oyebode et al., 2014) and cognitive decline (Morris et al., 2006). Meta-analyses of observational studies demonstrate associations between a higher vegetable consumption and reduced risk of stroke (Hu et al., 2014), dementia and cognitive decline (Loef & Walach, 2012), and various cancers (Jin et al., 2014; Li et al., 2014; Yang et al., 2014). An increased consumption of carotenoid-rich vegetables maintains the cholesterol level in blood since they reduce oxidative damage and causes an increase in LDL oxidation resistance (Southon, 2000). Vegetables have also been suggested to prevent osteoporosis in adults mainly for their rich sources of calcium and vitamins that are essential for bone health (Park et al. 2011). The high fiber content of vegetables may play a role in calcium absorption and reduce the "acid load" of the diet (New, 2001) enhancing bone formation and suppressing bone resorption, which consequently results in greater bone strength (Shen et al., 2012). Specific vegetable groups or types of vegetables have also been associated with improved health outcomes. Intakes of dark green leafy vegetables have been associated with reduced risk for type II diabetes (Carter et al., 2010), reduced risk for a number of cancers (Liu et al., 2012; Masala et al., 2012) and with reduced depression (Tsai et al., 2012). High intakes of cruciferous vegetables have been associated with reduced risk from various cancers (Chen et al., 2013; Han et al., 2014). Intakes of beta-carotene-rich vegetables, yellow and red-pigmented vegetables have also been associated with a reduced risk from various cancers (Liu et al., 2012; Masala et al., 2012), and root vegetable consumption has been associated with reduced type II diabetes risk (Wu et al., 2015).

The adoption of diets rich in vegetables resulted in positive effects not only for human health but also for planetary health. Global food production is identified as a great threat to the environment, considering that global production of food is responsible for 30% of GHG emissions (from food production through to consumption) and more than 70% of fresh water use (Whitmee et al., 2015). In combination with technical advances in agriculture and greater efficiency in reducing food losses, dietary change through an increase of plant-based foods to the detriment of animal-based foods is suggested to be necessary to reduce the environmental impact of the food system (Notarnicola et al., 2017). Several studies in recent years have examined the carbon footprint associated with different dietary patterns, highlighting a low environmental impact of vegetables and fruit production (Hallström et al., 2015; Auestad & Fulgoni, 2015). Although the reduction in greenhouse gas emissions associated with dietary shifts will differ from one context to another, shifting toward a vegan diet will likely elicit the largest reductions in greenhouse gas emissions (Hallström et al., 2015; Tilman & Clark, 2014). More specifically, a vegan diet would reduce emissions by between 24 and 53%, a vegetarian diet would result in a GHG emission reduction between 18 and 35 % whereas a Mediterranean diet would result in a reduction between 6 and 17 % (Hallström et al., 2015). Although less research has been conducted on the water footprint of food, it is likely that any reduction in animal products and an increase in vegetable products would result in a lower water footprint (Mekonnen & Hoekstra, 2012).

The Food and Agriculture Organization has defined *sustainable diets* as "diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources." Because of the recognized benefits of vegetable consumption, vegetable foods and derived products should therefore play a central role in diets that are intended to be sustainable.

1.1.2 Recommended and actual consumption of vegetables

Many countries have adopted the recommendation to eat at least 400g of fruit and vegetables a day, and many experts and organizations include this recommendation in their guidelines (World Health Organization, 2003). Campaigns advise people to eat five portions of fruit and vegetables daily, adopting the well-known simple message of "5 A Day", initiated in the United States and extended to several countries such as The United Kingdom and New Zealand (Agudo, 2004). However it has been reported that 5 servings a day are not enough, since those people consuming 7 or more servings of fruits and vegetables a day are having more health benefits and prolonged lives. Specifically, those who ate 5 to 7 servings of fruits and vegetables per day had a 36% lower risk of dying from any cause, 3 to 5 servings was associated with 29% lower risk while 1 to 3 servings was linked with a 14% lower risk (Oyebode et al., 2014). In line with these evidences, countries like Canada, Argentina, Mexico and Greece have adopted recommendations in the range of 5 to 10 servings of fruit and vegetables daily (Agudo, 2004). The recommendations are not unified, especially in the case of vegetables, where cases range from 2 daily servings (The Netherlands) to 8 (Australia) (Agudo, 2004). Since different countries are using different guidelines, the ideal recommendation of vegetables is still being debated, while the official World Health Organization guidelines now suggest the consumption of at least 160-240 g or 2-3 portions of vegetables/day. While it is clear that consumers' knowledge alone does not guarantee to take appropriate actions, it is equally clear that people unaware of health risks are unlikely to make positive behavioral changes. Unsurprisingly, given the lack of awareness of what constitutes a healthy diet, studies show that large proportions of Americans and Northern Europeans consume fewer vegetables than recommended. Consumption data from 22 EU member states detail consumption of 119-182 g vegetables/day, compared to WHO guidelines of 160-240 g, and in the US, current reports demonstrate average intakes of 1-1.5 cups of vegetables per day, while recommendations suggest 2.5-3 cups/day for all those over the age of 13 years. Considering the consumption of vegetables along the life-span, vegetable consumption in adolescents resulted particularly low. In Europe, data from adolescents in 33 countries revealed that the prevalence of daily vegetable intake in 2010 ranged from 20% in Estonia to 54% in Flemish Belgium (European Food Safety Authority, 2008). The proportion of adolescents eating vegetables daily was 45% in France, 42% in Denmark, 38% in England and only 25% in Italy (Vereecken et al.,

2015) and in general large proportion of children and adolescents do not meet the World Health Organization goal of a daily intake of at least 400 grams of fruit and vegetables (Yngve et al., 2005; Vereecken et al., 2005). Considering older adults (aged 65 and older), it is particularly important for this segment of the population to be aware of the consumption of fruits and vegetables because they tend to eat smaller quantities of food overall, which can lead to deficiency of important vitamins and minerals (Drewnowski & Schultz, 2001). Studies highlighted a consumption of more servings of fruits and vegetables compared to younger adults, which might be nutritionally necessary given the change in metabolic processes that occurs in old age (USDA & CNPP, 2007). Although the majority of adults incorporate at least one serving of fruits and vegetables into their daily diet (85% and 95%, respectively), less than half of older adults eat the recommended five servings of fruit and vegetables per day (USDA & CNPP, 2007) and even the specific consumption of vegetables was lower than WHO recommendation (Appleton et al., 2017). Therefore, for improved health and diet sustainability, increased intakes of vegetables are required. For intakes of vegetables to be increased, strategies and interventions are needed. These interventions should be based on in-depth understanding of the underlying determinants of preference for vegetables.

1.1.3 Determinants of preference for vegetables

1.1.3.1 Influences on preference for vegetables

Food preference is the selection of a food over relevant alternatives at the point of choice, including intrinsic factors (e.g. liking, desire, health values) and extrinsic factors (e. g. brand, cost, convenience, etc.) (Mela, 2006). Liking is believed to play a major role in human food choices and intake in the absence of economic and availability constraints (Cowart, 1981; Rozin & Schulkin, 1990) and refers to the perceived attractiveness or aversiveness of specific objects against an internal reference scale for intensity, linked to a specific context and a present time frame (Mela, 2000). A range of individual motivations apart from liking drives the choice. For example we know that a specific choice is not always made for the best-liked alternative and even the poor alternatives are sometimes chosen (De Graaf et al., 2005; Prescott et al., 2005). A number of models have been proposed in literature to delineate the many variables involved in food choice and the relation among them (Harper, 1981; Land, 1983; Cardello, 1996; Tuorila, 2007). A more recent end exhaustive representation of the many factors that influence eating and drinking behavior and food choice was reported in Mojet's model (Köster, 2009). This model considered variables afferent to the spheres of the product, the context and the person (Figure 1.1). The product-related sphere of the product included intrinsic characteristics, such as the sensory properties, and extrinsic characteristics, such as the packaging. The person-related sphere included biological and physiological factors, such as sensory acuity, included psychological factors, such as personality traits and memory, and socio-cultural factors, such as belief and attitudes. The context-related sphere included situational factors, such as time of consumption, physical surrounding, habituation and attribution. Clarifying how consumers make decisions about food liking, preference and choice is therefore necessary in order to identify the many variables involved in the decisional process, in order to understand how these variables interact and what impact they have on eating behaviors.

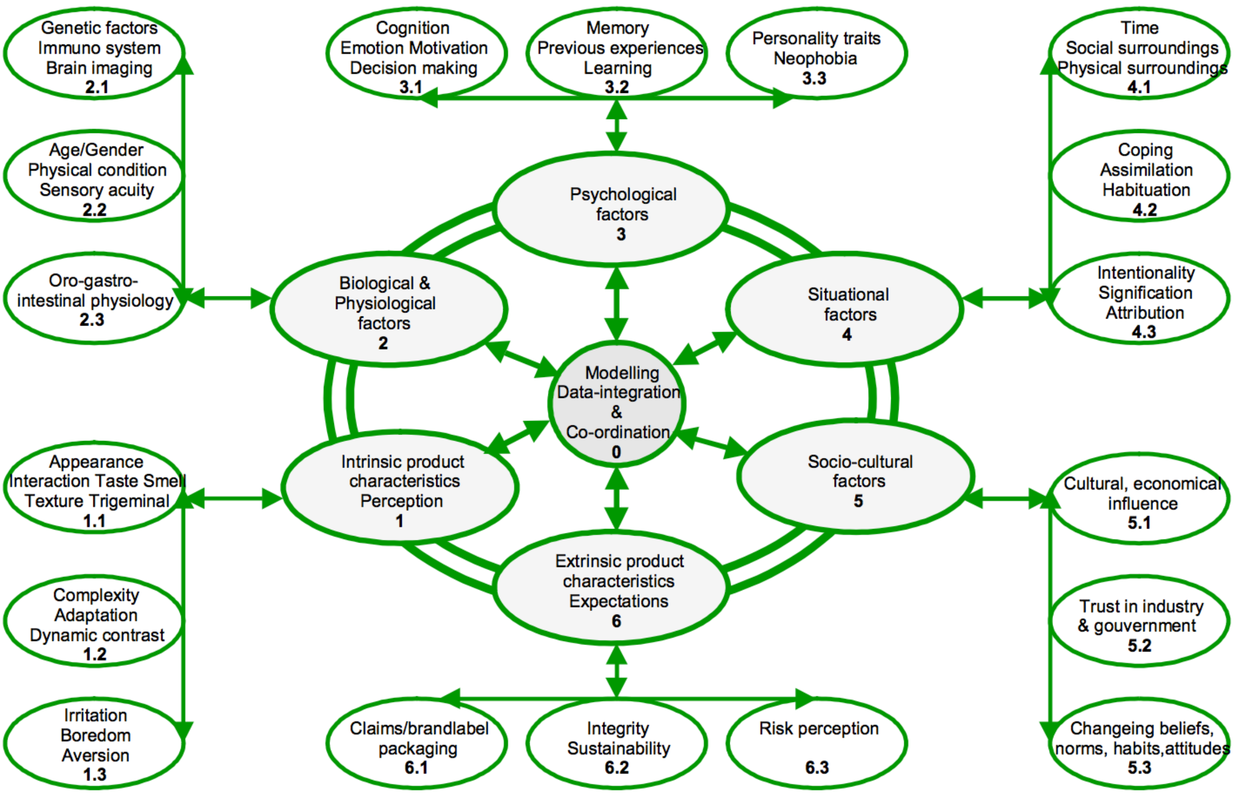


Figure 1.1. Mojet's model of factors influencing eating behaviour

1.1.3.2 The role of context-related factors

An approach to encourage vegetable consumption focuses on changing the environment and increasing consumption through increasing the provision of vegetables, or improving the manner in which provision is implemented. The transfer of childhood eating habits and food preferences into adulthood is well known, and

adult vegetable intake is often related to childhood experiences (Larson et al., 2008). Among adolescents, availability of vegetables at home emerged as an important factor affecting vegetable consumption (Walker et al., 1973; Monge-Rojas et al., 2005; Campbell, 2009). In advance availability of unhealthy, competitive food options at home resulted as a barrier to eating vegetables (Gellar et al. 2007; Evans et al. 2006). Low availability produced a barrier of consumption also in schools, where vegetables were only available in small quantities or not available at all (Cullen et al., 1998). Literature reported that children who were exposed to a wide variety of vegetables at home, liked and ate a greater variety of vegetables (Keim et al., 2001) and lack of variety in vegetables available was mentioned as a barrier to vegetable consumption by children (Niklas et al., 1997). Availability and variety influenced consumption even among adults and older adults, where affluence was detected as one of the main determinants (Appleton et al., 2017). Food stores in less affluent communities tend to have fewer fresh food options available (Morland et al., 2002). In disadvantaged neighborhoods, food is not only more difficult to access, but prices are often higher for the same products (Jetter et al., 2006). Together with socio-economic status, the physical environment and food culture influences consumption. For example, older adults eat more servings of fruit and vegetables in regions where the Mediterranean diet is predominant, particularly in Spain, Italy, and Greece (Bamia et al., 2005). In contrast, older adults living in rural areas of the United States face unique challenges in accessing vegetables. If unable to drive, rural elders have limited transportation options to food stores, and greater distance to such stores has been found to result in lower vegetables intake among rural elders (Sharkey et al., 2010).
After decades of addressing unhealthy dietary behaviors through information campaigns, legislation and education, the public health sector now suggests targeting the food environment in order to promote desirable food choices (Appleton et al., 2016). In fact, the architectural setting of an eating environment was shown to be able to change eating behavior (Skov et al., 2013) and preliminary tentatives to influence preference for vegetables through architectural setting were carried out (Friis et al., 2017; Redden et al., 2015) highlighting an effect of vegetables presentation strategies on preference.

1.1.3.3 The role of person-related factors

Knowledge of the health benefits of vegetables and concern for consuming a healthy diet can be increased through educational and motivational campaigns (Glasson et al., 2011), and various studies demonstrate the benefits of these types of intervention for increasing vegetable consumption in adults (Appleton et al., 2016). The scope of nutrition education is broader than just educating about nutrition in relation to personal health. It can cover a wide range of issues and topics such as an increase in quantity and quality of healthy foods, improving nutritive value of a diet and improving cooking abilities. To meet vegetables recommendation many countries have developed targeted campaigns and interventions to increase vegetables consumption to adequate level. For instance Pollard et al. (2009) monitored changes in behaviors regarding fruit and vegetables in Australia before and after the "Go for 2&5" and found that most changes mainly in knowledge, attitudes, and behaviors concerning food and vegetables took place after the campaign. Exposure to vegetables, through educational campaigns or tasting, resulted in increased consumption of many vegetables, and some studies are beginning to demonstrate these effects (Coulthard et al., 2014; Maier et al., 2008). Liking can be improved through repeated experience, increasing familiarity and the addition of ready-liked and familiar flavors to existing dishes, and various work demonstrates the value of these techniques for increasing likings for vegetables in different age groups (Keim et al., 2001; Appleton et al., 2016). Exposure may influence psychological traits such as food neophobia, defined as the reluctance to try and eat novel foods (Pliner & Hobden, 1992). Food neophobia can interfere with acceptance of vegetables among young children, considering that neophobia typically results in the rejection of bitter tasting foods and foods that do not "look right" (Dovey et al., 2008), of which vegetables are good examples. Food neophobia typically emerges towards the end of the second year and remains influential during the preschool years, but gradually declines thereafter. If children have to eat healthily it is necessary that their neophobic reactions to novel foods can be overcome. Fortunately, it appears that these reactions are transitory rather than permanent. An extensive literature indicates that with experience of repeated tasting (sometimes referred to as "mere exposure"), neophobia can be reduced, and dislikes transformed into likes. These findings are consistent with the "mere exposure" hypothesis (Zajonc, 1968), which was based on observations of changes in affective reactions to novel visual, auditory and edible stimuli. The mechanism by which repeated exposure increases liking is thought to be 'learned safety' (Kalat & Rozin, 1973). This hypothesis holds that repeated ingestion of an unfamiliar food without negative gastro-intestinal consequences leads to increased acceptance of that food. On the other hand, if eating a food is followed by good feelings (e.g. satiety) a learned preference may result. Exposure may also participate in the creation of positive attitudes and beliefs toward vegetables, in turn increasing the preference toward this product category. In fact people more concerned about health were more prone to include fruits and vegetables in their diet, while avoiding fats and highly processed carbohydrates (Zandstra et al., 2001; Kourouniotiset al., 2016; Appleton et al., 2017).

Past studies have provided evidence of heritability for food preferences (Breen et al., 2006; Pirastu et al., 2012). One of the heritable aspects that may influence the preference for vegetables is the sensitivity to bitter compounds. The genetic of bitter perception was widely investigated concerning the phenylthiocarbamide and the 6-n-propylthiouracile (PROP), whose perceived intensity was considered an index of oral sensitivity (Bufe et al., 2005). Research on the genetic of the preference for vegetables found that greater PROP bitterness sensitivity was associated with greater vegetable bitterness sensitivity, in turn resulting in lower acceptability for this category of foods (Kaminski et al., 2000; Dinehart et al., 2006).

1.1.3.4 The role of product-related factors

Repeated research demonstrates the role for liking in the consumption of vegetables throughout the lifespan (Glasson et al., 2011; Larson et al., 2008; Brug et al., 2008). Liking for vegetables may be influenced by context-related and person-related factor, anyway finding in the intrinsic characteristic of the product the main determinant. In fact many studies concluded that taste is the main reason for not liking vegetables (Cullen et al., 1998; Lautenschlager et al., 2007; Ross, 1995). Bitter taste is a well-recognized sensory barrier for vegetable liking and consumption (Drewnowski & Gomez-Carneros, 2000; Drewnowski, 1997) and the perceived intensity of both bitter and sweet tastes have been reported as negative and positive predictors of vegetable acceptance respectively (Cox et al., 2012; Dinehart et al., 2006). The bitter taste in vegetables is due to phenols, flavonoids, isoflavones, terpenes, and glucosinolates that are almost always bitter, acrid, or astringent (Bravo, 1998; Fenwick et al., 1983). In addition to their bactericidal or biological activity (Scalbert, 1991), these substances may provide a defense against potential predators by making the plant unpalatable (Bravo, 1998). The human instinctive rejection of bitter taste may be immutable because it has long been crucial to survival (Glendenning, 1994). In fact, although potentially beneficial to human health in small doses, many such compounds are toxic (Ames et al., 1990). As a consequence the food industry routinely removes phenols and flavonoids, isoflavones, terpenes, and glucosinolates from plant foods through selective breeding and a variety of debittering processes (Fenwick et al., 1983; Roy, 1990). Despite the bitter taste, vegetables may be characterized also by well-accepted tastes such as salty, sweet and umami. On the other hand, the hedonic valence of a generally well accepted taste such as salty can be dependent on the type of vegetable, e.g. a salty taste may assume a positive valence in peas and a negative valence in sweet corn (Dinnella et al., 2016).

Beyond the taste, other sensory modalities also play an important role in vegetable perception and acceptance. Retro-nasal olfaction reinforces both positive and negative hedonic responses to vegetables, thus indicating that flavor and the complex net of interplaying factors involved in its perception are key factors in vegetable acceptance (Lim & Padmanabhan, 2013; Poelman & Delahunty, 2011; Dinnella et al., 2016). Furthermore, individual sensitivity to the compounds responsible for the objectionable odors of cruciferous vegetables has been found related to their consumption (Engel et al., 2006).

The texture and mouth feel of vegetables was reported as another important factor influencing preference for vegetables, but the hedonic value of specific texture descriptors depends on age-group and vegetable type. Experimental data indicate that slimy, slippery and granular vegetables tend to be disliked while hard/crunchy or soft/juicy vegetables can be both highly accepted by children and teens depending on the vegetable type (Poelman & Delahunty, 2011; Szczesniak, 2002). Vegetables in general (Hildenbrandt et al., 1997), and particularly carrots, apples and nuts (Sheiham & Steele, 2001) have been reported to cause eating difficulties among older adults due to sensory attributes like hard and tough, which reflect the difficulties in biting and chewing.

Appearance, color and shape also influence vegetable acceptance, more for younger than for older children (Zeinstra et al., 2007). Small, brightly colored vegetables are preferred to large, dark green vegetables (Baxter et al., 2000; Zeinstra et al., 2007). Furthermore, in the case of familiar vegetables, atypical bright colors (yellow versus dark green) can positively affect vegetable acceptance by children (Poelman & Delahunty, 2011). The perceived level of visual complexity influences the hedonic responses to vegetable combinations. Due to a general lower exposure to different foods and food combinations, younger participants tend to prefer less complex mixes compared to adults. However, the same optimal level of visual complexity for visual preferences for vegetable mixes has been reported for adolescents and adults (Mielby et al., 2012). Across studies, adolescents rejected imperfect fruit such as brown spots as this was interpreted as possible signs of unsatisfactory taste and texture (Walker et al., 1973; Baranowski et al., 1993; Evans et al., 2006)

1.2 Methodological approaches to investigate preference for vegetables

1.2.1 Traditional methods

1.2.1.1 Measuring preference for vegetables through affective tests

Among the most often used instruments to estimate fruit and vegetable pleasure derived from consumption are preference measurements and acceptance measurements, commonly mentioned as hedonic or affective responses.

Preference tests were widely used to investigate the preference for vegetables (Zeinstra et al., 2010; Dominguez et al., 2013; Just & Wansink, 2009). In preference measurement the consumer panelist has a choice. One product is to be chosen over one or more other products. If there are two products, the test is known as a Paired Preference Test. Classic Paired Preference Tests are simple to carry out and friendly to consumers (Lawless & Heymann, 2010). Consumers are presented with two samples (A and B) and requested to point out the sample of their preference. Samples should be presented according to a balanced design, e.g., half of the consumers try first sample A and then sample B and the second half of consumers tries first sample B and then sample A. The primary goal of a preference test is to find a "winner," that is the product that has significantly higher appeal to consumers than other versions in the test. However, it is also possible that a product could win in a choice test, but still be unappealing on its own. This is one shortcoming of a preference test that it gives you no absolute information on the overall appeal of a product. Acceptance testing with a scale is designed to do just that.

As mentioned, the other approach to study preference for vegetables was the measurement of acceptance or liking (Dinnella et al., 2016; Lakkakula et al., 2010). In acceptability measurements the consumers rate their liking for the product on a hedonic scale (Lawless & Heymann, 2010). Acceptance measurements can be done on single products and do not require a comparison to another product. An efficient procedure is to determine consumers' acceptance scores in a multi-product test and then to determine their preferences indirectly from the scores. Among hedonic scales, 9-point verbally anchored degree of liking scale (9 = "Extremely Like"; 8 = "Like Very Much"; 7 = "Moderately Like"; 6 = "Slightly Like"; 5 = "Neither Like nor Dislike"; 4 =

"Slightly Dislike"; 3 = "Moderately Dislike"; 2 = "Dislike Very Much"; 1 = "Extremely Dislike") is probably the most common. The use of the hedonic scale has extended worldwide and has become a standard tool to determine consumers' acceptance of food products (Yeh et al., 1998). However, this methodology poses various problems that have led some authors to question its validity. For instance, due to the fact that the original scale was created in English, there has been some difficulty regarding the translation of the scale categories. Every time the hedonic scale is translated into other languages, categories can be misunderstood or not understood as having the same intensity of the original version (Curia et al., 2001). Moreover, it has been reported that the acceptance categories are not equally spaced for consumers, which means that results cannot be interpreted directly (Lawless & Heymann, 2010). Psychologically, the distance from 8 ("Like Very Much") to 9 ("Extremely Like") is greater than the distance from 6 ("Slightly Like") to 7 ("Moderately Like"). A possible solution to this problem would be to try to quantify the consumers' acceptance of a product and to avoid using verbal categories (Curia et al., 2001). Another problem with the hedonic scale is related to the predictive power of the measure. In fact, despite the fact that hedonic scales were assumed to estimate actual preference (Tuorila, 2007), in some cases the predictive power was shown to be limited (Villegas-Ruiz et al., 2008). Hedonic scales have been widely used due to the assumption that they enable us to predict the consumers' consumption and purchasing decisions (Tuorila et al., 2008). However several research studies have shown that acceptance scores may not reflect the consumers' behavior at the purchasing moment (Lange et al., 2002; Rosas-Nexticapa et al., 2005)

1.2.1.2 Measuring preference for vegetables through consumption

Among the most often used instruments to estimate fruit and vegetable consumption are the food frequency questionnaire and the dietary recall.

The "food frequency questionnaire" method (Cade et al., 2004) is used to assess past intake or the usual intake over a longer period. The food frequency questionnaire contains lists of individual foods or food groups. Subjects are asked to estimate the frequency of consumption of those foods, indicating the number of times the food is consumed over a given timeframe. In some cases the food frequency questionnaire is semi-quantitative as it specifies a standard serving or portion for each item. It can also be quantitative when, in addition to frequency, the respondent may indicate any amount of food consumed. Questionnaires allow quantitative estimates if they provide a detailed list of fruit and vegetable consumption in a population and specified quantities for each food item. However, it is commonly accepted that food frequency questionnaires are better suited to ranking subjects by level of intake than to producing absolute estimates of intake (Byers, 2001; Block, 2001). The best characteristic of a food frequency questionnaire is its great flexibility and ease of application (Krebs-smith & Kantor, 2001), even if the quality of the estimates is highly dependent on specification: whether fruit and vegetables are expressed as groups or single foods in the questionnaire, and the number of items included. While this approach gives information on dietary exposure over a defined period of time, there are limitations to the types of data obtained. For example, there are no data on mixed dishes that contain substantial amounts of fruits and vegetables. Other limitations include the restrictions imposed by a fixed list of foods and the cognitive challenge of reporting foods consumed over a broad timeframe (Neuhouser et al., 2000).

The diet history is a collection of usual food intake that aims to report the dietary intake of a specific timeframe. The "24-hour dietary recall" method is used to assess past intake referred to a short period very close to the interview. This method is appropriate to measure current consumption in groups of subjects. It is therefore particularly well suited to assess the group mean of fruit and vegetable consumption, assuming the representativeness of the population sample and a well-balanced distribution of 24-hour dietary recall surveys by season and weekdays. The main limitation is that the 24-hour dietary recall method does not provide reliable estimates of the usual intake, reflecting day-to-day variations, unless the same subject answers repeated surveys.

A general limitation of these approaches is that they are based on memory, and recall problems may appear in either of them. Moreover, for fruit and vegetables, subjects may be influenced in their reporting by social desirability. They may over-report consumption simply because high intake of such foods is promoted as a healthy habit. Over-reporting or underreporting has been assessed in validation studies. Fruit and vegetable intake, estimated by means of the food-frequency questionnaire or a diet history, was compared with the average intake of twelve 24-hour dietary recall records over a period of one year in a sample of European consumers. The correlation coefficients for fruit and vegetables ranged from 0.30 to 0.79 (Kaaks et al., 1997), highlighting the limits in the predictive power of these methodologies when studying fruit and vegetables

1.2.2 New approaches to investigate preference for vegetables

1.2.2.1 Measuring new responses beyond liking

Academic and industrial research on food choice frequently makes an underlying assumption that taste is the driver of food selection and purchase. This is often used as a motivation for research on orosensory perception and liking, despite limited and inconsistent evidence that these explain meaningful variation in energy intakes or nutritional status. In fact, humans frequently exhibit preference for less "desired" food alternatives. We choose less desired or less liked foods when these positive drivers of choice are outweighed by, for example, physical/economic constraints or cognitive/attitudinal considerations such as health concerns. Understanding these aspects could be of interest, assuming that a goal of many public health campaigns is to try to shift consumer choice toward foods that are initially less liked and/or less desired, such as vegetables and plant-based dishes. This fact positions the understanding and ability to guide food likes and wants as a central challenge to academic and industrial research and several authors have begun to draw attention to distinctions between ''liking'' and ''wanting'' (Finlayson et al., 2007a; Finlayson et al, 2007b). Wanting has been defined as the intrinsic motivation to engage in eating a food, now or in the near future (Mela, 2006). Liking is one contributor to wanting, which presumably carries a component of anticipated pleasure. However, liking is clearly not enough to predict desire (Mela, 2000). We may like fish soup or a favorite wine but feel no desire to consume these at breakfast. Thus desire can also be strongly influenced by feelings of appropriateness, that is, whether a food matches the situation and context. The matching of foods and use-contexts is largely determined by cultural and social conventions. Furthermore, there are psychophysiological conditions that prompt desire irrespective of other factors (Mela, 2006). New research in academia and industry should therefore consider liking and desire, in order to understand why certain food stimuli are liked and also have a high and sustained desired frequency of consumption.

Research on adults evidenced that the measurement of emotions can be used to explore differences between food products when the acceptability or preferences for the products are similar (Jaeger et al., 2013; King et al., 2010). The concept of emotions as drivers of actions or choices is neither new nor controversial. At a fundamental level, we recognize that experiencing fear is likely to drive us away from the perceived cause of that fear, while we are attracted to anything that produces happiness. Decades of research into the affective consequences of how actions are reinforced is consistent with such everyday views of emotion (Berridge, 2001). Hence, it is not surprising that there has been a turn towards emotions as predictors of food choices and as a consequence in the past decade an increased interest in the measurement of emotions occurred. Several food-specific questionnaires have been developed of which the EsSense Profile (King et al., 2010; King et al., 2013) appears to be best validated and gains influence in the field of sensory science. The EsSense Profile includes a large number of emotion terms based on the observation that people tend to describe food products using a large variety of terms. The context-specificity and the definitional issues that surround emotions make their measurement challenging. The lists of emotion terms that participants can use to identify their current emotional state may themselves influence which emotions are expressed. In order take this aspect into consideration, an approach named EmoSemio (Spinelli et al., 2015) was recently proposed and developed to take into consideration the appropriateness of the listed words for the specific language context and set of products in evaluation.

1.2.2.2 Enhance external validity of results

Even if numerous techniques have been developed to identify the sensory attributes expressed by consumers regarding their acceptance for food products, most of these methodologies are based on correlations with data provided by trained judges. In the last decade many approaches to obtaining sensory information directly from consumers were developed. This was done in order to enhance the external validity of responses, which is the ability of a sensory test to predict actual marketplace behavior. These approaches belong to the class of rapid descriptive methodologies, which can be classified as "reductionist", where assessors are asked to decompose the stimulus into multiple attributes, and "holistic", where assessors are asked to consider the product as a whole. Among "reductionist" rapid descriptive methodologies, Check-All-That-Apply (CATA) (Adams et al., 2007) especially has gained popularity due to its high rapidity and ease of use. The CATA questions have been introduced to sensory and consumer science to obtain information about consumers' perception of products. Although the method has been previously used with trained assessors (Campo et al., 2010; Le Fur et al., 2003), its popularity has increased for product sensory characterization with consumers (Varela & Ares, 2012; Giacalone et al., 2013). The application of CATA questions has been reported to be a quick alternative for gathering information about consumer perception of the sensory characteristics of food products, providing similar information to that obtained using descriptive analysis with trained assessors (Ares et al., 2010). In the CATA approach, consumers are presented with a set of products and a CATA question to characterize them. Consumers are asked to try the products and to answer the CATA question by selecting all the terms that they consider appropriate to describe each of the samples, without any constraint on the number of attributes that can be selected. The list of words or phrases in the CATA question usually includes exclusively sensory characteristics of the product but can also include hedonic terms, as well as terms related to non-sensory characteristics (Ares & Jaeger, 2013; Parente et al., 2011; Piqueras-Fiszman and Jaeger, 2014). Selecting terms from a list has been claimed to be an easy and intuitive task for consumers, which requires less cognitive effort than other attribute-based methodologies such as just-about-right or intensity scales (Adams et al., 2007). The CATA approach has already been used in consumer research for characterizing fruit (Laureati et al., 2017) and so far little research was carried out considering vegetables.

Among "holistic" rapid descriptive methodologies, the simplest and best known is the Free sorting task, which has been applied on many food products and is reported to be applicable with trained assessors and consumers alike (Chollet et al., 2011). The Frees sorting task is a method based on categorization, a natural cognitive process where objects with common characteristics are grouped and inference is made about their properties, in order to obtain considerable information with minimum cognitive effort (Rosch & Lloyd, 1978). The method has been shown to be easily applicable with consumers considering that little training is required, quantitative rating systems are not requested, and in general the method is based on a simple and spontaneous cognitive process. Further details about Free sorting task are reported in paragraph 1.2.3.3.

1.2.2.3 Scale-less evaluations for new consumers

The majority of the methods used to study consumers' responses were developed with younger adults, without taking into account the physical and cognitive difficulties that may be present in specific segments of population such as older adults and children. Taking into consideration the increasing interest of interventions targeted at older adults and children to increase vegetable consumption (Appleton et al., 2016), the use of investigative tools that allow evaluation of the perceptions and preferences in an effective and reliable way is needed. In healthy older adults and children most sensory and consumer methods can be applied (Methven et al., 2016; Laureati et al., 2015). However the use of consumer tests with these segments of population should be evaluated carefully, due to the possible presence of difficulties related to the comprehension and use of rating scales, difficulties in the use of introspection processes, and a general tendency to have cognitive and perceptive fatigue with long and complex methodologies. Ranking is one of the simplest methods to use with these segments of population. Ranking reduces the dependency on memory and eliminates any difficulties the consumer might have in interpreting and using scales (category or VAS). However, in ranking, all products must be judged before deciding on rank and large sample numbers can cause sensory fatigue and adaptation to sensory attributes (Barylko-Pikielna et al., 2002). Moreover participants have to remember what they thought about each product, as they taste subsequent products. Nevertheless, one study which compared ranking and rating (nine-point hedonic scale) for their discriminability and appropriateness for hedonic assessment with older adults showed that due to the simplicity and ''user friendliness'' of the tasting procedure, hedonic ranking had some advantages over nine-point hedonic scaling. Among children, sensory and hedonic ranking were successfully used in participants with an age range from 4 to 11 years old (Liem & Mennela, 2003; Kildegaard et al., 2011), highlighting the applicability of ranking also for this segment of population. Sorting techniques resulted also in this case applicable to study preference and perception of older adults and children. Evidence of application of sorting techniques with school-aged children has been provided by Morizet et al. (2012), who reported that children were able to correctly classify several vegetables according to liking and familiarity. Although further research is needed to assess the potential of projective and sorting techniques for assessing children's preference, it seems that the procedures can be easily understood and can be considered a promising tool in consumer research with children (Laureati et al., 2015). Among older adults, sorting task has been successfully used to produce a preference map constructed entirely from the consumer data (Withers et al., 2014). In this research it was reported that sorting methodologies could be used with healthy older adults in general. However, the authors did not explore in depth the applicability of the method, considering both the elderly population as a whole and the different age segments.

1.2.2.4 Overcome limits of self-report: social desirability and lack of introspection

In a consumption environment that features ever-changing social trends and norms, deviant attitudes and behaviors are often not readily admitted. One example is provided by the case of consumers asked about their attitudes toward vegetables. It is likely that because of the enhanced pressure to think and act in a healthy manner, many respondents may be reluctant to express unfavorable attitudes toward vegetables. Accordingly, they may engage in response management strategies to conceal their true attitudes and instead provide socially desirable answers (Meneses, 2010), which can lead to invalid inferences regarding their attitudes and behavior. On the other hand, even if participants respond as honestly as possible, the survey may not be targeting the same thought processes that a consumer faces in the product use scenario or in the marketplace. In fact consumers may lack conscious access to their own cognitive processes or information stored in memory. Explicit measures may simply be inadequate to capture these types of data. In these situations, a theoretically interesting dissociation of explicit and implicit responses may occur, and the question of whether explicit or implicit measures of cognition are more predictive of actual behavior becomes directly relevant. In fact, decision-making and choice may be considered as the result of two different cognitive processes: one that is conscious, slow and deliberative and one that is unconscious, rapid and automatic (Kahneman & Frederick, 2002). Therefore it seems plausible that food choices are the results of both these processes, and that the control over eating habits is not necessarily explicit (Cervellon et al., 2007). The study of eating behavior related to meat consumption may represent an example of the discrepancy between declared and actual behavior, where was documented that consumers claimed they were vegetarians but then simultaneously acknowledged that they consumed animal flesh (Rothgerber, 2014). The use of both implicit and explicit measurements may therefore be useful to classify with higher reliability the consumers' eating behavior.

Implicit measurements (De Houwer & Moors, 2010) may overcome some of the problematic elements of traditional self-report measures of attitudes. The term *implicit* has come to be applied to measurement methods that avoid requiring introspective access, decrease the mental control available to produce the response, reduce the role of conscious intention, and reduce the role of self-reflective, deliberative processes. Although few measures are truly implicit in the sense of fulfilling all these conditions, there is evidence that participants are less able to consciously control the outcome of implicit measures compared to self-report (De Houwer, 2006). Implicit methods have been applied in psychology for various purposes, ranging from investigation of addictions and phobias to indication of racial bias. However, due to the benefits outlined above, implicit measures may also be useful in interpreting consumer attitudes towards products (Maison et al., 2001). Among them, the most commonly employed measure has been the Implicit Association Test (Greenwald et al., 1998). The Implicit Association Test is designed to implicitly measure the strength of associations between concepts and evaluative attributes using a categorization task, a peculiarity that can be used to implicitly study consumer attitudes (Maison et al., 2001).

1.2.2.5 The contribution of categorization

An aspect that links many of the new methodological approaches previously described is the process of categorization. Among the methods for obtaining information directly from consumers, the sorting task was reported, based on the evaluation and consequent categorization of sensory stimuli. Sorting techniques were highlighted as being of particular interest also for the study of new consumers, such as older adults and children, where there is need for methods that require a limited cognitive effort and that avoid the use of rating scales. Related to categorization there are a number of methodologies of implicit measure, that find in the process of categorization the operative task carried out by subjects during the implicit test. The reaction time of the categorization task is consequently used to implicitly obtain information about consumers' attitudes. Considering the relevance of categorization among the approaches to overcome the current limits in sensory and consumer research, it is therefore of interest to study in depth the mechanism that underlines this process and further explore its use among consumers.

1.2.3 The process of categorization and related methodologies for consumers' studies

1.2.3.1 Concepts and categorization

A concept can be defined as a mental representation of a class or individual and deals with *what* is being represented and *how* that information is typically used during the categorization (Goldstone et al., 2012). Fundamentally, concepts function as filters. We do not have direct access to our external world. We only have access to our world as filtered through our concepts. Concepts are useful when they provide informative ways of structuring this world. Concepts are cognitive elements that combine together to generatively produce an infinite variety of thoughts. The use of concepts can be useful to reduce the cognitive effort related to the external world. In fact we can discriminate far more stimuli than we have concepts. For example, estimates suggest that we can perceptually discriminate at least 10,000 colors from each other, but we have far fewer color concepts than this. Storing a category in memory rather than a complete description of an individual is efficient because fewer bits of information are required to specify the category. For example, Figure 1.2 shows a set of objects described along two dimensions. Rather than preserving the complete description of each of the 19 objects, one can create a reasonably faithful representation of the distribution of objects by just storing the positions of the four triangles. In addition to conserving memory-storage requirements, an important advantage of concepts is to reduce the need for learning (Bruner et al., 1956). An unfamiliar object that has not been placed in a category attracts attention because the observer must figure out how to think of it. Conversely, if an object can be identified as belonging to a pre-established category, then less cognitive processing is necessary.

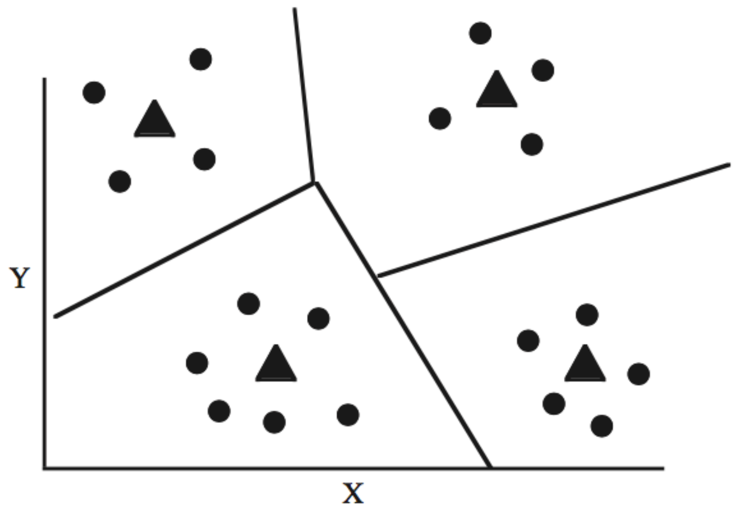


Figure 1.2. Examples of categorization of concepts: Exemplar theory (circles) and Prototype theory (triangles). Adapted from Goldstone et al. (2012).

1.2.3.2 Theories behind categorization

Prototype theory and Exemplar theory represent two prominent theories of how categories are created in memory (Goldstone et al., 2012).

The Prototype theory is the base of the rule-based process of categorization (Ashby et al., 1998), and assumes that categories are represented by abstract composites, called prototypes, based on central tendency information. To provide a graphical example, the prototype model would represent the four categories in Figure 1.2 in terms of the triangles. These summary representations are based on the most likely features of the category, based on a person's experiences with category members (Rosch & Mervis, 1975). The prototype for a category consists of the most common attribute values associated with the members of the category. The likelihood of placing an object into a category increases as it becomes more similar to the category's prototype and less similar to other category prototypes (Rosch & Mervis, 1975). Several converging tasks can predict the similarity of an item to its category prototype (Goldstone et al., 2012). Typicality resulted correlated with the average rating that item receives when subjects are asked to rate how good an example the item is of its category (Rioux et al., 2016; Rosch & Mervis, 1975), resulted correlated with subjects' speed in verifying statements of the form: "An *item* is a *category name*" (Smith et al., 1974) or with the frequency and speed of listing the item when asked to supply members of a category (Mervis & Rosch, 1981). Taken in total, results from these approaches indicate that different members of the same category differ in how typical they are of the category, and that these differences have a strong cognitive impact. Therefore categories seem to be organized by graded typicality to the category' s prototype (Goldstone et al., 2012). The category's prototype can be generated finding the most common features shared among category members. An alternative conception views prototypes as the central tendency of continuously varying features (Goldstone et al., 2012). These features were previously extracted for vegetable foods through a features applicability judgment task (Storms et al., 2001; Smits et al., 2002), where subjects were asked to judge whether or not each attribute of a list of features applied to different food stimuli presented as words.

The Exemplar theory is the base of the similarity-based process of categorization (Juslin et al., 2003), and assumes that categories are represented by specific, stored instances of the category, rather than by general, abstracted prototypes. The exemplar model would represent the categories in Figure 1.2 as circles. The new stimulus is assigned to a category based on the greatest number of similarities it holds with exemplars in that category. For example, the model proposes that people create the "bird" category by maintaining in their memory a collection of all the birds they have experienced: sparrows, robins, ostriches, penguins, etc. If a new stimulus is similar enough to some of these stored bird examples, the person categorizes the stimulus in the "bird" category (Nosofsky et al., 2011).

The two theories are similar in that they emphasize the importance of similarity in categorization: only by resembling a prototype or exemplars can a new stimulus be placed into a category. They also both rely on the same general cognitive process: we experience a new stimulus, a concept in memory is triggered, we make a judgment of resemblance, and draw a categorization conclusion. However, the specifics of the two theories are different. Prototype theory suggests that a new stimulus is compared to a single prototype in a category, while exemplar theory suggests that a new stimulus is compared to multiple known exemplars in a category. While a prototype is an abstract average of the members of a category, an exemplar is an actual member of a category. Another difference is that exemplars are more likely to be used than prototypes after long experience with a concept (von Helversen et al., 2010) due to the lower cognitive demand in respect to the rule-based processes. Research suggests that we may use both the exemplar and prototype method in making category judgments, and they often work in tandem to produce the most accurate conclusions (Mack et al., 2013). As a result of the categorization, when a novel item is classified as a member of an existing category, information in that category is transferred to the novel item and used to structure the new representation (Gregan-Paxton, 1999; Waldmann et al., 1995).

The study of categorization has been operationalized in different methodological approaches. In the following paragraphs, presented in detail will be two of the most popular approaches that rely on categorization: Free sorting task and the Implicit association test.

1.2.3.3 Methods to investigate categorization: Free sorting task

The free sorting task (FST) is a procedure for collecting data in which assessors are asked to group together stimuli based on their perceived similarities. This information is used to interpret the differences among products. In fact, in this method similarity is a group-derived estimate that is inferred from the number of times two items are sorted into the same group across a panel of participants. The final objective of FST is to reveal the structure of products categorization and to interpret its underlying dimensions. FST originated in psychology (Hulin and Katz, 1935) and was used for the first time with food products by Lawless et al. (1995). The method has been used on a large variety of food products including beverages (Chollet and Valentin, 2001; Piombino et al., 2004), vegetables (Deegan et al., 2010) and animal products (Lawless et al. 1995; Hoek et al., 2011).

Assessors

The sorting task has been successfully used on trained and untrained subjects (Cartier et al., 2006; Lelièvre et al., 2008). Concerning the number of assessors needed in sorting tasks, it has been suggested that a large number of assessors is required (Faye, 2004). However, other studies carried out with beers indicated that stable results could be reached with 20 untrained assessors (Lelièvre et al., 2008; Chollet et al., 2011). So it is likely that the stability of the results may vary with some aspects of the task, and recently, Blancher et al. (2007) have suggested that the stability of sorting task results depends on the characteristics of the product sets and on the assessor expertise level.

Products

As a general rule the range of products that can be used in FST is between 9 and 20 (Chollet et al., 2014). The optimal number of products is dependent on the intrinsic properties of the product and issues related to memory. In fact some products cannot be tasted in large numbers because of their intrinsic properties, such as alcoholic beverages and products with taste persistence. Moreover, because of the necessity of comparing products, performing a sorting task involves short-term memory that has a limited capacity (Miller, 1956). As a consequence, when the number of products to sort exceeds the assessor's memory span, then these products have to be tasted several times and this increases the risk of confusion.

Procedure

All products are presented simultaneously and randomly displayed on a table with a different order per assessor. Assessors are asked first to look at, smell, and/or taste (depending on the objectives of the study) all the products and then to sort them into groups based on perceived product similarities (Valentin et al., 2012). In this way items that have something in common are placed in the same group, whereas items that differ from one another should be placed in different groups. Assessors can use the criteria they want to sort the stimuli, and they are free to make as many groups as they want and to put as many products as they want in each group. The sorting task can be stopped at this point or can be followed by a description step where assessors are asked to describe each group of products, a procedure called *labeled sorting* (Bécue-Bertaut & Lê, 2011).

Data analysis

The results of each assessor are encoded in an individual co-occurrence matrix where the rows and the columns are products. A value of 1 at the intersection of a row and a column indicates that the assessor sorted these two products together, whereas a value of 0 indicates that the products were not put together. All the individual matrices are then summed to obtain a global matrix (Figure 1.3). The sorting similarity matrix is generally analyzed by multidimensional scaling (MDS), a technique used to visualize proximities or distances between objects in a low dimensional space. In MDS, a point on a map represents each object. In this map, the points are arranged so that objects that are perceived to be similar to each other are placed near each other and objects that are perceived to be different are placed far away. Multiblock analyses that take into account individual data such as DISTATIS (Abdi et al., 2007), MCA (Abdi & Valentin, 2007), or Multiple factor analysis (Dehlhom et al., 2012) have also been developed. These techniques provide a common map (often called a compromise) and also show how each assessor positions the products in the common space.

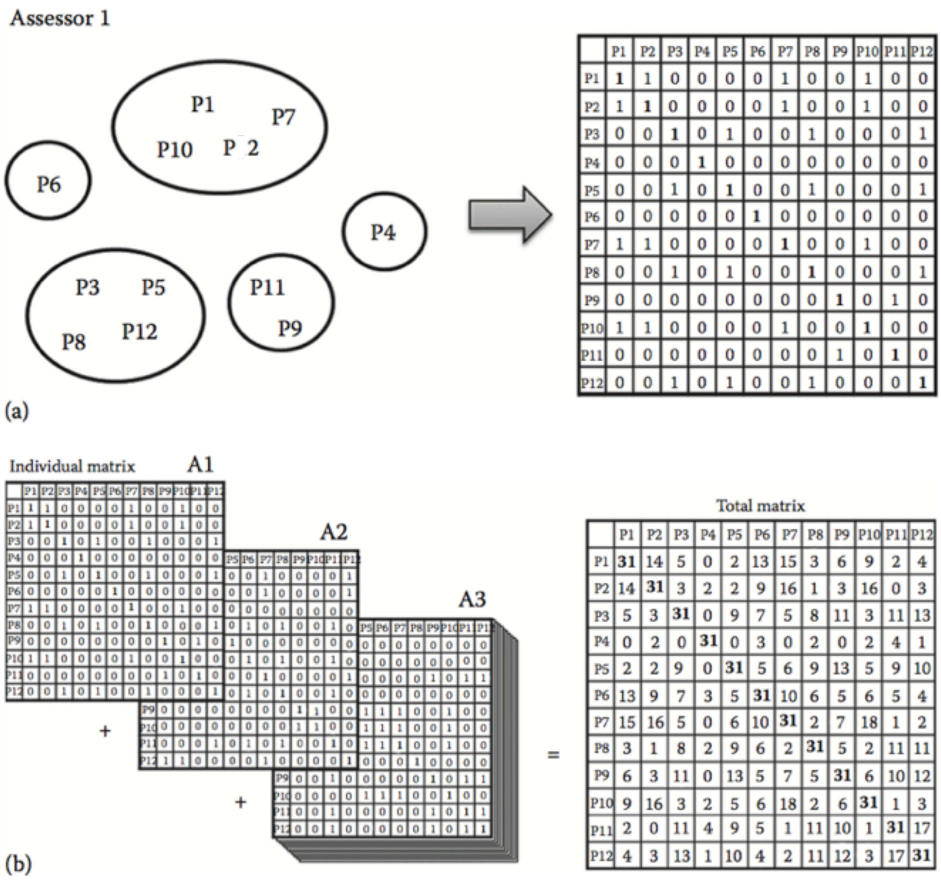


Figure 1.3. Example of data from a free sorting task: individual data (a) and grouped data (b). Adapted from Chollet et al. (2014).

1.2.3.4 Methods based on categorization: Implicit association test.

The Implicit Associaton Test (IAT) (Greenwald et al., 1998) is a method for indirectly measuring the strengths of associations among concepts. The task requires sorting of stimulus exemplars from four concepts using two response options, each of which is assigned to two of the four concepts. The logic of the IAT is that this sorting task should be easier when the two concepts that share a response are strongly associated than when they are weakly associated. This peculiarity can be used to implicitly study consumer attitudes (Maison et al., 2001). Since its initial publication, the IAT has been applied in many disciplines including social and cognitive psychology (Fazio & Olson, 2003; Greenwald & Nosek, 2001), neuroscience (Cunningham et al., 2004), market research (Maison et al., 2001), health psychology (Teachman et al., 2003) and more recently in consumer science (Kraus & Piqueras-Fiszman, 2016; Mai et al., 2015).

Categories and exemplars

The subjects' primary task in the IAT is to identify the category membership of stimulus items (exemplars of categories) as quickly as possible. Stimulus items can be presented as words, pictures, sounds, or in a combination of modalities. Generating stimulus items requires an accurate representation of the superordinate category, avoiding exemplars that are only weakly representative of the category. Therefore each stimulus item must be identifiable as representing just one of the four categories used in the IAT procedure. If the category membership of a stimulus item is difficult to identify or confounded with multiple categories, then subjects may be unable to categorize accurately, or may attempt to complete the task with sorting rules different from those intended for the design. Another important aspect of exemplar selection is to ensure that stimulus items are categorized on the basis of the intended nominal feature rather than an irrelevant stimulus feature. In other words, it should be difficult to distinguish the two categories of a single nominal dimension (e.g., men or women) using any characteristic except the nominal feature (gender). If the categories *men* and *women* were comprised of Black male and White female faces respectively, category membership would be clear, but subjects could sort items based on race (irrelevant) or gender (relevant) (Nosek et al., 2007)

Procedure

The IAT consists of seven subsequent phases of items categorization, where reaction time (response latency) of categorization and frequency of errors in categorization are recorded. An example of the different phases in the IAT is reported in Table 1.1. The first phase (B1) represents a practice task where subjects are asked to categorize items (e.g. faces of males and females) representing the two target concepts (e.g. *male, female*) in order to train with stimulus and sorting rules. The task is carried out through a pc screen, where the concept associated to the left key (*male*) is reported at the top left of the screen and the concept associated to the right key (*female*) is reported at the top right (Figure 1.4a). Each item appears at the center of the screen one at time and subjects are asked to sort the items using the two keys. The second phase (B2) represents a practice task where subjects are asked to categorize items (e.g. pleasant and unpleasant words) representing the two attribute concepts (e.g. *pleasant, unpleasant*), following the same procedure of the previous phase (Figure 1.4b). The critical phases of the IAT involve simultaneous sorting of stimulus items representing four concepts (e.g., *female, male, pleasant, unpleasant*) with two response keys. In the first critical phase (B3 and B4 in the example), items representing the concepts *male* and *pleasant* (e.g., male faces and pleasant words) are associated to the left key, and items representing the concepts *female* and *unpleasant* (e.g., female faces and unpleasant words) are associated with the right key (Figure 1.4c). In the second critical phase (B6 and B7 in the example), items representing the concepts *female* and *pleasant* are sorted with the left key, and items representing the concepts *male* and *unpleasant* are sorted with the right key. For subjects who possess stronger associations of positive evaluation with females compared to males, the second critical phase (B6 and B7) should be much easier than the first. Conversely, subjects who possess stronger associations of positive evaluation with males compared to females should find the first critical phase (B4 and B5) to be easier than the second. Ease of sorting can be indexed both by the speed of responding (faster responding indicating stronger associations) and the frequency of errors (fewer errors indicating stronger associations).

Table 1.1. Sequence of blocks in the Implicit Association Test measuring gender prejudices

Block	*No. of trials*	*Trials*	*Categories key assignment*	
			Left-key	*Right-key*
B1	20	Practice	Male	Female
B2	20	Practice	Pleasant	Unpleasant
B3	20	Critical practice	Male + Pleasant	Female + Unpleasant
B4	40	Critical test	Male + Pleasant	Female + Unpleasant
B5	40	Practice	Female	Male
B6	20	Critical practice	Female + Pleasant	Male + Unpleasant
B7	40	Critical test	Female + Pleasant	Male + Unpleasant

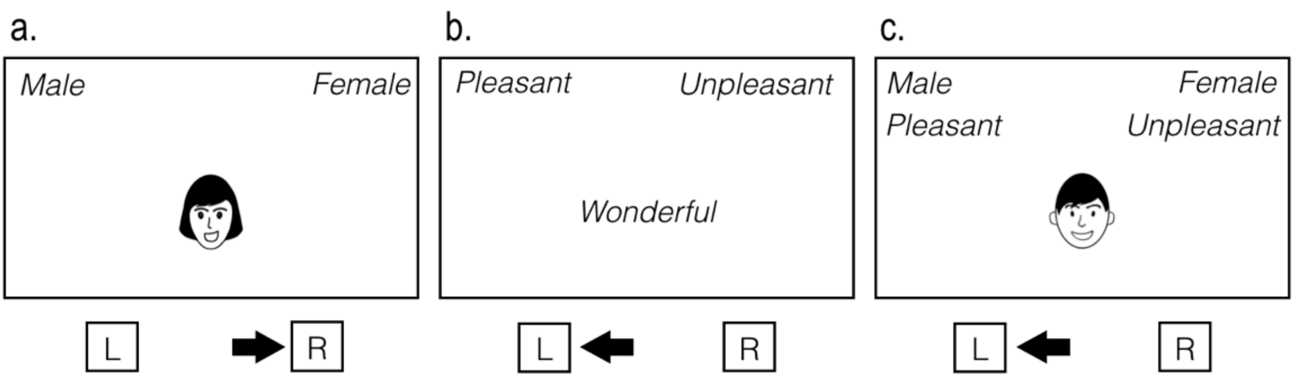


Figure 1.4. Examples of pc screens in the Implicit Association Test measuring gender prejudices: block 1 (a), block 2 (b), block 3 (c). The black arrow indicates the right response within each block.

Data analysis

Greenwald and colleagues (2003) evaluated a variety of candidate scoring algorithms on a wide range of psychometric criteria (sensitivity to known influences, correlations with parallel self-report measures, internal consistency, and resistance to extraneous procedural influences) on very large Internet samples. The best performing algorithm, the *D-score*, strongly outperformed the conventional scoring procedures and was recommended by Greenwald and colleagues (2003). The D-score algorithm has the following steps for IAT designs in which subjects are not asked to correct errant responses before continuing:

(1) use data from Blocks 3, 4, 6, and 7 (see Table 1.1);
(2) eliminate trials with latencies > 10,000 ms;
(3) eliminate subjects for whom more than 10% of trials have latencies <300 ms;
(4) compute the mean of correct latencies for each of the four blocks;
(5) replace each error latency with the block mean from Step 4 + a 600 millisecond error penalty;
(6) compute one standard deviation for all trials in Blocks 3 and 6, and another standard deviation for all trials in Blocks 4 and 7;
(7) compute means for trials in each of the four blocks (Blocks 3, 4, 6, 7);
(8) compute the two difference scores;
(9) divide each difference score by its associated standard deviation from Step 6;
(10) average the two quotients from Step 9.

The obtained D-score is an index that indicates the direction of stronger association and the degree of associative strength between concepts. Relative to the example in Table 1.1, D-scores < 0 indicate stronger associations between *male* and *pleasant* while D-scores > 0 indicate stronger associations between female and unpleasant. Absolute scores between −0.15 and 0.15 are considered to represent no differences in associative strength between combinations (Whitaker et al., 2016).

1.3 Research questions on the preference for vegetables and the contribution of categorization

The study of preference for vegetables has been widely studied and solutions for increasing consumption were proposed. Despite this, the consumption of vegetables still remains under the recommended level, warranting more research on the underlying determinants of preference. For this purpose, three research questions in the domain of the preference of vegetables were selected for this study. A possible way to tackle each topic was provided considering the contribution of methods related to the process of categorization.

1.3.1 Categorization of plant-based dishes among consumers

Besides the suggestion to consume a specific number of portions of vegetable, it is of particular importance to understand which items consumers include in the word "vegetable". Comparing dietary guidelines, foods classified as vegetable may be shared or even differ. For instance, the inclusion of potatoes and tubers, and legumes or pulses as vegetables is controversial (WCRF, 1997). While potatoes are often considered as vegetables, many dietary guidelines put this group together with cereals as starchy foods (Painter et al., 2002). Some dietary guidelines explicitly exclude them from the recommendation to increase intake of vegetables (WCRF, 1997). In most cases legumes are included as vegetables, although sometimes beans are put with meat and fish in the protein-rich foods (Painter et al., 2002). Despite the intentions of guidelines, culinary definitions correspond better to what is understood by consumers (IARC, 2003), highlighting possible mismatches between guidelines and consumers. For instance children showed difficulties in deciding which food items belong to the vegetable group, including chips that are based on corn or potatoes among vegetables (Baranowski et al., 1993; Wind et al., 2005). Considering these aspects, a deeper comprehension of what consumers include in the vegetable category may be useful to improve the effectiveness of dietary guidelines and increase the consumption of recognized vegetables. This research question may be investigated recurring to the prototype theory in order to evaluate how a number of pictures of plant-based dishes are organized around the prototype. The typicality of each category member with the prototype of the category can be assessed through a similarity-rating task (Rosch & Mervis, 1975), while the sensory features of the members more central for the category can be extracted through a features applicability judgment task, such as Check-all-that-apply questionnaire (Meyners & Castura, 2014). Moreover can be of interest to investigate how the expected liking may change for members more or less typical of the category, and in relation to perceptive features characterizing the plant-based dish category.

1.3.2 Differences and similarities in perception of vegetable among new consumers

Taking into consideration the increasing interest of interventions targeted at older adults and children to increase vegetable consumption (Appleton et al., 2016), the use of investigative tools that allow evaluation of the perceptions and preferences in an effective and reliable way is needed. In healthy older adults most sensory and consumer methods can be applied (Methven et al., 2016). However the use of consumer tests with this segment of population should be evaluated carefully, due to the possible presence of difficulties related to the comprehension and use of rating scales (Dermiki et al., 2013), difficulties in the use of introspection processes, and a general tendency to have cognitive and perceptive fatigue with long and complex methodologies. A methodology with big potential, yet to be fully explored with older adults is the free sorting task (FST). The free sorting task is a method based on categorization, a natural cognitive process where objects with common characteristics are grouped and inference is made about their properties, in order to obtain considerable information with minimum cognitive effort (Rosch & Lloyd, 1978). The method has been shown to be easily applicable with consumers considering that little training is required, quantitative rating systems are not requested, and in general the method is based on a simple and spontaneous cognitive process. FST has been found highly correlated with the sensory maps obtained with descriptive analysis (Cartier et al., 2006). A further dimension relevant in food product categorization is the hedonic one (Ballester et al., 2008; Chollet & Valentin, 2000), even if only a limited effect on the structuring of similarity space has been reported. Considering these aspects, the study of usability of FST among healthy older adults would be of interest. If well performed, FST associated to a description of formed groups may represent a rapid and effective tool for studying perception and preference among older adults.

1.3.3 Implicit attitudes toward vegetables among subjects with different eating habits

Among the different approaches to investigating eating behavior, the use of interviews and questionnaires may be considered as the most common, thanks to their relative low cost and ease of submission. However, explicitly measured concepts may suffer from limitations such as voluntary self-presentation strategies (e.g. social desirability), resulting in a discrepancy between declared and actual behavior (Maass et al., 2000). A further limitation is that respondents, even carrying out an accurate introspective effort, may not be able to report their own actual cognitive contents and behavior (Nosek et al., 2007). In fact, decision-making and choice may be considered as the result of two different cognitive processes: one that is conscious, slow and deliberative and one that is unconscious, rapid and automatic (Kahneman & Frederick, 2002). Therefore it seems plausible that food choices are the results of both these processes, and that the control over eating habits is not necessarily explicit (Cervellon et al., 2007). The study of eating behavior related to vegetable and meat consumption may represent an example of the discrepancy between declared and actual behavior, where it has been documented that consumers claimed they were vegetarians but then simultaneously acknowledged that they consumed animal flesh (Rothgerber, 2014). The use of both explicit and implicit measurements, such as the Implicit Association Test, may therefore be an effective approach with which to classify with higher reliability consumers' attitudes toward the vegetable category. This approach can be useful to create a model to investigate the variability in the implicit attitudes toward vegetables in relation to individual characteristics, such as psychological and personality traits, attitudes, beliefs and taste responsiveness measures.

2. AIM

The aim of this thesis was to explore the contribution of methodologies related to the process of categorization to study the preference of vegetable foods among different typologies of consumers. For this purpose methodologies based on prototype theory, real product sorting and implicit measures were considered.

In particular, the objectives of this research were the following:

Study I: To explore the representation of the plant-based dish category among consumers with a different level of familiarity toward vegetables, in order to investigate the relation between the typicality of dishes and dish features with expected liking.

Study II: To investigate the role of product familiarity, sensory dimension and hedonic dimension in affecting the categorization of samples within different age segments of the healthy elderly consumers.

Study III: To investigate the influence of psychological and personality traits, attitudes, beliefs and taste responsiveness on eating behavior of vegetarians, flexitarians and omnivores, assessed through implicitly measured attitudes toward plant-based and animal-based dishes.

3. MATERIALS AND METHODS

3.1 Study I: Categorization of plant-based dishes and implications for consumer preferences

3.1.1 Participants

A total of 123 consumers (females: 66.6%; age: mean = 31.2 years old, SD = 10.1, range = 20 – 67 years old) recruited by means of announcements published on blogs, social networks, emails, pamphlet distribution and word of mouth were involved in the study.

3.1.2 Selection of the pictures

A database of 80 pictures of plant-based dishes was created for this study following the guidelines of Blechert et al. (2014). Pictures of ready to eat dishes were selected by two researchers from open source databases in order to represent the variability of preparations of vegetables in the Italian food culture. To guide the selection, recognized and popular recipes books were consulted (d'Onofrio, 2011; Pedrotti & Pigozzi, 2015). The selection was carried out considering the variability of ingredients, the physical composition and the cooking mode. Only pictures where the food content of the dish was recognizable were considered. Pictures with the presence of meat, fish and dairy products were excluded. The selection included color photographs without symbols or texts and with a minimum resolution of 720 x 540 pixels (72 dpi, RGB format). In order to discard pictures too bright or too dark, only pictures with a grey-scale between 100.000 and 150.000 were considered. After the selection, each picture was modified, removing the surrounding tableware, in order to visualize only the dish content. The evaluation of physical properties of pictures was carried out with ImageJ software (Schneider et al., 2012). The collection of pictures of plant-based dishes resulted in a total of 16 recipe typologies: Boiled vegetables (n = 12), Burgers (n = 1), Couscous (n = 2), Fried vegetables (n = 4), Marinated vegetables (n = 2), Pasta (n = 7), Pizza (n = 1), Purées (n = 5), Rice (n = 6), Roasted vegetables (n = 5), Salads (n = 13), Sandwiches (n = 3), Soups (n = 9), Stewed vegetables (n = 9). A brief description of each picture is reported in Table 3.1.

3.1.3 Pictures evaluation by consumers

For each picture, consumers were asked to respond to the following sentences in this order:

1. Expected pleasantness of the dish (Expected liking), through the question: "How pleasant would it be to taste this dish?". The answer was provided with a 9-point scale (1 – Not at all pleasant; 9 - Extremely pleasant);
2. Healthiness of the dish (Healthiness), through the question: "How much do you think this dish is healthy?". The answer was provided with a 9-point category scale (1 – Not at all; 9 – Extremely healthy);
3. Level of preparation of the dish (Preparation level), through the question: "How much preparation do you think that this dish needs?". The answer was provided with a 9-point category scale (1 – Little preparation; 9 – A lot of preparation);
4. Typicality of the dish, measured as the extent to which it represented their idea or the category, through the question: "Indicate how much do you agree with the following sentence: this is a plant-based dish". The answer was provided with a 9-point Likert scale (1 – I strongly disagree; 9 – I strongly agree);
5. Family resemblance between the dishes in terms of expected sensory characteristics was evaluated through a Check-All-That-Apply questionnaire with 19 terms, presented randomly: 6 related to texture (Firm, Crunchy, Rubbery, Soft, Creamy, Watery), 4 related to taste (Sweet, Sour, Bitter, Salty), 5 related to visual aspects (Green, Yellow, Red, Orange, Brown, White), 2 related to flavor intensity (Tasty, Bland) and 1 related to trigeminal sensations (Pungent).

3.1.4 Consumers background

3.1.4.1 Socio-demographics

Consumers were asked to declare their own gender, age, height and weight. The Body Mass Index was computed for each respondent and the individual index was used to classify respondents (Underweight: <18.50 kg/m^2; Normal range: 18.50-24.99 kg/m^2; Overweight: 25.00-29.99 kg/m^2; Obese: ≥30.00 kg/m^2) (World Health Organization, 2000).

3.1.4.2 Familiarity with plant-based foods

A list of 16 vegetables, pulses and cereals (Broccoli, Artichokes, Chicory, Tomatoes, Radishes, Spinach, Zucchini, Cucumbers, Beetroots, Fennels, Asparagus, Chards, Beans, Peas, Sweet corn, Green beans) and 12 plant-based dishes (Grilled eggplant, Eggplant and parmesan cheese, Vegetable soup, Legume soup, Lettuce and valerian salad, Chicory and rocket salad, Cauliflower salad, Carrot salad, Soy sprouts salad, Vegetables crudité, Green olives, Breaded fried olives) was presented. Independently for each item, consumers were asked to indicate the level of familiarity through a 5-point category scale (1: ''I do not recognize the product'', 2: ''I recognize the product, but I have not tasted it'', 3: ''I have tasted it, but I do not consume the product'', 4: ''I occasionally eat the product'' and 5: ''I regularly eat the product) (Bäckström et al., 2004). An individual index was obtained as the sum of the rating to the twenty-eight items, with the score ranged from 28 to 140, with higher scores reflecting higher familiarity.

3.1.4.3 Food Neophobia Scale

The trait of food neophobia, defined as the reluctance to try and eat novel foods, was quantified using the Food Neophobia Scale (Pliner & Hobden, 1992). The individual score was computed as the sum of ratings given to the ten statements and ranged from 10 to 70, with higher scores reflecting higher food neophobia levels.

3.1.4.4 Health and Taste Attitudes Scale

The importance of health and pleasure on food choices was quantified using the Health and Taste Attitudes Scale (Roininen et al., 1999). The Health and Taste Attitudes Scale consists of six subscales: *General Health Interest*, *Light Product Interest*, *Natural Product Interest*, *Craving for Sweet Food*, *Using Food as Reward* and *Pleasure*. For each subscale, the individual score was obtained as the mean of ratings given to the items and ranged from 1 to 7, with higher scores reflecting more positive attitudes.

3.1.5 Procedure

The experimental procedure consisted of three steps carried out in a home test:

1. Q1: socio-demographics and familiarity: At the beginning of the test, Socio-demographics and "familiarity for vegetables" questionnaires were submitted to consumers in an online version. After the conclusion of this part, consumers were involved in the picture evaluation.

2. Q2 - Pictures evaluation: The pictures were evaluated by consumers with an online questionnaire and were provided in two blocks: block 1 (pictures from 1 to 40) and block 2 (pictures from 41 to 80). The order of presentation of blocks and pictures within each block was randomized among participants. Each picture was presented at the beginning of the page, followed by a list of questions (see § 3.1.3). The evaluation of expected pleasure was always provided before the evaluation of expected sensory properties (Meyners & Castura 2014). The attributes in the Check-All-That-Apply questionnaire were randomized among pictures and consumers. In order to facilitate the evaluation and avoid fatigue, consumers were allowed in each moment to register their progress in the questionnaires, to stop the evaluation and then restart it in a subsequent moment. During the whole test, consumers were asked to carry out the evaluation at least two hours after from the main meals of the day (breakfast, lunch, dinner).
3. Q3 – Attitudes and psychological traits: After the conclusion of pictures evaluation, Food Neophobia Scale and Health and Taste Attitudes Scale questionnaires were submitted to consumers in an online version.

3.1.6 Data analysis

3.1.6.1 Consumer segments identification and characterization (Familiarity with plant-based foods)

Three segments of consumers were obtained using a cut-off the 33° and 66° percentile computed on the overall distribution of the individual indexes of familiarity toward vegetables. Consumers with an index of familiarity below the 33° percentile were defined as the consumers with a relatively low level of familiarity (Lower familiarity segment), consumers with the index above the 66° percentile were defined as consumers with a relatively higher level of familiarity (Higher familiarity segment), while consumers with the index between the 33° and 66° percentile were defined as consumers with an intermediate level of familiarity (Intermediate familiarity segment). The effect of the consumer segments on age and psycho-attitudinal variables was tested using a 1-way ANOVA and LSD, while the effect of the segment on Body Mass Index was tested using Fisher's exact test.

3.1.6.2 Characterization of pictures

The effect of the picture on the typicality of the dish and the effect of the familiarity segment on the typicality of each single picture was tested using a 1-way ANOVA (Pictures) and LSD test.

The data produced with Check-All-That-Apply were treated as dichotomous responses (checked term = 1; unchecked term = 0) for each of the terms present in the Check-All-That-Apply ballot. The Cochran's Q test was computed on each attribute in order to identify attributes that do not significantly discriminate among pictures (Meyners & Castura, 2014). Significant attributes were considered for the creation of the overall cross tabulation matrix. Data were scaled and submitted to a Correspondence Analysis (Benzécri, 1973) in order to obtain a perceptive map. Expected liking, typicality, healthiness and preparation level variables were projected on the map as supplementary variables.

The correlation between expected liking, healthiness, preparation level and typicality variables was assessed through Pearson correlation coefficient independently for all the participants and for each segment. Regardless the typology of the recipe represented in the pictures, the influence of expected sensory attributes on typicality and expected liking was tested through a Penalty-lift analysis (Ares et al., 2014). If a rating for each product (e.g. liking; typicality, etc.) is collected along with the Check-All-That-Apply data, Penalty-lift analysis can be used to average the variable across all observations for which the attribute under consideration was elicited and across all observations for which it was not elicited. The difference between these two mean values is an estimate of how much the variable changes when an attribute applies compared to when it doesn't apply (impact). The outcome of Penalty-lift analysis is a score for each attribute, where positive scores represent an increase of the dependent variable due do the attribute and negative scores a decrease of the dependent variable due to the attribute. Data analysis was performed with R Statistics Package version 3.2.3 (R Core Team, 2015).

Table 3.1 Pictures of plant-based dishes selected for the study: picture code, recipe typology and brief description of dish content. (V = vegetables).

Picture code	*Recipe typology*	*Dish content*	*Picture code*	*Dish category*	*Dish content*
1	Soups	Soup with potatoes, carrots, peas and celery	21	Boiled V	Boiled chard, mushrooms and carrots
2	Salads	Salad of broccoli, chickpeas, carrots and valerian	22	Salads	Salad of carrots, zucchini and almonds
3	Purées	Peas pureed soup	23	Salads	Rocket salad with flowers
4	Stewed V	Stewed lentils, carrots and potatoes	24	Soups	Soup of carrots, potatoes and peas
5	Sandwiche s	Sandwich of salad, avocado, tomatoes and olives	25	Pasta	Rice pasta with snap peas
6	Stewed V	Stewed beans	26	Stewed V	Stewed zucchini, snap peas and carrots
7	Purées	Pumpkin pureed soup	27	Rice	Risotto with beans
8	Salads	Salad with tomatoes, beans, cucumbers, celery	28	Boiled V	Boiled potatoes and green beans
9	Boiled V	Boiled peas and carrots	29	Soups	Soup of beans, black cabbage and carrots
10	Couscous	Couscous with peas and carrots	30	Boiled V	Boiled carrots
11	Fried V	Fried potatoes	31	Salads	Salad with tomatoes and avocado
12	Boiled V	Boiled pumpkin	32	Pasta	Pasta with tomato sauce
13	Stewed V	Boiled Brussels sprouts	33	Stewed V	Stewed carrots
14	Soups	Soup of potatoes, tomatoes and carrots	34	Salads	Salad of soy sprouts, valerian, carrots and seeds
15	Purées	Tomato pureed soup	35	Boiled V	Boiled potatoes with fennel and celery
16	Salads	Salad of rocket, tomatoes, olives and yellow peppers	36	Soups	Soup with pasta, chickpeas and carrots
17	Sandwiche s	Tomato toast	37	Boiled V	Boiled broccoli and carrots
18	Salads	Salad of cucumbers, green peppers, carrots and salad	38	Stewed V	Stewed chard with seeds
19	Boiled V	Boiled black cabbage	39	Roasted V	Roasted zucchini and mushrooms
20	Soups	Soup of chickpeas, mushrooms, rice and cabbage	40	Roasted V	Grilled onions

Table 3.1 Continued

Picture code	*Recipe typology*	*Dish content*	*Picture code*	*Dish category*	*Dish content*
41	Roasted V	Roasted tomatoes	61	Stewed V	Boiled broad bean
42	Purées	Potatoes purée	62	Boiled V	Boiled asparagus
43	Marinated V	Marinated artichoke	63	Salads	Salad with chickpeas and radish
44	Salads	Salad with tomatoes, avocado, pepper and radish	64	Fried V	Chips of vegetables
45	Roasted V	Roasted eggplants with tomatoes	65	Pasta	Pasta with tomato and basil
46	Soups	Soup with spelt and beans	66	Burgers	Burgers of vegetables
47	Couscous	Couscous with red peppers and zucchini	67	Boiled V	Boiled asparagus, peas, celery and carrots
48	Soups	Broth of vegetables with roasted bread	68	Rice	Rice with soy sprouts, broccoli and cauliflowers
49	Soups	Soup of spelt and carrots	69	Rice	Risotto with zucchini
50	Boiled V	Boiled broccoli and red peppers	70	Salads	Salad of cucumbers, onion, olives and tomatoes
51	Boiled V	Boiled soy sprouts and zucchini	71	Rice	Risotto with mushrooms
52	Salads	Salad with tomatoes, carrots and radish	72	Rice	Risotto with peas
53	Stewed V	Stewed peas	73	Rice	Risotto with pumpkins
54	Stewed V	Stewed beetroot	74	Pasta	Pasta with pesto sauce
55	Sandwiches	Tomato toast	75	Pasta	Pasta with tomato and basil
56	Purées	Pumpkin pureed soup	76	Roasted V	Roasted potatoes
57	Pasta	Pasta with asparagus	77	Pasta	Gnocchi with tomato sauce
58	Salads	Salad with carrots and tomatoes	78	Fried V	Fried vegetables
59	Marinated V	Marinated mushrooms	79	Fried V	Fried zucchini flowers
60	Marinated V	Marinated olives	80	Pizza	Pizza with broccoli

3.2 Study II: Exploring salient dimensions in a free sorting task: a cross-country study within the elderly population

3.2.1 Products and samples

Pea and sweetcorn were selected as vegetable typologies because of their differential adoption in European food culture, where sweetcorn was introduced only in the second part of the 20th century while pea has been present for several centuries (Pelt, 1993). Canned versions of peas and sweetcorn were chosen because of their large availability in the markets of the countries involved in the study and because they represent a convenient way to promote vegetable intake (Kapica & Weiss, 2012). Ten canned pea (codes: A,B,D,E,F,J,L,O,P,Q) and eight canned sweetcorn (codes: H,R,S,T,U,V,W,Z) samples were considered for the study. The amount of each sample needed for the whole study was purchased from the producer company and from the same production batch, then delivered to the Institutions participating in the study. The samples were selected in order to cover as much as possible of the sensory spaces of peas and sweetcorn (i.e. diversity of size, texture, colour, flavour) and DA (Lawless & Heymann, 2010) was carried out in order to confirm and quantify the sensory variability of samples.

3.2.1.1 Sensory characterization of pea and sweetcorn samples by Descriptive Analysis

The evaluation of the samples was carried out with two panels trained at the Sensory Lab of Florence University. Twelve participants, 3 males and 9 females, mean age 29.8 years, were selected for the DA of the pea samples. Eleven participants, 4 males and 7 females, mean age 30.1 years, were selected for the DA of the sweetcorn samples. After sample familiarization and sensory descriptor elicitation, the calibration and performance evaluation of each panel was assessed in three sessions where four samples were presented. Data were analyzed using Panel Check software (ver 1.4.0, Nofima, Tromso, Norway). Panel calibration was assessed using the multi-block PCA (Tucker-1), while assessor performance was assessed using the p*MSE plot. (Næs et al., 2010). Having completed the training, and after performance validation, panels participated in three evaluation sessions. In each session, ten samples of peas or eight samples of sweetcorn were evaluated in two sub-sets. Samples (25 gr) were presented in a 100cc plastic cup identified by a 3-digit code. Samples presentation was balanced across participants. Pea samples were evaluated at 54-56°C, while sweetcorn samples were evaluated at room temperature. Evaluations were performed in individual booths under white light for appearance description and under red light for the rest of the attributes. Data were collected with the software Fizz (ver.2.47.B, Biosystemes, France). Sample differences for each attribute were assessed by a three way ANOVA mixed model using assessor and replicate as random factors, while sample was the fixed factor. Differences and similarities in sensory properties among samples were evaluated on a score plot and a correlation loading plot obtained from a Principal Component Analysis (PCA). PCA models were computed on panel averages of each significant sensory attribute ($p<0.05$) arising from the ANOVA models. Data were analyzed with the software Fizz (ver.2.47.B, Biosystemes, France). The ANOVA model computed on DA data for the pea samples showed a significant sample effect for 23 of the 26 attributes (Table 3.2). The first two components of the score plot for the pea samples obtained from PCA accounted for 86% of explained variance (Figure 3.1). Results from the ANOVA model computed on DA data for the sweetcorn samples showed a significant sample effect for 15 of the 19 attributes (Table 3.2). The first two components of the score plot for sweetcorn obtained from PCA accounted for 82% of explained variance (Figure 3.2). F and p-values in Table 3.2 confirmed that the size of differences between samples in each product set was comparable.

Table 3.2 Sensory attributes of peas and sweetcorn samples: F and p-values resulted from the three way ANOVA computed for each attributed on assessors scores.

	Peas			*Sweetcorn*		
	Attribute	F	p	Attribute	F	p
Appearance	Green	14.60	<0.001	Yellow	40.44	<0.001
	Color uniformity	5.66	<0.001	Seed size	17.40	<0.001
	Seed size	96.58	<0.001	Size uniformity	1.40	0.220
	Size uniformity	4.20	<0.001	Swollen	6.43	<0.001
	Swollen	21.95	<0.001	Damaged	11.67	<0.001
	Damaged	22.45	<0.001			
Aroma	o-Raw peas	1.73	0.092	o-Cooked vegetables	0.80	0.593
	o-Cooked peas	4.15	<0.001	o-Acrid	1.75	0.115
	o-Cooked vegetables	3.98	<0.001			
	o-Acrid	1.68	0.105			
	o-Metallic	2.99	0.005			
	o-Onion	3.96	<0.001			
Flavor	f-Raw peas	1.20	0.306	f-Sweet corn	24.25	<0.001
	f-Cooked peas	13.95	<0.001	f-Cooked vegetables	1.44	0.2084
	f-Cooked vegetables	14.33	<0.001	f-Acrid	4.13	<0.001
	f-Acrid	2.32	0.021	Sweet	20.47	<0.001
	f-Metallic	7.40	<0.001	Salty	10.24	<0.001
	f-Onion	6.69	<0.001	Sour	7.68	<0.001
	Sweet	9.16	<0.001	Bitter	7.49	<0.001
	Bitter	5.55	<0.001	Astringent	2.73	0.018
	Sour	5.40	<0.001			
	Umami	10.46	<0.001			
	Salty	14.55	<0.001			
Texture	Skin hardness	8.16	<0.001	Skin hardness	7.08	<0.001
	Softness	19.22	<0.001	Softness	13.52	<0.001
	Melty	10.57	<0.001	Crunchiness	24.95	<0.001
				Thickness	8.25	<0.001

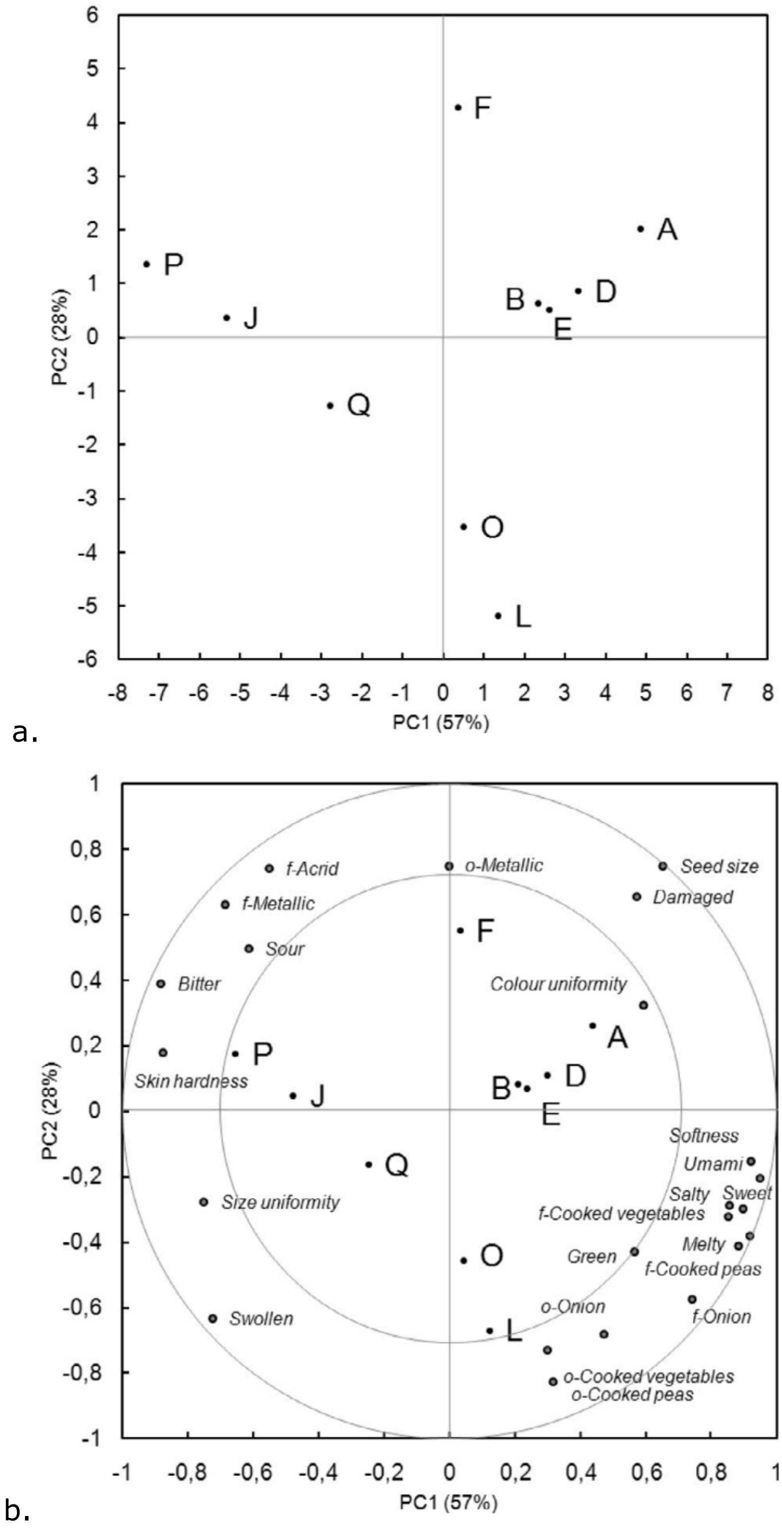
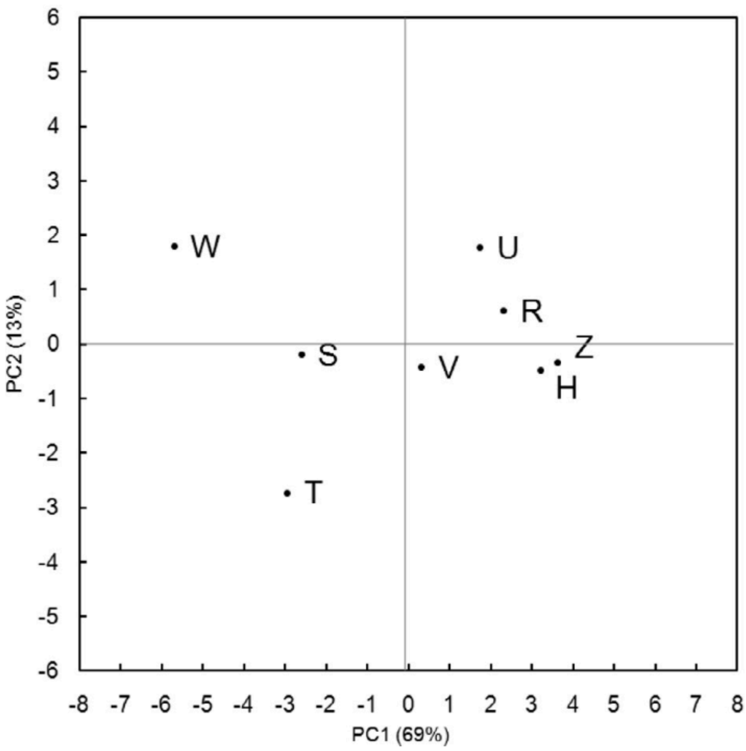
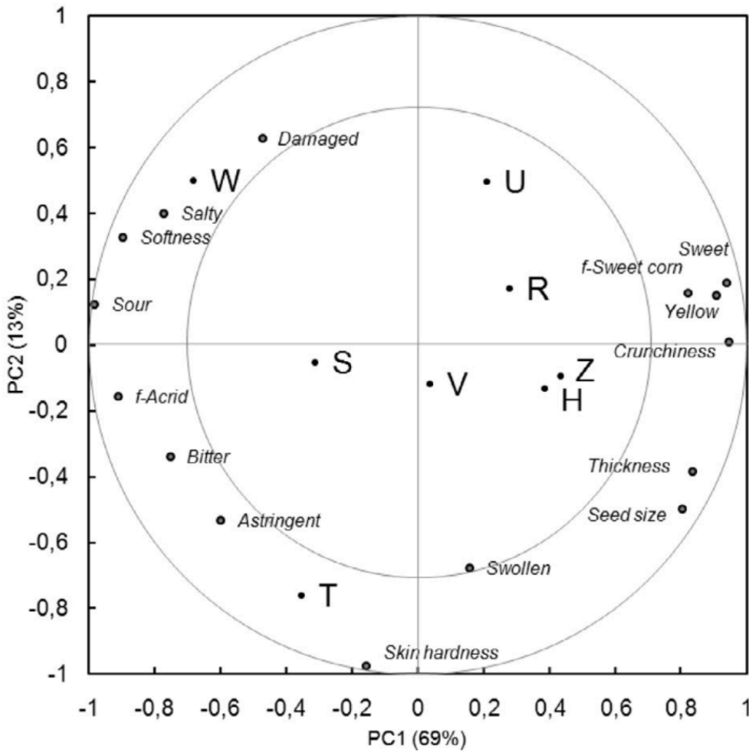


Figure 3.1 Sensory maps: Score plot (a) and correlation loading plot (b) from PCA on panel averages of each significant attribute ($p<0.05$) describing the sensory properties of pea samples. In the correlation loading plot outer and inner circles on the map represent 100% and 50% explained variance respectively.



a.



b.

Figure 3.2 Sensory maps: Score plot (a) and correlation loading plot (b) from PCA on panel averages of each significant attribute ($p<0.05$) describing the sensory properties of sweetcorn samples. In the correlation loading plot outer and inner circles on the map represent 100% and 50% explained variance respectively.

3.2.2 Samples evaluation by consumers

3.2.2.1 Participants

Elderly people were recruited at elderly care institutions and leisure facilities for the elderly in Florence (Italy, IT) and Lille (France, FR). The age of subjects covered different age segments of the elderly population (Forman et al., 1992), with a segment aged from 65 to 69 years (Young old) and a segment aged from 70 to 79 years (Middle old). Demographic details of the participants as a function of country and age segment are reported in Table 3.3.

All elderly participants had no medical conditions and were able to independently perform the test. Participants aged from 18 to 64 years (Adults) were also recruited in the Florence area as control segment, respectively for the evaluation of the pea samples (34 females, 21 males, mean age 28.0 years) and sweetcorn samples (38 females, 21 males, mean age 36.3 years). Appropriate health and safety considerations, together with a risk assessment protocol, were carried out prior to the commencement of the research. Individual written informed consent was obtained from participants.

Table 3.3 Characteristics of the elderly respondents per product: country, demographics and total number per age segment and country. Values in brackets represent standard deviations.

	Peas					*Sweetcorn*				
	Country		Total	Females	Mean age	Country		Total	Females	Mean age
	France	Italy				France	Italy			
Young old	78	42	120	65.8%	65.7 (2.0)	41	41	82	68.3%	65.9 (1.9)
Middle old	18	28	46	63.8%	72.8 (2.9)	38	28	66	81.8%	73.7 (3.0)
Total	96	70	166	65.1%	67.7 (3.9)	79	69	148	74.0%	69.4 (4.6)
Females	65.7%	61.4%				78.4%	69.5%			
Mean age	67.7 (3.0)	68.7 (4.8)				69.9 (2.7)	69.2 (4.9)			

3.2.2.2 Experimental procedure

Pea and sweetcorn samples were evaluated in two independent sessions. The experiment took place in public spaces such as canteens or common rooms. Tests were conducted individually and social interaction was not allowed. The experimental procedure consisted of three steps: 1. Liking test, 2. Collection of questionnaire data, 3. Sorting task.

Liking test: Participants were provided with individual trays with 11 or 9 three-digit coded pea or sweetcorn samples (10 pea samples plus a replicate; eight sweetcorn samples plus a replicate). Twenty-five grams of product were used for each sample. Peas were presented at 54-56 °C in a foam cup sealed with a plastic top. Sweetcorn samples were presented in a plastic cup at room temperature. Presentation order was randomized across participants. Participants were asked to look at the appearance, and to smell and taste a teaspoon of each sample, then they were asked to rate their liking on a horizontal 9-point category scale (Right label: dislike extremely; central label: neither dislike nor like; left label: like extremely). Participants were asked to rinse their mouth with water before starting the evaluation and after each sample.

Questionnaire: After completing the liking task, participants filled in a questionnaire consisting of two sections: 1. Demographic characteristics (age, gender); 2. Familiarity with pea and sweetcorn products on a 5 point category scale (1: ''I do not recognize the product'', 2: ''I recognize the product, but I have not tasted it'', 3: ''I have tasted, but I do not use the product'', 4: ''I occasionally eat the product'' and 5: ''I regularly eat the product) (Bäckström et al., 2004). In this scale, scores increase from lexical/visual knowledge (scores 1 and 2), to a taste experience not associated with consumption (score 3) and to frequency of consumption (scores 4 and 5).

Sorting task: In the last part of the session, subjects were provided with a new tray with 11 or 9 three-digit coded pea or sweetcorn samples (ten pea samples plus a replicate; eight sweetcorn samples plus a replicate). Subjects were asked to observe, smell and taste the samples and then to group them according to their similarities, using their own criteria. Subjects were allowed to taste each sample more than once and were asked to note their groupings, and the characteristics of each group, individually. Subjects were asked to rinse their mouth with water before starting evaluation and after each sample.

3.2.3 Data analysis

3.2.3.1 Liking data

Liking data obtained from each product were submitted to a PCA in order to obtain an internal preference map (IPM) for each country and each age segment of participants. Cross-validation (Martens and Martens, 2000) was used to estimate the number of statistically reliable principal components. As suggested by Lawless & Heymann (2010) a simple way to check the reliability of a perceptual map is to consider the closeness of blind duplicate samples. These authors specifically suggested this approach to check the reliability of sorting configurations. Considering the several influences on the use of liking rating scale in elderly (Methven et al. 2016), in the present paper the distance between duplicated sample was used to check the internal reliability of internal preference maps computed on liking for pea and sweetcorn samples. In particular here the reciprocal of the percentage ratio of distance (Dr%) was computed. The calculation of Dr% is based on the ratio between the distance of the two replicated samples and the distance of the two most distant samples on the map (Torri et al., 2013).

3.2.3.2 Questionnaire

The comparison of the familiarity between pea and sweetcorn inside each country was assessed using Wilcoxon rank sum test on scores from the familiarity category scale within each age segment and in total. The comparison of the familiarity with pea and sweetcorn between countries was assessed using Chi-square test on frequencies of each category of the familiarity scale for each age segment and in total.

3.2.3.3 Sorting data

For each subject a distance matrix was generated, where a value of 0 between a row and a column indicates that the assessor put the samples together, whereas a value of 1 indicates that samples were not put together. Individual distance matrices were submitted to DISTATIS (Abdi et al., 2007), a generalization of classical multidimensional scaling that considers individual sorting data. DISTATIS was computed for each country and each age segment, in order to obtain a spatial representation of product similarity in which products are represented by points on a map. The points are arranged in this representation so that the distances between pairs of points reflect the similarities among the pairs of stimuli. The adoption of DISTATIS also allowed consideration of the individual variability in the process of categorization, in this way providing a spatial representation less influenced by assessors that behave differently from others. The internal reliability of the obtained maps was assessed considering the reciprocal of the Dr%. In order to identify groups of samples in each FST configuration, a hierarchical cluster analysis with Ward's criterion was performed on samples coordinates on the first two components (Lelièvre et al., 2009).

3.2.3.4 Maps comparison

The similarity of the first two dimensions of the maps was assessed considering the RV coefficient (Robert & Escoufier, 1976). The RV coefficient is a measure of the similarity between two factorial configurations, which takes the value of 0 if the configurations are uncorrelated, and the value of 1 if the configurations are homothetic. The minimum RV value that has been considered as an indicator of good agreement between sample configurations ranges from 0.65 to 0.85 (Vidal et al., 2014), therefore a cut-off of 0.75 was considered for this study. With respect to each vegetable, the RV coefficient and its statistical significance was computed for all combinations between the compromise maps from DISTATIS on FST data (categorization maps), the score plots from PCA on DA data (sensory maps) and the score plots from PCA on liking data (preference maps), within each country and age segment. Considering that RV coefficients put particular emphasis on the component with the largest variance, the similarity between maps was assessed also considering a visual evaluation of the configurations as suggested in Tomic et al. (2015).

All analyses on consumer data were conducted with the R Statistics Package version 3.2.1 (R Core Team, 2015) using the FactoMineR package (Le et al., 2008) and the DistatisR package (Beaton et al., 2013).

3.3 Study III: The influence of psychological traits, beliefs and taste responsiveness on implicit attitudes toward plant- and animal-based dishes among vegetarians, flexitarians and omnivores

3.3.1 Subjects

A total of 125 subjects (females: 72.8%; mean age: 28.6 years old) were recruited in the Florence area (Italy) by means of announcements published on blogs, social networks, emails, pamphlet distribution and word of mouth. The recruitment aimed to cover a wide range of dietary variability for the consumption of animal products, from omnivores to vegetarians. For this reason, part of the recruitment was specifically conducted in social environments attended by vegetarians (vegetarian no profit societies and clubs, restaurants and shops).

3.3.2 Experimental procedure

At the time of recruitment, respondents were given general information about the study aims and individual written informed consent was obtained from participants. In the days preceding the sensory lab session, respondents were asked to complete at home an online questionnaire aimed at collecting data about demographic, social characteristics and general eating habits. In the sensory lab session, participants were introduced to the general organization of the day, which included three IAT measures and the measurement of PROP responsiveness. Tests were conducted individually and social interaction between participants was not allowed. Designated breaks (5 min) between tests were observed. After the sensory lab session, participants were asked to complete at home an online questionnaire aimed at measuring a number of variables on demographics, psychological and personality traits, food attitudes and beliefs on food animals (Table 3.4).

3.3.3 Questionnaires

3.3.3.1 Socio-demographics and eating habits

Respondents were asked to declare their own gender, age, height, weight, educational level (Lower secondary school; Upper secondary school; Degree; Post-degree), and the monthly expense for food (Up to 200€; From 201 to 400€; From 401 to 600€; More than 600€). A Body Mass Index (BMI) was computed for each respondent and the individual index was used to classify respondents according to the World Health

Organization criteria (Underweight: <18.50 kg/m^2; Normal range: 18.50-24.99 kg/m^2; Overweight: 25.00-29.99 kg/m^2; Obese: ≥30.00 kg/m^2).

Respondents were asked to indicate which statement best represented their own eating habits out of list of nine alternatives (De Backer & Hudders, 2015): 1 - I regularly eat red meat, fish and chicken; 2 – I consciously reduce meat intake, but eating meat now and then; 3 - I don't eat red meat, but I eat fish, chicken and other poultry; 4 – I don't eat red meat nor chicken, but I eat fish and shellfish; 5 – I eat organic and locally grown foods, with a great overlap with foods consumed in a vegetarian diet, yet also including certain kinds of meat; 6 – I don't eat meat or fish, but I eat eggs and dairy products; 7 – I don't eat meat, fish or eggs, but I eat dairy products; 8 - I don't eat meat, fish or dairy products, but I eat eggs; 9 – I don't eat meat and I don't use products of animal origin. Responses to these statements were then grouped into three categories according to published criteria (Dagevos, 2016; De Backer & Hudders, 2015): 1. Omnivores (statement 1), defined as those who do not follow any limitation concerning the consumption of meat and fish; 2. Flexitarians (2, 3, 4 and 5), defined as those who consciously consume a limited quantity of either all types or specific types of meat; 3) Vegetarians (6, 7, 8, and 9), defined as people who totally limit the consumption of meat and fish.

3.3.3.2 Psychological and personality traits

Food neophobia scale

The trait of food neophobia, defined as the reluctance to try and eat novel foods, was quantified using the Italian version of the Food Neophobia Scale (FNS) (Pliner & Hobden, 1992; Laureati et al, submitted). The individual scores were computed as the sum of ratings given to the ten statements and ranged from 10 to 70, with higher scores reflecting higher food neophobia levels.

Interpersonal Reactivity Index

In order to explain the psychological bases behind the development of cognitive dissonance toward animal-based foods we measured the empathic responsiveness, defined as the capacity to understand or feel what another person is experiencing. Empathic responsiveness was assessed using the Italian version of the Interpersonal Reactivity Index (IRI) (Albiero et al., 2006; Davis, 1980). The IRI consists of four subscales, each of which reflects a separate aspect of the global concept of "empathy": *Fantasy* (F), defined as the tendency to identify strongly with fictitious characters; *Perspective Taking* (PT), defined as the ability to adopt the perspective, or point of view, of other people; *Empathic Concern* (EC), defined as the tendency to experience compassion and concern for others undergoing negative experiences; and *Personal Distress* (PD), which indicated that the respondent experienced feelings of discomfort and anxiety when witnessing the negative experiences of others. The individual score for each subscale was obtained as the mean of ratings given to the items and ranged from 1 to 5, with higher scores reflecting higher responsiveness.

Three-Domain Disgust Scale

Disgust was assessed using two domains of the Three-Domain Disgust Scale (TDDS) (Tybur et al., 2009). The TDDS used in the study consisted of two subscales, each of which reflects a separate aspect of the global concept of "disgust": *Pathogen Disgust (*PD), defined as the tendency to experience disgust for objects that may contain infectious agents; and *Moral Disgust* (MD), defined as the tendency to experience disgust for social transgressions and antisocial activities. The individual score for each subscale was obtained as the mean of ratings given to the items and ranged from 1 to 7, with higher scores reflecting higher disgust.

3.3.3.3 Attitudes toward foods

Health and Taste Attitudes Scale

The importance of health and pleasure on food choices was quantified using the Health and Taste Attitudes Scale (HTA) (Roininen et al., 1999). The HTA consists of six subscales: *General Health Interest* (GHI), *Light Product Interest* (LPI), *Natural Product Interest* (NPI), *Craving for Sweet Food* (CSF), *Using Food as Reward* (FR) and *Pleasure* (P). The individual score for each subscale was obtained as the mean of ratings given to the items and ranged from 1 to 7, with higher scores reflecting more positive attitudes.

Food Involvement

Food Involvement, defined as the level of importance of food in a person's life, was measured using the Food Involvement Scale (FIS) (Bell & Marshall, 2003). The FIS consists of two subscales: *Set and Disposal* (SD) and *Preparation and Eating* (PE). The individual score for each subscale was computed as the sum of ratings given to the statements (SD range: 3-21; PE range: 9-63), with higher scores reflecting higher involvement levels.

3.3.3.4 Beliefs on food animals

Human-animal emotional and mental capacity similarity

To assess the extent to which participants believed food animals share emotional states similar to humans, a scale (HAES) was adapted from Bilewicz et al. (2011). Participants were asked to indicate the extent to which they thought a food animal (swine) might experience six primary emotions (rage, surprise, pain, fear, happiness, pleasure) and six secondary emotions (shame, hope, melancholy, love, guilt, tenderness). To assess the extent to which participants thought food animals possessed certain mental capacities, a scale (HAMCS) was adapted from Bastian et al. (2012). Participants were asked to indicate the extent to which they thought a food animal (swine) possessed eight mental capacities (self-control, morality, memory, emotion recognition, planning, communication, thought). The individual score for, respectively, HAES and HAMCS was obtained mediating the items of each scale in order to obtain a score ranging from 1 to 5, with higher scores reflecting higher similarity between human and food animals.

Meat eating justification questionnaire

The extent to which participants justified meat consumption was measured using the Meat-eating Justification scale (MEJ) (Rothgerber, 2013). The MEJ consists of nine subscales, each of which taps a separate strategy for justifying eating meat: *Pro-Meat Attitude* (PMA), *Denial* (D), *Hierarchical Justification* (HIJ), *Dichotomization* (DIC), *Dissociation* (DIS), *Religious Justification* (RJ), *Avoidance* (A), *Health Justification* (HEJ), *Human Destiny/fate Justification* (HDJ). The individual score for each subscale was obtained as the mean of ratings given to the items and ranged from 1 to 7, with higher scores reflecting higher justification of meat consumption.

Table 3.4 Psychological and personality traits, food attitudes and beliefs on food animal measurements: questionnaires and their relative acronym, items and domains, rating scale and references.

Questionnaire	Items/Domains	Scale	Sample items
Food Neophobia Scale (FNS) (Pliner & Hobden, 1992)	10 items	7 point Likert scale (1=disagree strongly; 7=agree strongly)	‶I don't trust new foods″; ‶I will eat almost everything".
Interpersonal Reactivity Index (IRI) (Davis, 1980)	28 items, 4 domains: - Fantasy (F) - Perspective Taking (PT) - Empathic Concern (EC) - Personal Distress (PD)	5 point Likert scale (1=never true; 5=always true)	‶I try to look at everybody's side of a disagreement before I make a decision"; "I am often quite touched by things that I see happen".
Three-Domain Disgust Scale (TDDS) (Tybur et al., 2009)	14 items, 2 domains: - Pathogen Disgust (PD) - Moral Disgust (MD)	7 point Likert scale (1=not at all disgusting; 7=extremely disgusting)	"Accidentally touching a person's bloody cut"; "Stealing from a neighbor"
Health and Taste Attitudes Scale (HTA) (Roininen et al., 1999)	38 items, 6 domains: - General Health Interest (GHI) - Light Products Interest (LPI) - Natural Products Interest (NPI) - Craving for Sweet Foods (CSF) - Food as a Reward (FR) - Pleasure (P)	7 point Likert scale (1=disagree strongly; 7=agree strongly)	‶I would like to eat only organically grown vegetable"; "I reward myself by buying something really tasty".
Food Involvement Scale (FIS) (Bell & Marshall, 2003)	12 items, 2 domains: - Set and Disposal (SD) - Preparation and Eating (PE)	7 point Likert scale (1=disagree strongly; 7=agree strongly)	‶Talking about what I ate or am going to eat is something I like to do″; ‶I do most or all of my own food shopping".
Human-animal emotions similarity (HAES) (Bilewicz et al., 2011)	12 items	5 point Likert scale (1 = highly unlikely; 5 = highly likely)	
Human-animal mental capacity similarity (HAMCS) (Bastian et al., 2012)	7 items	5 point Likert scale (1 = definitely does not possess; 5 =definitely does possess)	
Meat Eating Justification (MEJ) (Rothgerber, 2013)	27 items, 9 domains: - Pro-meat attitude (PMA) - Denial (D) - Hierarchical justification (HIJ) - Dichotomization (DIC) - Dissociation (DIS) - Religious justification (RJ) - Avoidance (A) - Health justification (HEJ), - Human destiny justification (HDJ)	7 point Likert scale (1=disagree strongly; 7=agree strongly)	"Meat is essential for strong muscles"; "Animals do not feel pain the way humans do".

3.3.4 PROP responsiveness

A 3.2mM PROP solution was prepared by dissolving 0.5447 g/L of 6-n-propyl-2-thiouracil (European Pharmacopoeia Reference Standard, Sigma Aldrich, Milano, IT) into deionized water (Prescott et al., 2000). Subjects were presented with two identical samples (10 ml) coded with a three-digit code. Subjects were instructed to hold each sample (10 ml) in their mouth for 10 s, then expectorate, wait 20 s and evaluate the intensity of bitterness using the General Labelled Magnitude Scales (gLMS). Between evaluation of samples, subjects rinsed their mouth with water for 60 seconds. Individual PROP intensity scores were determined using the mean intensity rating across samples, with higher scores reflecting higher responsiveness. Individual PROP taster status was obtained with the arbitrary cut-offs used in previous studies to categorize subjects in PROP non-taster (gLMS score ≤ 17), PROP medium-taster (17 < gLMS score < 53) and PROP super-taster (gLMS ≥ 53) (Fischer et al., 2013; Hayes et al., 2010).

3.3.5 Implicit Association Test

3.3.5.1 Procedure

Subjects completed three independent seven-block IATs, designed to measure relative associative strength of three concept pairs: Vegetable and Meat (VM-IAT), Vegetable and Dairy (VD-IAT), and Meat and Dairy (MD-IAT). Ten pictures of dishes (culinary preparations) were used to represent each of the target concepts. Each picture was validated in an independent study (see § 3.3.5.2). All IATs used positive and negative emotions as attributes, represented by eight words each for the positive emotion (happiness, cheerfulness, enthusiasm, relaxation, satisfaction, joy, pleasure, amusement) and negative emotions (disgust, distress, boredom, annoyance, sadness, dissatisfaction, disappointment, shame) categories. The number of trials in each IAT block was identical for the three IATs: 20 in Blocks 1 (practice on target discrimination), 16 in Block 2 (practice on attribute discrimination), 20 in Block 3 (practice of first combined-task), 36 in Block 4 (test of first combined-task), 40 in Block 5 (practice on reversed target discrimination), 20 in Block 6 (practice of second combined-task), and 36 in Block 7 (test of second combined-task blocks). The task sequence and response keys assignment of the three IATs is reported in Table 3.5. The additional trials in Block 5 were included to reduce the order effect of the two combined-task conditions, as suggested by Nosek et al. (2007). Concept and attribute trials were alternated on combined-task blocks and respondents were not asked to correct errors. In order to study individual variability, the order of the combined-task blocks within each IAT was not counterbalanced such that within each IAT the order of blocks was done with a fixed order across subjects, as described by Schnabel et al. (2007). The presentation order of the three IATs and the images presented in each IAT were randomized among participants.

3.3.5.2 Selection of the images for the IAT

The stimulus items for the target concepts for each IAT were selected from a pictures database created for this study following the guidelines of Blechert et al. (2014). The database included 80 pictures of plant-based dishes, 80 pictures of meat-based dishes and 80 pictures of dairy-based dishes. Pictures were selected by two operators from open source databases in order to represent the variability of preparations of the Italian food culture, taking into consideration ingredients and cooking mode. Only pictures where the food content of the dish was fully visible were considered. The selection included color photographs without symbols or texts and with a minimum resolution of 720 x 540 pixels.

Picture assessment by consumers

A total of 123 consumers different from those involved in the main study (females: 66.6%; vegetarians: 4.4%; mean age: 31.4 years old) evaluated each picture included in the database through an on-line questionnaire. The order of presentation of blocks and pictures within each block was randomized among participants. Within each block, only pictures of a specific kind of dish category were presented (plant-based, meat-based or dairy-based). Independently for each picture, subjects were asked to answer to the following sentences:

1. How pleasant would it be to taste this dish? (1 – Not at all pleasant; 9 - Extremely pleasant);
2. How pleasant is the appearance of this dish? (1 – Extremely unpleasant; 9 – Extremely pleasant);
3. How much preparation do you think that this dish needs? (1 – Little preparation; 9 – A lot of preparation);
4. Indicate your level of agreement with the following sentence: this is a plant-based (or meat-based, or dairy-based) dish. (1 – I strongly disagree; 9 – I strongly agree).

Table 3.5 Task sequence and response key assignment of the three Implicit Association Test measures: VM-IAT, VD-IAT and DM-IAT.

VM-IAT

Block	*No. Trials*	*Task*	Response key assignment	
			Left key	*Right key*
1	20	Practice target	Vegetables	Meat
2	16	Practice attribute	Positive emotions	Negative emotions
3	20	Practice combined-task	Vegetables, Positive emotions	Meat, Negative emotions
4	36	Test combined-task	Vegetables, Positive emotions	Meat, Negative emotions
5	40	Practice on reversed target	Meat	Vegetables
6	20	Practice combined-task	Meat, Positive emotions	Vegetables, Negative emotions
7	36	Test combined-task	Meat, Positive emotions	Vegetables, Negative emotions

VD-IAT

Block	*No. Trials*	*Task*	Response key assignment	
			Left key	*Right key*
1	20	Practice target	Vegetables	Dairy
2	16	Practice attribute	Positive emotions	Negative emotions
3	20	Practice combined-task	Vegetables, Positive emotions	Dairy, Negative emotions
4	36	Test combined-task	Vegetables, Positive emotions	Dairy, Negative emotions
5	40	Practice on reversed target	Dairy	Vegetables
6	20	Practice combined-task	Dairy, Positive emotions	Vegetables, Negative emotions
7	36	Test combined-task	Dairy, Positive emotions	Vegetables, Negative emotions

DM-IAT

Block	*No. Trials*	*Task*	Response key assignment	
			Left key	*Right key*
1	20	Practice target	Dairy	Meat
2	16	Practice attribute	Positive emotions	Negative emotions
3	20	Practice combined-task	Dairy, Positive emotions	Meat, Negative emotions
4	36	Test combined-task	Dairy, Positive emotions	Meat, Negative emotions
5	40	Practice on reversed target	Meat	Dairy
6	20	Practice combined-task	Meat, Positive emotions	Dairy, Negative emotions
7	36	Test combined-task	Meat, Positive emotions	Dairy, Negative emotions

Table 3.6 Characterization of the pictures referred to the target concepts in the three Implicit Association Test measures: mean values for VM-IAT, VD-IAT and DM-IAT.

	VM-IAT			VD-IAT			DM-IAT		
	Concepts		*p value*	*Concepts*		*p value*	*Concepts*		*p value*
	Vegetables	Meat		Vegetables	Dairy		Dairy	Meat	
Q1	6.1	6.3	0.135	6.3	6.5	0.248	6.3	6.3	0.822
Q2	6.0	6.4	0.204	6.1	6.2	0.734	6.2	6.4	0.279
Q3	4.2	4.4	0.741	4.2	2.8	0.012	3.3	4.2	0.057
Q4	8.4	8.4	0.893	8.4	8.3	0.166	8.3	8.4	0.591

Q1: How pleasant would it be to taste the dish?
Q2: How pleasant is the appearance of this dish?
Q3: How much preparation do you think that this dish needs?
Q4: Indicate your level of agreement with the following sentence: this is a plant-based (or meat-based, or dairy-based) dish.

Stimulus selection and target concept validation

A sub-database of pictures to be used as stimulus in the three IAT paradigms was created, selecting pictures that were highly typical of the category of the dish category (Typicality mean score ≥ 8) and that were accepted (Hedonic liking mean score ≥ 5; Visual liking mean score ≥ 5). The images included in the sub-database were assigned in a randomized way to the target categories used in the three IAT measures, for a total of 20 pictures of plant-based dishes (10 for VM-IAT and 10 for VD-IAT), 20 pictures of meat-based dishes (10 for VM-IAT and 10 for MD-IAT), 20 pictures of dairy-based dishes (10 for VD-IAT and 10 for DM-IAT). The pictures selected for each IAT are reported in the Appendix (Figures 3.3, 3.4, and 3.5). The randomized assignation was carried out with the aim of ensuring that the pictures assigned to the two target categories within each IAT resulted non significantly different for hedonic liking, visual liking, preparation level and typicality. The characterization of the pictures used in the three IATs is reported in Table 3.6.

3.3.6 Data analysis

3.3.6.1 Questionnaires

Associations between the declared eating habits and, respectively, gender, age, BMI groups, educational level, monthly expense for food, and PROP status was tested using Chi-square tests. The reliability of subscales of each questionnaire was assessed with Cronbach's alpha.

3.3.6.2 Implicit Association Test

Response latencies from the three IATs were submitted to the D600 algorithm (Schnabel et al., 2007) in order to obtain an individual D-score for each IAT, for a total of three D-scores for each participant. The D-score represents the difference in reaction time between first (block 3 and 4) and second (block 6 and 7) combined-tasks, as a function of the standard deviation of the distribution. D-scores were computed with the R Statistics Package "IAT" version 0.3 following the procedure reported in Nosek et al. (2007). D-scores between -0.15 and 0.15 were considered as arbitraty cut-offs to represent the condition of no differences in association between first and second combined-task (Whitaker et al*.,* 2016), with D-scores below -0.15 indicating a stronger association between concepts in first combined-task compared to second, and a D-scores above 0.15 indicating a stronger association between concepts in second combined-task compared to first. The effect of declared eating habits on psychological and personality traits, attitudes toward foods, beliefs on food animals, taste responsiveness, D-scores and response latencies within each IAT block was tested using a 1-way ANOVA (Eating habit group) and post-hoc Least Significant Difference (LSD) tests. D-scores and univariate data analysis was performed with R Statistics Package version 3.2.3 (R Core Team, 2015).

3.3.6.3 Partial least square regression model

A preliminary Partial Least Square (PLS) regression model was computed considering the D-scores from VM-IAT (Y) and 18 explanatory variables (X). In particular, we considered the following X variable blocks: seven domains related to psychological traits (FNS; IRI: F, PT, EC, PD; TDDS: PD, MD); eight domains related to attitudes toward foods (FIS: SD, PE; HTA: GHI, LPI, NPI, CSF, FR, P); two domains related to beliefs on food animals (HAES, HAMC); PROP responsiveness. The Uncertainty test was used to estimate the significant X variables for each component of the model while Cross-validation was used to estimate the number of statistically reliable principal components. A final PLS regression model was computed assuming the D-scores from VM-IAT as response variables (Y) and the significant variables from the preliminary PLS regression model as explanatory variables (X). Not significant variables from the preliminary PLS regression model were considered as down-weighted X variables. Uncertainty test was used to estimate the significant X variables for each component of the model while Cross-validation was used to estimate the number of statistically reliable principal components. In both cases, the PLS regression models were computed on standardized variables in order to have unit variance and D-scores from VD-IAT and DM-IAT were considered as down-weighted Y variables. Multivariate data analysis was performed with the software Unscrambler version 10.3 (Camo Software, Norway).

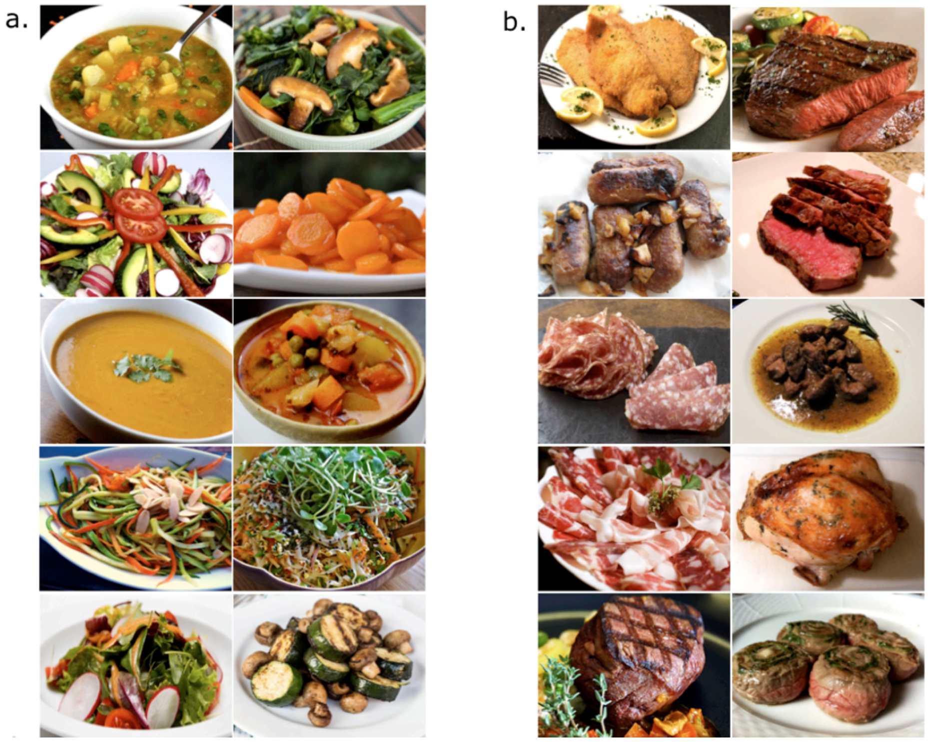


Figure 3.3 Stimuli used in the VM-IAT for the plant-based dish category (a) and the meat-based dish category (b).

Figure 3.4 Stimuli used in the VD-IAT for the plant-based dish category (a) and the dairy-based dish category (b).

Figure 3.5 Stimuli used in the DM-IAT for the dairy-based dish category (a) and the meat-based dish category (b).

4. RESULTS

4.1 Study I: Categorization of plant-based dishes and its implications for consumer preferences

4.1.1 Segments characterization

Socio-demographic and psycho-attitudinal variables for consumers with a relatively lower, higher and with an intermediate level of familiarity are reported in Table 4.1.

4.1.1.1 Socio-demographics

The three segments were formed by young respondents and did not differ according to age, while a higher presence of females in the Higher familiarity segment compared to the Lower familiarity segment was reported. Normal range consumers mainly characterized the three segments and no significant difference of Body Mass Index distributions was found. Despite the relative differences in familiarity, the three segments shared a good level familiarity toward vegetables foods. In fact, in the Lower familiarity and the Intermediate familiarity segments the overall mode on familiarity scores for the listed vegetables was 4 (I occasionally eat the product), while in the Higher familiarity segment the mode was 5 (I regularly eat the product).

4.1.1.2 Questionnaires: Food Neophobia Scale and Health and Taste Attitude Scale

The Food Neophobia Scale was shown to be highly internally consistent, with an alpha of 0.86. The three segments were characterized by a low neophobia score and did not significantly differ for the mean Food Neophobia Scale score ($F = 1.27$; $p = 0.266$), suggesting a similar attitude toward the consumption of novel foods.

Light Product Interest, *Craving for Sweet Food* and *Using Food as Reward* domains were shown to be highly internally consistent, with an alpha of 0.86, 0.90, and 0.85 respectively. *General Health Interest* and *Natural Product Interest* domains resulted in an acceptable internal consistence, with an alpha of 0.68 and 0.69 respectively. The *Pleasure* domain resulted in a low internal consistence (alpha = 0.30) and for this reason it was not further considered in the study. Overall the three segments showed positive attitudes toward healthy food consumption, with the exception of *Light Product Interest* domain. The Intermediate familiarity and the Higher familiarity segments were characterized by higher scores in *General Health Interest* compared to the Lower familiarity segment ($F = 15.31$; $p < 0.001$). A significant effect was detected also for the *Natural Product Interest* domain (F = 25.52; p < 0.001), with a higher interest for the Higher familiarity segment compared to the Intermediate familiarity and Lower familiarity segment. A tendency was found for the *Light Product Interest* domain (F = 7.12; p =0.050), with a higher interest for the Lower Familiarity segment compared to the Intermediate familiarity and the Higher familiarity segment. Regarding the role of taste on food choices, in general the three segments showed a tendency to positive attitudes toward tasty food consumption with no significant differences between segments (*Craving for Sweet Foods, Using Food as Reward*).

Table 4.1 Socio-demographic and psycho-attitudinal variables for Lower familiarity (LF), Intermediate familiarity (IF) and Higher familiarity (HF) segments. Mean values followed by different letters are significantly different (p < 0.05).

	Cluster			*p-value*
	LF (n=41)	IF (n=31)	HF (n=49)	
Age (years)	29.4	33.8	31.4	0.411
Gender (females %)	46.3%	66.0%	69.5%	
Body mass index (kg/m^2) (N)				
Underweight (<18.50)	1	0	3	0.905
Normal range (18.50-24.99)	33	26	37	
Overweight (25.00-29.99)	5	4	6	
Obese (≥30.00)	2	1	3	
Index of familiarity (mean score)	104.8 c	116.7 b	126.5 a	<0.001
Food neophobia (mean score)	27.1 a	25.6 a	24.4 a	0.266
Health and taste attitudes (mean)				
General health interest	4.0 b	4.6 a	4.7 a	<0.001
Light product interest	3.7 a	3.2 b	3.2 b	0.050
Natural product interest	3.7 b	4.1 b	4.9 a	<0.001
Craving for sweet food	5.0 a	4.6 a	4.9 a	0.755
Using food as reward	3.9 a	4.2 a	4.4 a	0.642

4.1.2 Characterization of pictures

4.1.2.1 Typicality of dishes (pictures)

The pictures selected for the study varied for typicality, meaning that the level of typicality of the plant-based dish category changed among the considered pictures. The typicality ranged from a minimum reached in picture 32 (Pasta with tomato sauce) (mean = 5.57, SD = 2.29) to a maximum reached in picture 50 (Boiled broccoli and red peppers) (mean = 8.79, SD = 0.59).

The ANOVA showed that the picture had a significant effect on typicality ($F = 163.6$; $p < 0.001$), with the presence of 54 different groups from LSD test. These results suggest that almost all the variability of positive typicality of the scale was covered. The ANOVA models computed on typicality scores within each picture did not show any significant effect of segments, with the only exception of picture 7 (Pumpkin pureed soup). Therefore the variability in familiarity among the segments did not affect the typicality of pictures, meaning that overall the dishes were perceived as equally typical of the plant-based dish category.

4.1.2.2 Typicality for each dish typology

The distribution of the recipe typology along the scale of typicality is reported in Table 4.2. Dish typologies where vegetables are present as an ingredient and coupled with starch-based ingredients (e.g. Pasta, Rice) were present in the first (5.0-5.9) and second (6.0-6.9) scale range. A higher variety of dish typologies was present in the third scale range (7.0-7.9), with a prevalence of starch-free dishes and processed recipes (e.g. Soups, Fried vegetables). Present in the fourth scale range were both dish typologies where the vegetables are cooked (e.g. Boiled and Stewed vegetables) and where the vegetables are raw (e.g. Salads), with the absence of starch-based dishes. The least typical dish resulted starchy-based dish typologies, Burgers and Fried vegetables, while the most typical resulted Boiled vegetables and Salads.

4.1.2.3 Expected sensory perception of dishes

Results from the Cochran Q test computed on Check-All-That-Apply data showed a significant sample effect for all the 19 attributes ($p < 0.001$) and therefore all the terms were included in data analysis. The representation of the expected perceptive space obtained from Check-All-That-Apply attributes is reported in Figure 4.1.

The first two components of the plot accounted for the 37% of explained variance. In this map it is possible to see how pictures are distributed along the first dimension as function of the occurrences of the descriptors Creamy and Brown at the right side of the map, and the descriptor Crunchy and Bitter at the left side of the map. Along the second dimension, pictures were described as function of the descriptors Red, Spicy and Sour in the positive side of the map and the descriptors Bland, Green and White in the negative side of the map.

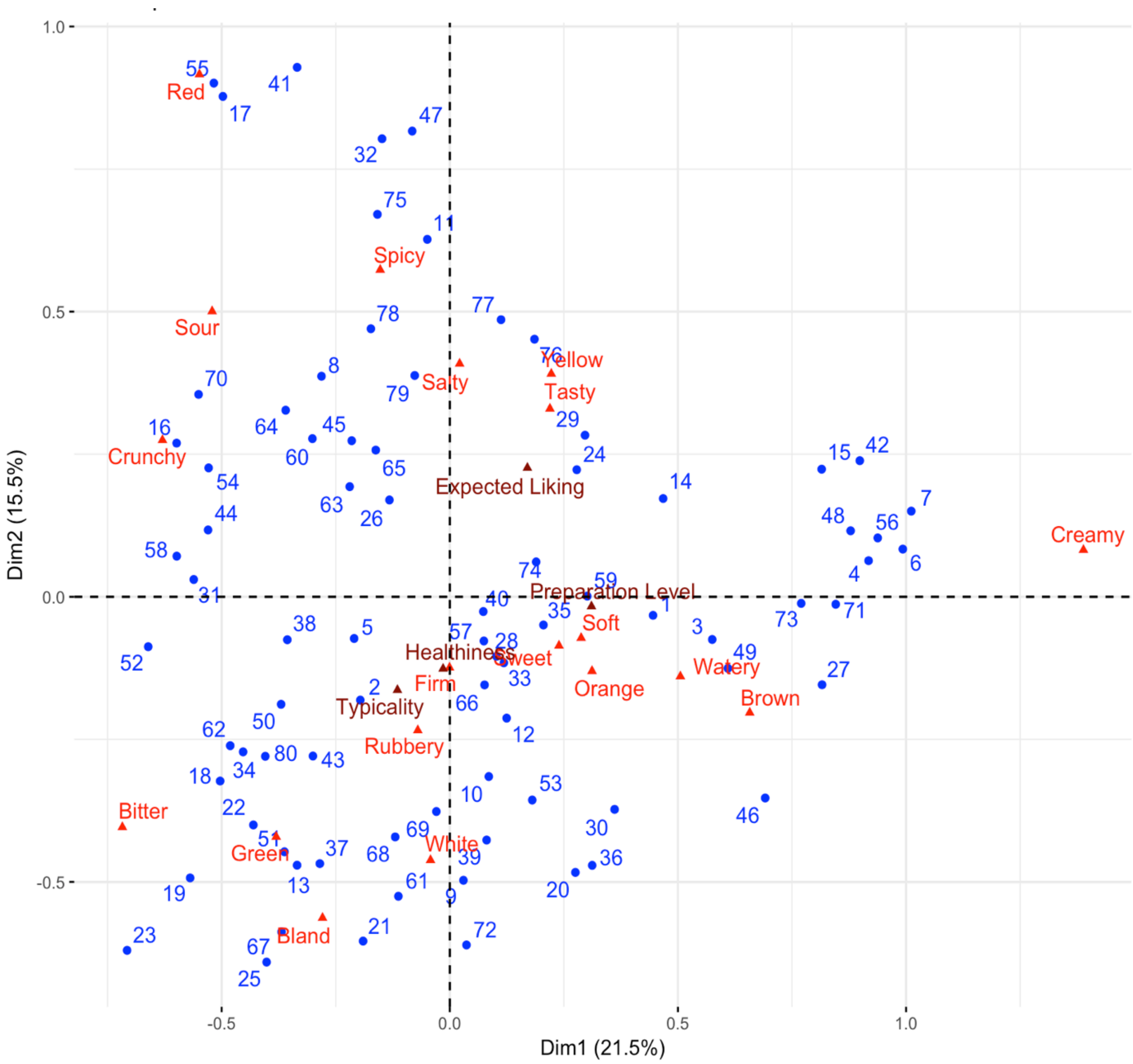


Figure 4.1 Representation of the terms in the first and second dimensions of the Correspondence Analysis performed on data from the Check-all-that-apply questionnaire.

Table 4.2 Occurrences of recipe typologies per scale range and mean of typicality for each dish category.

Recipe typology	*Scale range*				*Typicality (mean)*
	5.0-5.9	6.0-6.9	7.0-7.9	8.0-9.0	
Pasta	3	4	1		6.15
Sandwiches		3			6.63
Rice		5	1		6.72
Pizza		1			6.77
Couscous		1	1		7.10
Burgers			1		7.14
Fried vegetables		1	3		7.39
Soups		1	5	3	7.75
Purées		1	1	3	7.84
Marinated vegetables			2	1	7.86
Roasted vegetables			1	4	8.12
Stewed vegetables			2	7	8.15
Boiled vegetables			2	9	8.39
Salads			2	11	8.40

4.1.3 Association between variables describing pictures

The correlation between the variables used to describe the different dishes is reported in Table 4.3. For the whole sample of consumers, it is possible to see that typicality was moderately positively related to healthiness and moderately negatively related to expected liking and preparation level. Preparation level was weakly negatively related to healthiness and weakly positively related to expected liking, while expected liking was weakly negatively related to healthiness. Considering the relations within segments, the direction of the correlation follows the same patterns presented for the whole sample of consumers, even if the strength of correlation changes among segments, highlighting an effect of familiarity on the relation among variables. One example is represented by the correlation between typicality and expected liking. This correlation was moderately negative in the Lower familiarity segment, while it was weakly negative among the Higher familiarity segment, with the Intermediate familiarity segment falling between the other two segments. A further example is represented by the correlation between healthiness and expected liking. This correlation was moderately negative in the Lower familiarity segment, weakly negative in the Intermediate familiarity segment, and not significant in the High familiarity segment.

Table 4.3 Correlation coefficient values between variables describing pictures (typicality, preparation level, expected liking, healthiness) for all consumers and as a function of Lower familiarity, Intermediate familiarity and Higher familiarity segments.

	Preparation level	Expected liking	Healthiness
All consumers			
Typicality	-0.40***	-0.48***	0.49***
Preparation level	1.00	0.27*	-0.24*
Expected liking		1.00	-0.32**
Healthiness			1.00
Lower familiarity segment			
Typicality	-0.36***	-0.57***	0.58***
Preparation level	1.00	0.30**	-0.23*
Expected liking		1.00	-0.43***
Healthiness			1.00
Intermediate familiarity segment			
Typicality	-0.30**	-0.45***	0.43***
Preparation level	1.00	0.22	-0.17
Expected liking		1.00	-0.33**
Healthiness			1.00
Higher familiarity segment			
Typicality	-0.43***	-0.29**	0.45***
Preparation level	1.00	0.25*	-0.26*
Expected liking		1.00	-0.14
Healthiness			1.00

* = p<0.05; ** = p<0.01; *** = p<0.001

4.1.4 Impact of Check-All-That-Apply attributes on typicality

The impact of Check-All-That-Apply attributes on typicality is reported in Figure 4.2. Bitter, Green, Orange and Bland had the higher positive impact on typicality in both the whole sample group and the different segments. Orange, Sweet, Watery and Crunchy also had a positive impact on it. In turn, Brown and Creamy had the higher negative impact on typicality. Yellow, White and Rubbery also seemed to negatively impact on it, even if not in all the segments. The effect of familiarity with vegetables was limited but also in this case was present. For instance, in the Lower familiarity segment the attribute Tasty resulted in a negative impact on typicality, while in the Intermediate familiarity and in the Higher familiarity segments it was not found to have a significant impact. Red, Firm, and Spicy were not found to significantly drive typicality in any segments.

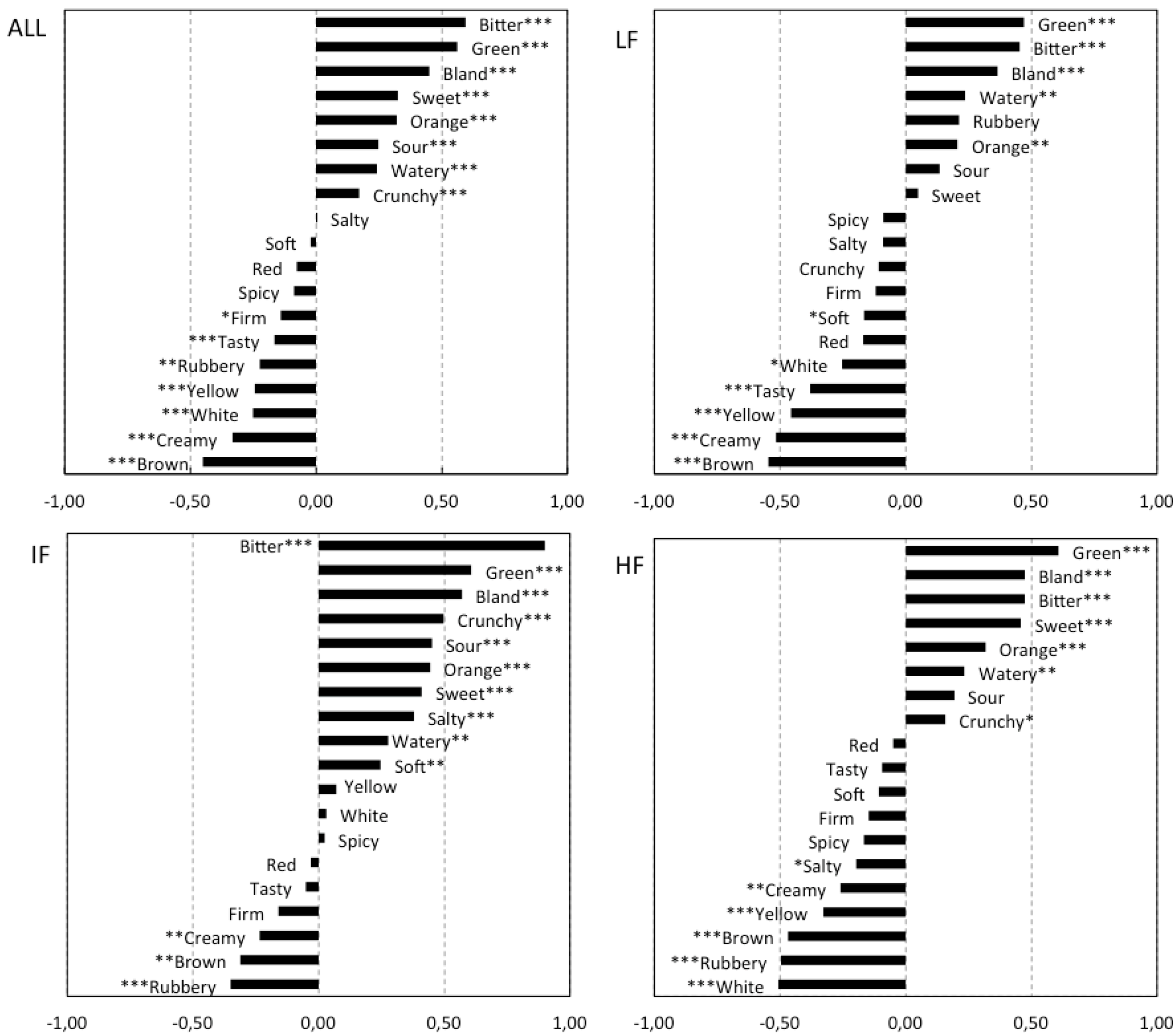


Figure 4.2 Penalty-lift analysis: influence of CATA attributes on typicality for all consumers (ALL) and as a function of Lower (LF), Intermediate (IF) and Higher (HF) familiarity segments.

4.1.5 Impact of Check-All-That-Apply attributes on expected liking

The impact of Check-All-That-Apply attributes on expected liking is reported in Figure 4.3. Considering both the whole sample group and the different segments, Tasty and Creamy are found to be the most important drivers of expected liking. Salty, Sweet, Red, Yellow, and Soft also seemed to positively impact on it. In turn, Bland, Bitter and Rubbery had the highest negative impact on expected liking. Watery and Green also seemed to negatively impact on it. The effect of familiarity on responses can be highlighted also in this case, with a higher variability compared to the case of typicality. For the Lower familiarity segments the attribute Bitter had a stronger negative impact on expected liking, while in the Intermediate familiarity and Higher familiarity segments the relation between Bitter and expected liking seemed weaker. In the Lower familiarity segment the attribute Sour had a negative impact on expected liking, while in the Intermediate familiarity and Higher familiarity segments it had a positive impact. A further example is provided by the attribute Green, that in the Lower familiarity and Intermediate familiarity segments was found to have a negative impact on expected liking, while in the Higher familiarity segment did not significantly impact on it. Brown and White terms were not found to impact significantly the expected liking.

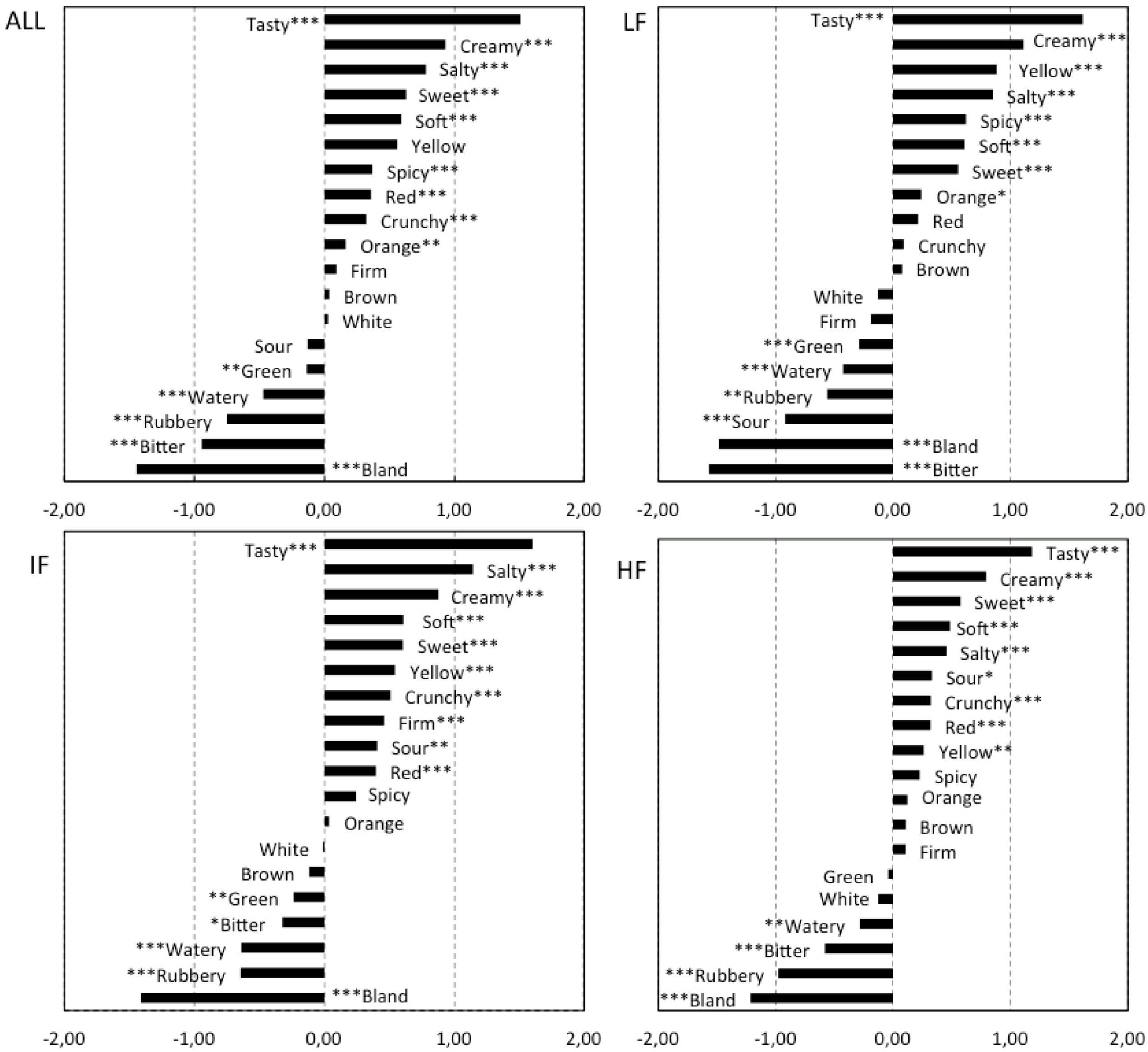


Figure 4.3 Penalty-lift analysis: influence of CATA attributes on expected liking for all consumers (ALL) and as a function of Lower (LF), Intermediate (IF) and Higher (HF) familiarity segments.

4.2 Study II: Exploring salient dimensions in a free sorting task: a cross-country study within the elderly population

4.2.1 Familiarity for pea and sweetcorn products across countries and age segments

In order to evaluate the familiarity for pea and sweetcorn products, familiarity scores from each country and age segments were analyzed independently (Table 4.4). The sum of scores for each vegetable highlighted that pea typology was in general more familiar than sweetcorn, irrespective to country and age segment. Familiarity with peas was significantly higher than for sweetcorn (rank sum $_{peas}$: 480; rank sum $_{sweetcorn}$: 421; $p<0.001$) in the Adult control segment too. No significant differences in the distribution of familiarity scores in the scale categories were found for both products when comparing either countries, or age segments (Table 4.5). Irrespective to country and age segment, pea product resulted to be mainly associated with ''I regularly eat the product", while sweetcorn resulted mainly associated with "I occasionally eat the product''. Overall these results show that pea typology was more familiar than sweetcorn typology, while the familiarity for each vegetable between countries resulted comparable.

4.2.2 Similarity among categorization, preference and sensory maps

4.2.2.1 Comparison across countries

The categorization maps obtained from the two countries are shown in Figure 4.4. In the case of peas (Figure 4.4, a-b), the maps from Italian and French respondents were very similar in terms of relative categorization of the samples. As consequence of the hierarchical cluster analysis performed on samples coordinates on the first two components in each map, three sample groups were identified in both countries (group 1: A, D, B, E, F; group 2: O, L, Q; group 3: J, P). Along the first dimension group 1 was separated from group 2 and 3. The second dimension further separated group 2 from group 3. Furthermore, the replicate samples (O and O’) were very close on the maps, meaning that the subjects have frequently sorted them in the same group. The correlation of FST configurations between countries was high for peas (RV=0.92, $p<0.001$).

Table 4.4 Familiarity with pea and sweetcorn as a function of country and segment for all tasters involved in the evaluation: rank sum of scores and p-values.

	France				*Italy*		
	Pea	Sweetcorn	p		Pea	Sweetcorn	p
All subjects	812	706	<0.001	*All subjects*	627	506	<0.001
Young old	555	483	<0.001	*Young old*	373	309	<0.001
Middle old	257	223	<0.001	*Middle old*	254	197	<0.001

Table 4.5 Distribution of subjects' familiarity scores between countries as a function of vegetable product and age segment: occurrences and p-values.

	Pea			*Sweetcorn*		
	France	Italy	p	France	Italy	p
All subjects						
1	0	0		1	2	
2	0	1		3	5	
3	6	5	0.213	28	52	0.220
4	51	60		100	67	
5	118	74		43	14	
Young old						
1	0	0		0	0	
2	0	0		2	1	
3	4	2	0.199	18	29	0.213
4	32	37		69	44	
5	83	44		30	9	
Middle old						
1	0	0		0	1	
2	0	0		2	5	
3	2	4	0.199	10	23	0.265
4	19	23		31	23	
5	35	30		13	5	

1: "I do not recognize the product",
2: "I recognize the product, but I have not tasted it",
3: "I have tasted, but I do not use the product",
4: "I occasionally eat the product" and
5: "I regularly eat the product"

Similarities between the spatial configurations of sweetcorn samples (Figure 4.4, c-d) across countries resulted less evident. Sample grouping resulting from the hierarchical cluster analysis showed that in both countries samples W, T and S were clearly separated from the rest. Globally identified sample groups were the same with the only discrepancy represented by the position of sample V. As consequence the correlation between the maps was lower (RV=0.62, p=0.021) than the one observed for peas. In both countries the replicate samples (H and H') fell in the same group thus still indicating the internal reliability of the configurations.

The comparison of preference maps from pea samples between countries resulted in a RV coefficient of 0.87 (p<0.001), showing a general agreement on the value of hedonic properties when discriminating between samples. In the case of sweetcorn the comparison between preference maps resulted in a low level of similarity (RV=0.65, p=0.008), suggesting that different sensory properties may drive the liking for sweetcorn among Italian and French population.

In order to evaluate the weight of sensory and hedonic dimensions on the process of categorization, the categorization map of each country was compared with the relevant sensory and preference maps (Table 4.6). For the pea samples, the categorization maps from both countries were highly correlated with the sensory maps and also with the corresponding preference map. For sweetcorn, the spatial configuration from FST was poorly correlated with the sensory map, reaching a maximum of the critical RV value of 0.78 (p=0.002) in the French group. This suggests that subjects gave a different weight to the sensory attributes that determinate the dimensions of the categorization map, particularly in the Italians (RV=0.61, p=0.014). Also the correlation between categorization and preference maps revealed a poor correlation between the configurations in both countries.

Table 4.6 RV coefficient values between samples configurations in the first two dimensions of categorization, preference and sensory maps as a function of country and vegetable products.

	Pea					*Sweetcorn*				
	FST Italy	FST France	IPM Italy	IPM France	DA	FST Italy	FST France	IPM Italy	IPM France	DA
FST Italy	1					1				
FST France	0.92^{***}	1				0.62^{**}	1			
IPM Italy	0.68^{***}	0.67^{***}	1			0.60^{**}	0.62^{**}	1		
IPM France	0.76^{***}	0.74^{***}	0.87^{***}	1		0.62^{**}	0.58^{*}	0.65^{**}	1	
DA	0.83^{***}	0.87^{***}	0.78^{***}	0.88^{***}	1	0.61^{**}	0.78^{**}	0.66^{**}	0.76^{**}	1

*= p<0.05 **= p<0.01 ***= p<0.001

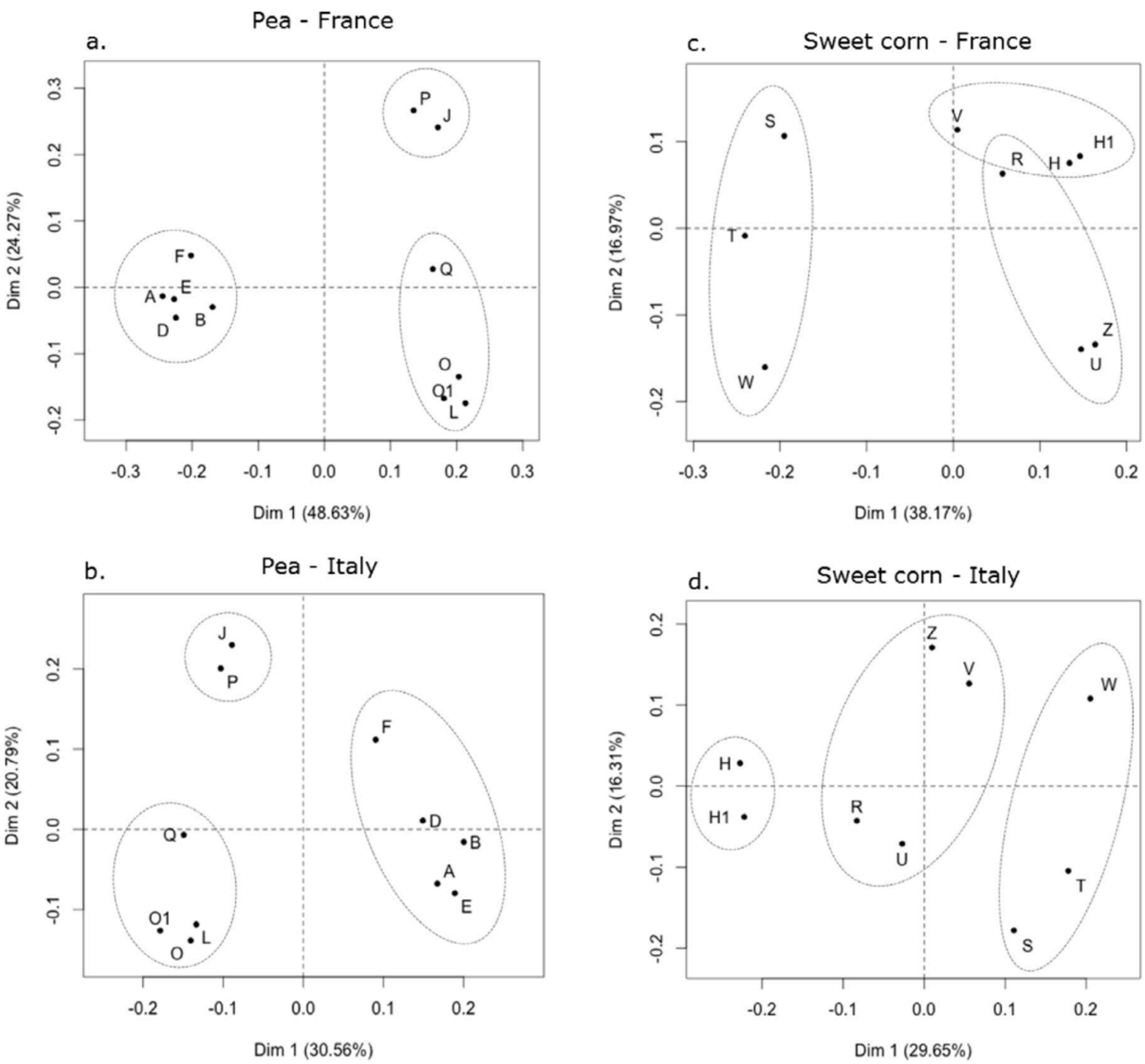


Figure 4.4 Categorization maps: Compromise map from DISTATIS for pea (left) and sweet corn (right) samples obtained from the free sorting task with French and Italian older adults. The ellipsoids correspond to the clusters identified with hierarchical cluster analysis.

4.2.2.2 Comparison across age segments

Considering that familiarity toward the tested vegetables and sample grouping resulted generally not affected by the country, in order to better investigate the process of categorization during ageing, sorting data and liking data for both countries were merged by age segment and data analysis was carried out independently for each age segment. A characterization of each age segment is reported in Table 3.3. Categorization and preference maps from the control group of Adults were used as reference.

The categorization maps obtained from the three age segments are shown in Figure 4.5. For the pea samples, substantial similarities can be noted across age segments in the FST configurations (Figure 4.5, a-c). As consequence of the hierarchical cluster analysis performed on samples coordinates on the first two components in each map, three sample groups were identified (group 1: A, D, B, E, F; group 2: O, L, Q; group 3: J, P). These groups were well separated one from each other in the configurations from Adults, Young old and Middle old subjects.
Figure 4.5 (d-f) shows that the spatial configuration of sweetcorn samples varied across age-segments. This is clearly shown by the different sample-groups obtained from the cluster analysis on sample coordinates of the first two dimensions of each map. The influence of age on sample categorization appeared evident in this case even if the opposition among specific samples (H vs. W, S, T) remained constant across age segments. It is worth to note that replicated samples always fell in the same group both for pea and sweetcorn samples irrespective to age, confirming the internal reliability of the configurations. Overall these results clearly show that the influence of age on samples categorization is associated to the level of familiarity toward the tested products. The level of similarity between categorization, preference and sensory maps as a function of aging is reported in Figure 4.6a for peas and in Figure 4.6b for sweetcorn. The following comparisons were considered: 1. The categorization map from the reference segment of Adults versus each categorization map from the two elderly age segment; 2. Categorization maps from Adults and the two elderly age segments versus the sensory map; 3. Categorization maps from Adults and from the two elderly age segment versus the relative preference maps. For all comparisons the RV coefficient computation and the visual inspection were used. The RV values were considered only after visually checking the similarity between two maps. Considering the pea samples, the correlation between the categorization maps from the Adults and each elderly group was high in the Young old ($RV=0.97$, $p<0.001$) and Middle old segment ($RV=0.97$, $p<0.001$), suggesting a strong similarity in the categorization of pea samples.

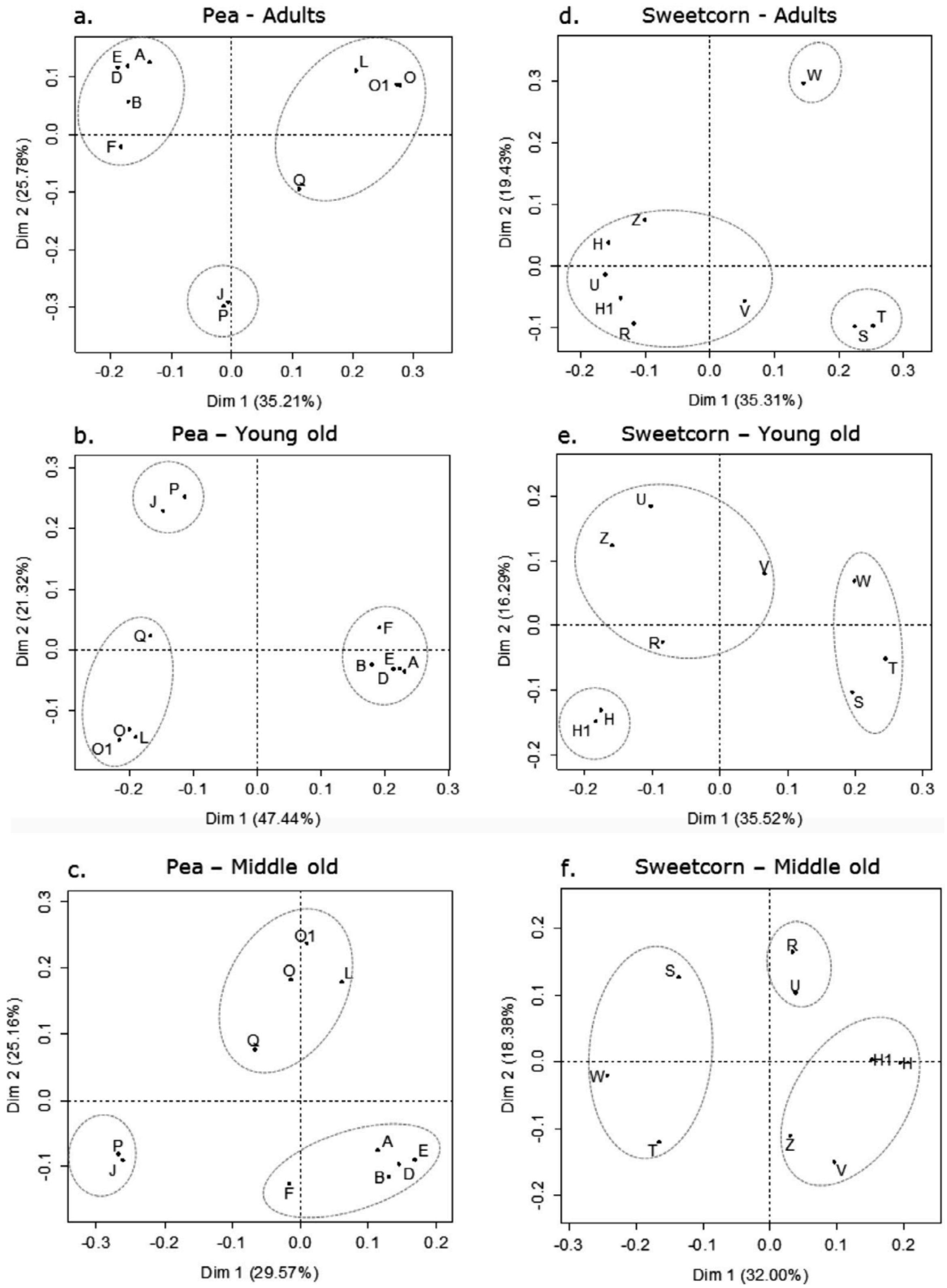


Figure 4.5 (a-f) Categorization maps: Compromise map from DISTATIS for pea (left) and sweet corn (right) samples obtained from the free sorting task with Adults, Young old and Middle old segments. The ellipsoids correspond to the clusters identified with hierarchical cluster analysis.

In the case of the sweetcorn samples, the maps follow a different pattern. The correlation between the categorization maps from the Adults and each elderly group decreased from Young old (RV=0.68, p=0.003) to Middle old (RV=0.53, p=0.024) segments. This evidence suggests that for this typology of product, the criteria used in categorizing the samples varies during the ageing process, with an overall effect on sorting configuration. Taking into consideration the similarity between the categorization maps and the sensory map, in the case of peas it is possible to see that the sensory dimension was highly important in each age segment (minimum RV value: Middle old segment (RV=0.86, p<0.001)). Conversely, in the case of sweetcorn the similarity between the categorization maps and the sensory map was lower and decreases from Adults to Middle old segment, the latter with the minimum level in similarity (RV=0.68, p=0.012). Concerning the similarities between the categorization maps and the preference maps, in the case of peas, the results showed little differences in the value of the hedonic dimension in the presented samples from Adults to the Middle old segment. Moreover, the contribution of the hedonic dimension to the categorization process remained lower than the sensory dimension in each age segment, with a maximum RV value reached in the Middle old segment (RV=0.77, p<0.001). A similar tendency was found for sweetcorn, with a minimum similarity reached in the Middle old segment (RV=0.55, p=0.042).

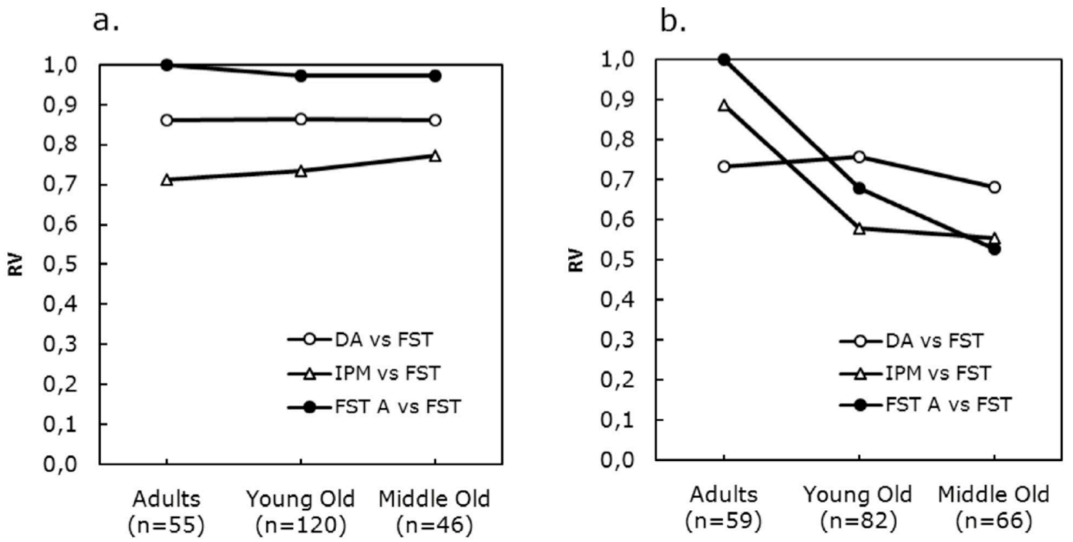


Figure 4.6 (a-b) RV coefficient values between samples configurations in the first two dimensions of categorization, preference and sensory maps as a function of the age segments and pea (a) and sweetcorn (b) typologies. FST A indicates categorization maps from Adults.

4.2.3 Free sorting task reliability within each age segment

The internal reliability of the maps generated with FST during ageing was explored by considering the ratio of distances between the two replicated samples (Dr%). The Dr% of categorization maps and preference maps are reported in Figure 4.7 (a-b), respectively for each age class and vegetable category. In these plots, the closer the two replicated samples are on the map the higher the Dr% value and thus the map internal reliability. For the pea samples, both the categorization and preference maps showed a high Dr% in each age segment. For the sweetcorn a high Dr% was found in each age segment only for the categorization maps, while for the preference maps the Dr% value decreased with age. In particular for the pea samples the lowest Dr% of the categorization maps was reached in the Middle old segment, while in the preference maps, the minimum Dr% was reached in the Adults segment. The FST on sweetcorn samples gave highly reliable maps in each age segment. On the contrary, Dr% values associated to the preference maps from the Adults and Young old were higher than the one computed for the Middle old segment.

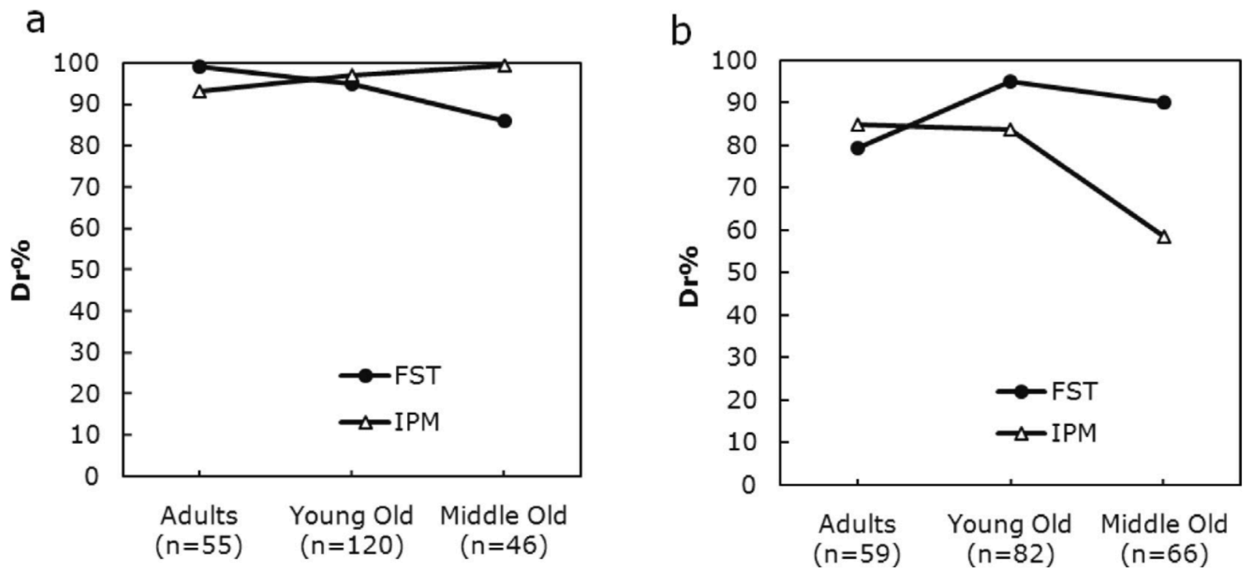


Figure 4.7 (a-b) Ratio of distances (%) values for the two replicated samples in the first two dimensions of the categorization and preference maps as a function of the age segments and pea (a) and sweetcorn (b) typologies.

4.3 Study III: The influence of psychological traits, beliefs and taste responsiveness on implicit attitudes toward plant- and animal-based dishes among vegetarians, flexitarians and omnivores

Data and responses collected in the study were compared among the three considered consumer segments: Omnivores, Flexitarian and Vegetarians. Results are presented first in relation to specific groups of variables (socio-demographic, psychological traits, questionnaires on attitudes and believes, taste responsiveness and reaction time responses from the IAT study), and then considering the associations among all of them.

4.3.1 Characterization of segments based on declared eating habits

4.3.1.1 Socio-demographics

The demographic and social characteristics of Omnivores, Flexitarians and Vegetarians are reported in Table 4.7. The three groups did not differ according to gender, with a higher presence of females in each group. The three segments were formed mainly by young adult respondents (18-30 years old range), even if a significant difference of age group distributions was found, due to a higher presence of adult respondents (31-40 years old range) among Omnivores compared to Vegetarians. Normal range BMI was the most common across the three groups and no significant difference of BMI distributions was found. The variables related to economical wellbeing, such as the educational level and the monthly expense for food, were also not significantly different between groups.

4.3.1.2 Psychological and personality traits

The psychological and personality traits measures obtained for Omnivores, Flexitarians and Vegetarians segments are reported in Table 4.8. The internal consistency of the Food Neophobia Scale score, as measured using Cronbach's alpha, was 0.83. The three groups were most commonly low in neophobia and did not significantly differ for the mean Food Neophobia Scale score, suggesting a comparable behavior toward the consumption of novel foods. Concerning the internal consistency of each Interpersonal Reactivity Index domain, *Fantasy* resulted in an alpha of 0.73, *Perspective Taking* resulted in an alpha of 0.73, *Empathic Concern* resulted in an alpha of 0.73 and *Personal Disease* resulted in an alpha of 0.74. With the exception of *Personal Disease* domain, overall the three segments showed a tendency to high scores of cognitive and emotional empathy. The eating habit had a significant effect on the *Perspective Taking* domain (F = 4.5; p = 0.035), showing a higher capacity to adopt the point of view of other people among Vegetarians as compared to Omnivores, while Flexitarian scores fell between these groups. A tendency, even if not significant, was detected for the *Empathic Concern* domain (F = 3.1; p = 0.085), suggesting a higher capacity to experience compassion for others undergoing negative experiences in Vegetarians compared to Omnivores, while Flexitarian scores fell between the other two segments. No eating habits effect was found for the domain *Fantasy* and *Personal Disease*. Concerning the internal consistency of each Three-Domain Disgust Scale domain, *Pathogen Disgust* resulted in an alpha of 0.79 and *Moral Disgust* in an alpha of 0.71. The eating habit had a significant effect on the *Pathogen Disgust* domain (F = 9.0; p = 0.003), showing a higher disgust toward infectious agents in Omnivores and Flexitarians compared to Vegetarians. A tendency, even if not significant, was detected for the *Moral Disgust* domain (F = 3.2; p = 0.007), showing higher disgust toward antisocial activities in Omnivores and Flexitarians compared to Vegetarians.

Table 4.7 Demographic and social characteristics of the respondents per category of eating habits.

	Omnivores (n=39) %	Flexitarians (n=55) %	Vegetarians (n=31) %	p-value
Gender				
Males	35.9	23.6	22.6	0.354
Females	64.1	76.4	77.4	
Age (years)				
18-30	89.7	72.7	51.6	
31-40	7.7	21.8	38.7	0.008
41-50	2.6	5.5	9.7	
Body mass index (kg/m^2)				
Underweight (<18.50)	7.7	9.1	12.9	
Normal range (18.50-24.99)	69.2	83.6	83.9	0.238
Overweight (25.00-29.99)	15.4	5.5	3.2	
Obese (≥30.00)	7.7	1.8	0.0	
Educational level				
Lower secondary school	0.0	1.8	3.2	
Upper secondary school	48.7	30.9	45.2	0.521
Degree	43.6	54.5	45.2	
Post-degree (MSc, PhD)	7.7	12.7	6.5	
Monthly expense for food (euro)				
Up to 200	35.9	32.7	32.3	
From 201 to 400	30.8	50.9	54.8	0.263
From 401 to 600	20.5	12.7	9.7	
More than 600	12.8	3.6	3.2	

Table 4.8 Psychological and personality traits, food attitudes and beliefs on food animal measurements per category of eating habits: mean values. Mean values followed by different letters are significantly different ($p < 0.05$).

	Omnivores (n=39)	Flexitarians (n=55)	Vegetarians (n=31)	p-value	Cronbach's alpha
Food Neophobia Scale	26.6	28.1	31.2	0.112	0.83
Interpersonal Reactivity Index					
Fantasy	3.5	3.7	3.6	0.559	0.73
Perspective Taking	3.7 b	3.9 ab	4.0 a	0.035	0.58
Empathic Concern	3.4	3.6	3.7	0.085	0.73
Personal Disease	2.8	2.9	2.7	0.333	0.74
Three-Domain Disgust Scale					
Pathogen Disgust	4.8 a	4.7 a	4.0 b	0.003	0.79
Moral Disgust	5.5	5.4	5.0	0.074	0.71
Health and Taste Attitudes Scale					
General Health Interest	4.3 b	5.1 a	5.3 a	<0.001	0.81
Light Product Interest	2.9	3.2	2.9	0.969	0.90
Natural Product Interest	4.2 c	4.9 b	5.5 a	<0.001	0.78
Craving for Sweet Food	5.1	5.1	4.9	0.542	0.88
Using Food as Reward	4.6	4.5	4.1	0.143	0.85
Pleasure	4.9	5.1	5.1	0.620	0.46
Food Involvement Scale					
Set and Disposal	14.9	15.2	13.4	0.061	0.64
Preparation and Eating	46.2	47.1	49.1	0.186	0.44
Human-Animal Emotion Similarity	3.0 c	3.5 b	3.9 a	<0.001	0.88
Human-Animal Mental Capacity Similarity	2.7 c	3.1 b	3.4 a	<0.001	0.82
Meat Eating Justification					
Pro-meat Attitude	5.2 a	3.1 b	1.0 c	<0.001	0.89
Denial	3.1 a	1.9 b	1.1 c	<0.001	0.58
Hierarchical Justification	3.9 a	2.3 b	1.1 c	<0.001	0.75
Dichotomization	4.8 a	4.0 b	2.6 c	<0.001	0.48
Dissociation	4.8 a	4.2 a	3.0 b	<0.001	0.57
Religious Justification	3.1 a	2.0 b	1.6 c	<0.001	0.85
Avoidance	5.2	5	4.3	0.158	0.55
Health Justification	5.5 a	3.6 b	1.2 c	<0.001	0.85
Human Destiny Justification	5.5 a	3.6 b	1.2 c	<0.001	0.73

4.3.1.3 Food-related lifestyles and attitudes

The food-related lifestyle and attitude measures obtained for Omnivores, Flexitarians and Vegetarians are reported in Table 4.8. Concerning the internal consistency of each Health and Taste Attitudes Scale domain, *General Health Interest* and *Light Product Interest* domains were shown to be highly internally consistent, with an alpha of 0.81 and 0.90 respectively. Also *Craving for Sweet Food* and *Using Food as Reward* domains were shown to be highly internally consistent, with an alpha of 0.85 and 0.88 respectively. *Natural Product Interest* domain resulted in an alpha of 0.78, while *Pleasure* resulted in an alpha of 0.46. Concerning the attitudes toward healthy food, with the exception of *Light Product Interest* domain, overall the three segments showed a tendency to positive attitudes toward healthy food consumption. The three groups resulted significantly different concerning the *General Health Interest* domain ($F = 21.5$; $p < 0.001$), with a lower interest for Omnivores compared to Flexitarians and Vegetarians. A significant effect was detected also for the *Natural Product Interest* domain ($F = 28.1$; $p < 0.001$), with a higher interest among Vegetarians compared to Omnivores, with Flexitarian scores falling between the other two groups. No significant effect was found for the *Light Product Interest*. In general, the three groups showed a tendency to positive attitudes toward tasty food consumption. Eating habits did not affect any of the considered subscales, highlighting a high and comparable importance of taste on food choices (*Craving for Sweet Food*: mean = 5.1, SD = 1.4; *Food as Reward*: mean = 4.5, SD = 1.4; *Pleasure*: mean = 5.1, SD = 0.8).

Concerning the internal consistency of each Food Involvement Scale domain, *Set and Disposal* resulted in an alpha of 0.64 and *Preparation and Eating* resulted in an alpha of 0.44. The involvement with food measured through Food Involvement Scale highlighted a general high level of interest in food in all segments (*Set and Disposal*: mean = 14.7, SD = 3.6; *Preparation and Eating*: mean = 47.7, SD = 7.7). Eating habits had no significant effect on FIS scores, suggesting a high comparable level of importance of food among the considered groups.

4.3.1.4 Beliefs regarding food animals

The beliefs regarding food animals measures obtained for Omnivores, Flexitarians and Vegetarians are reported in Table 4.8. Human-Animal Emotions Similarity and Human-Animal Mental Capacity Similarity were shown to be highly internally consistent, with an alpha of 0.88 and 0.82 respectively. In general Omnivores tended to deny the similarity between humans and animals, while Flexitarians and Vegetarians tended to

recognize that humans and food animals might experience the same emotions and mental capacities. The three segments significantly differed in the belief that food animals share emotional states and mental capacities similar to humans, with higher scores in Vegetarians compared to Omnivores, and Flexitarians scores falling between the other two segments.
Concerning the internal consistency of each Interpersonal Reactivity Index domain, *Pro-meat attitude*, *Religious Justification* and *Health Justification* domains were shown to be highly internally consistent, with an alpha of 0.89, 0.85 and 0.85 respectively. *Denial* resulted in an alpha of 0.58, *Hierarchical Justification* resulted in an alpha of 0.75, *Dichotomization* resulted in an alpha of 0.48, *Dissociation* resulted in an alpha 0.57, *Avoidance* resulted in an alpha of 0.55 and *Human Destiny Justification* resulted in an alpha of 0.73. The subscales that investigated the different strategies to justify meat consumption resulted to significantly differences between eating habits, with a general higher level of meat eating justification in Omnivores compared to Flexitarians, while Vegetarians obtained lower scores. The only exception is represented by the *Avoidance* domain, indicating that each group similarly tends to avoid thinking about where meat comes from and how it is processed. While for Vegetarians the low scores are the obvious consequence of refusing to eat meat, the scores from Omnivores and Flexitarians depict a more complex situation. Omnivores adopted six of the nine strategies to justify meat consumption (*Pro-meat attitude, Dichotomization, Dissociation, Avoidance, Health Justification* and *Human Destiny Justification*), while Flexitarians tended to positively adopt just three such strategies (*Dichotomization, Dissociation* and *Avoidance*).

Table 4.9 PROP status and PROP bitter intensity per category of eating habits. Mean values followed by different letters are significantly different ($p < 0.05$).

	Omnivores (n=39)	Flexitarians (n=55)	Vegetarians (n=31)	p-value
PROP status (%)				
No Taster	17.9	23.6	38.7	
Medium Taster	43.6	54.5	48.4	0.082
Super Taster	38.5	21.8	12.9	
PROP bitter intensity (mean)	43.7 a	37.4 ab	27.9 b	0.008

4.3.1.5 Taste responsiveness among declared eating habits

Taste responsiveness measures among declared eating habits are reported in Table 4.9. Based on an a priori cut-off, in each segment the majority of subjects were PROP medium-tasters (Omnivores: 43.6%; Flexitarians: 54.5%; Vegetarians: 48.4%). 17.9% of Omnivores, 23.6% of Flexitarians and 38.7% of Vegetarians were classified as PROP non-tasters, while 38.5% of Omnivores, 21,8% of Flexitarians and 12,9% of Vegetarians were classified as PROP super-tasters. The three groups did not significantly differed in PROP status distribution, even if a tendency was present (χ^2 = 8.25; p = 0.082). However, when PROP was considered as a continuous variable the 1-Way ANOVA model showed that the mean PROP intensity was different among groups, with Vegetarians rating PROP intensity significantly lower (mean = 27.9) than Omnivores (mean = 43.7), and Flexitarians (mean = 37.4) falling between the other two groups, even if not significantly differing from them (F = 7.34; p = 0.008).

4.3.1.6 Implicitly measured attitudes within declared eating habits

In the VM-IAT, the lower the D-score, the higher the speed of categorization when category pairings grouped vegetables with positive emotions and meat with negative emotions, compared to the complementary pairing. On average, subjects responded more rapidly when category pairings grouped vegetables with positive emotions and meat with negative emotions, compared to the complementary pairing (mean D-score = -0.30). Examination of eating habits differences in D-scores (Figure 4.8) showed that, within Omnivores, 50% of respondents resulted in a more rapid categorization vegetables with linked to positive emotions and meat with negative emotions compared to the complementary pairing. For Flexitarians and Vegetarians, however, the corresponding proportion was greater than 75%.

Eating habits had a significant effect on D-scores (Figure 4.9), with significantly higher scores in Omnivores (mean = -0.07) compared to Vegetarians (-0.63), while Flexitarians scores fell between the other two segments (-0.38) (F = 36.49; p < 0.001). The analysis of response latencies from VM-IAT (Figure 4.10) showed that the differences in D-score between segments originates in a significantly different performance of categorization in Block 6 (mean Omnivores = 919.6 ms; mean Flexitarians = 1077.4 ms; mean Vegetarians = 1149.6 ms) (F = 7.39; p = 0.007) and Block 7 (mean Omnivores = 821.5 ms; mean Flexitarians = 896.6 ms; mean Vegetarians = 971.3 ms) (F = 8.60; p = 0.004), in which category pairings grouped meat with positive emotions and vegetable with negative emotions. In contrast, no significant differences were found in either Block 3 (mean Omnivores = 890.0 ms; mean Flexitarians = 883.3 ms; mean Vegetarians = 781.3 ms) ($F = 3.48$; $p = 0.064$) or Block 4 (mean Omnivores = 781.7 ms; mean Flexitarians = 774.2 ms; mean Vegetarians = 695.9 ms) ($F = 3.61$; $p = 0.060$), in which category pairings grouped vegetable with positive emotions and meat with negative emotions.

In the VD-IAT, the lower the D-score, the higher the speed of categorization when vegetables were paired with positive emotions and dairy products with negative emotions, compared to the complementary pairing. On average, this pairing led to lower D-scores (mean = -0.13). Across groups, this was true for 25% of Omnivores and 50% and 75% of Flexitarians and Vegetarians, respectively. Mean D-scores are shown in Figure 4.9. Omnivores (mean = -0.01) and Flexitarians (mean = -0.14) had significantly higher scores than Vegetarians (mean = -0.41) ($F = 18.43$; $p < 0.001$), while between Omnivores and Flexitarians no significant differences were found.

The analysis of response latencies from VD-IAT (Figure 4.10) showed that the differences in D-scores between groups arises from significantly different performance of categorization in Block 6 (mean Omnivores = 879.1 ms; mean Flexitarians = 1004.1 ms; mean Vegetarians = 1144.7 ms) ($F = 12.91$; $p < 0.001$) and Block 7 (mean Omnivores = 823.8 ms; mean Flexitarians = 913.1 ms; mean Vegetarians = 915.6 ms) ($F = 4.52$; $p = 0.035$), in which category pairings grouped dairy with positive emotions and vegetable with negative emotions. No significant group performance differences were seen in either Block 3 (mean Omnivores = 926.2 ms; mean Flexitarians = 983.1 ms; mean Vegetarians = 878.1 ms) ($F = 0.264$; $p = 0.609$) or Block 4 (mean Omnivores = 804.5 ms; mean Flexitarians = 828.1 ms; mean Vegetarians = 758.4 ms) ($F = 0.78$; $p = 0.378$), in which category pairings grouped vegetable with positive emotions and dairy with negative emotions.

In the DM-IAT, the lower was the D-score, the higher the speed of categorization when category pairings grouped dairy products with positive emotions and meat with negative emotions, compared to the complementary pairing. On average, this pairing produced generally more rapid performance compared to the complementary pairing (mean D-score = -0.17). Across groups, this was true for 25% of Omnivores and 50% and 75% of Flexitarians and Vegetarians, respectively. Mean D-scores are shown in Figure 4.9, with significantly higher scores in Omnivores (mean = -0.10) compared to Vegetarians (mean = -0.40), with Flexitarians scores (mean = -0.24) falling between the other two groups, even if not significantly differing by them ($F = 18.43$; $p <0.001$).

Inspection of response latencies from DM-IAT (Figure 4.10) showed that the differences in D-score between arises from a significantly different performance of categorization in Block 6 (mean Omnivores = 903.8 ms; mean Flexitarians = 1020.4 ms; mean Vegetarians = 1050.1 ms) ($F = 4.76$; $p = 0.031$), in which category pairings grouped dairy with positive emotions and meat with negative emotions, while performance between groups was not significantly different in Block 7 (mean Omnivores = 823.4 ms; mean Flexitarians = 921.6 ms; mean Vegetarians = 921.6 ms) ($F = 3.23$; $p = 0.074$), Block 3 (mean Omnivores = 897.3 ms; mean Flexitarians = 973.2 ms; mean Vegetarians = 887.4 ms) ($F = 0.01$; $p = 0.417$) or Block 4 (mean Omnivores = 804.5 ms; mean Flexitarians = 828.1 ms; mean Vegetarians = 758.4 ms) ($F = 0.784$; $p = 0.378$), in which category pairings grouped meat with positive emotions and dairy with negative emotions.

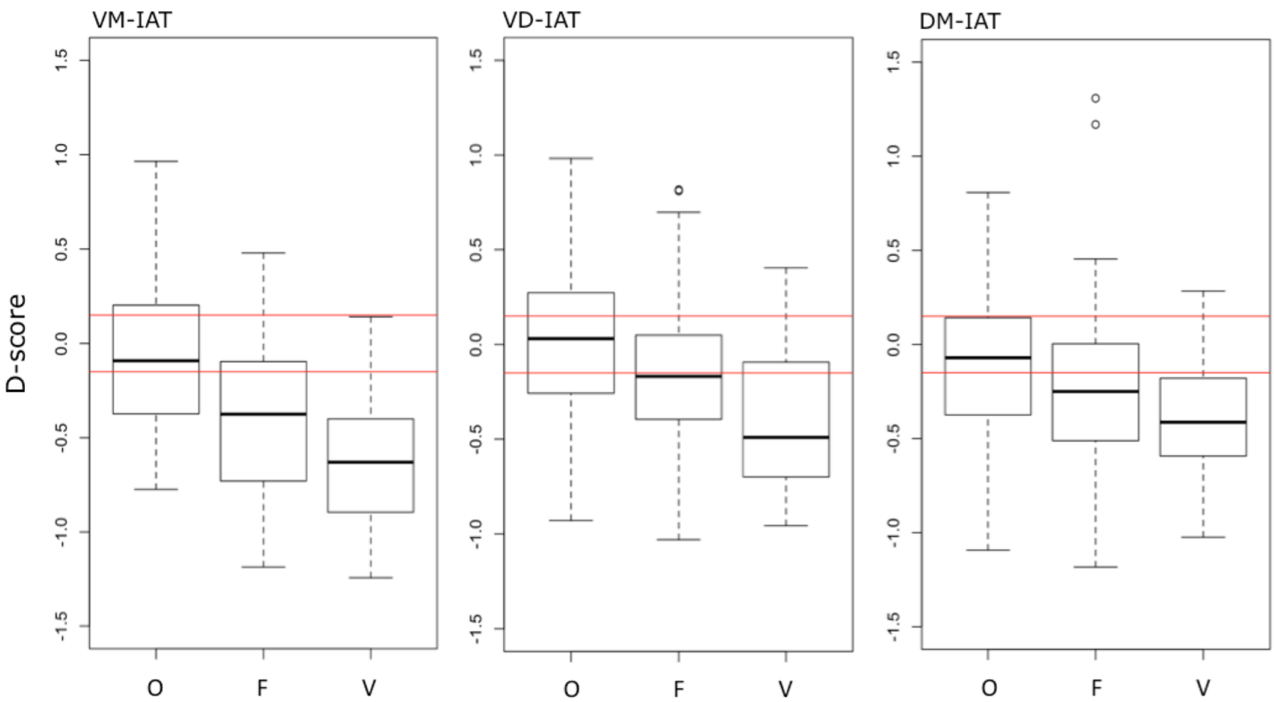


Figure 4.8 Box plot. Differences in D-scores within VM-IAT, VD-IAT and MD-IAT for Omnivores (O), Flexitarians (F) and Vegetarians (V) segments. D-scores within horizontal lines represent a condition of no preference between combinations.

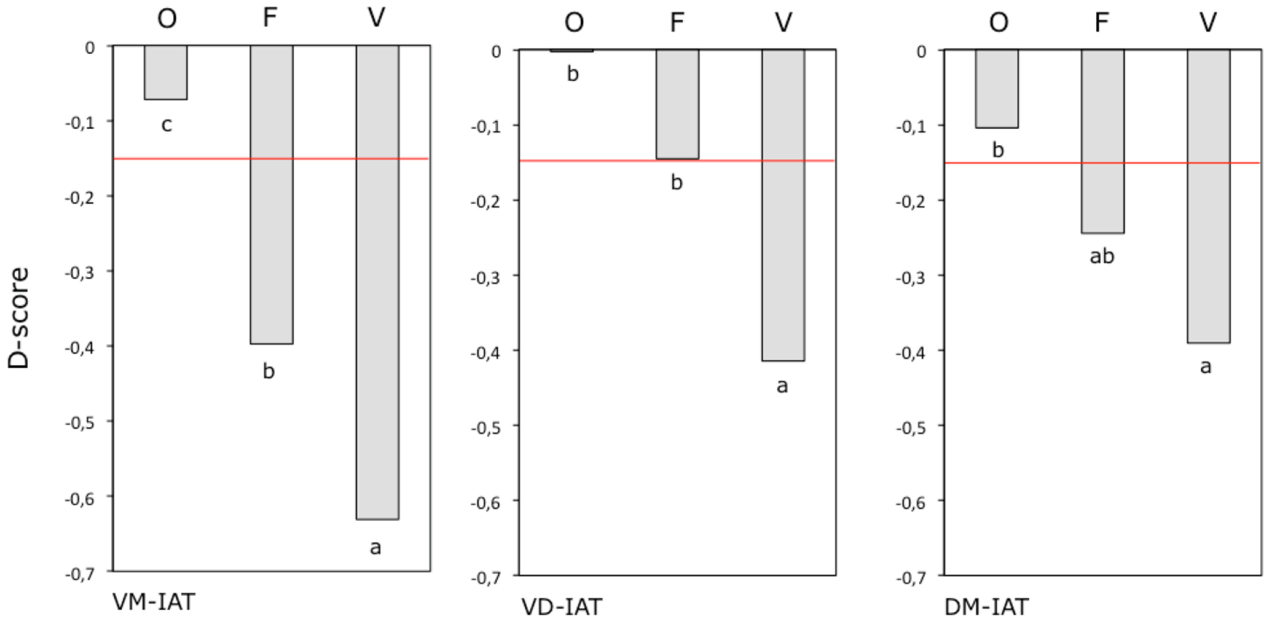


Figure 4.9 D-scores values within VM-IAT, VD-IAT and MD-IAT for Omnivores (O), Flexitarians (F) and Vegetarians (V) segments: mean values. Within each IAT, mean values followed by different letters are significantly different ($p < 0.05$). D-scores above the horizontal line represent a condition of no preference between combinations.

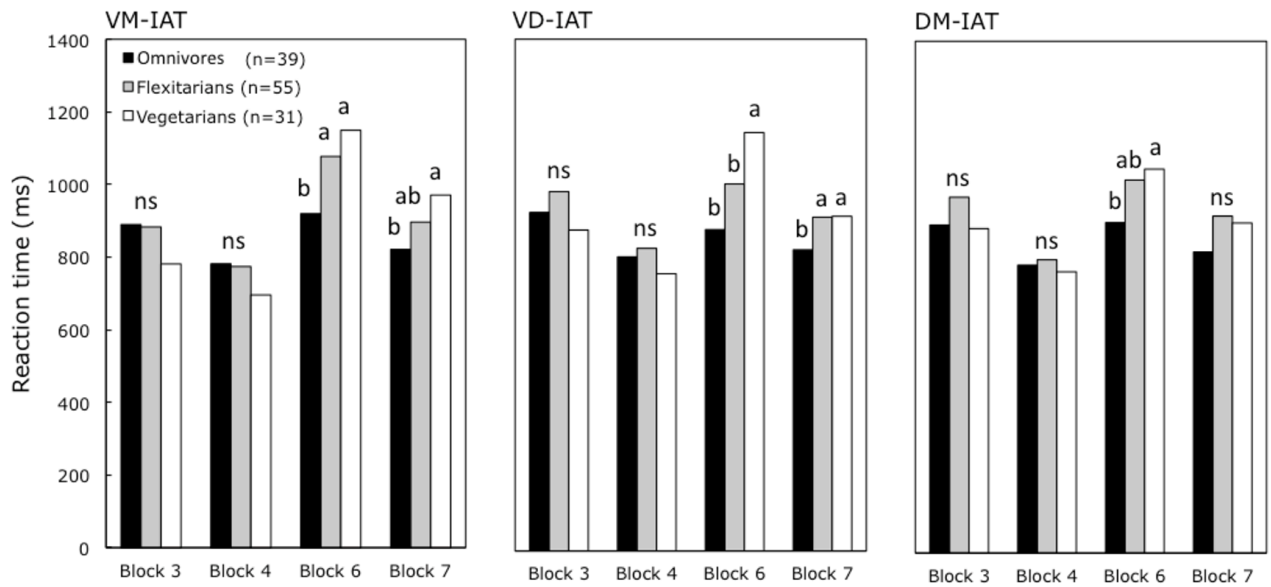


Figure 4.10 Response latency for Block 3, 4, 6 and 7 within VM-IAT, VD-IAT and MD-IAT obtained for Omnivores, Flexitarians and Vegetarians segments: mean values. Within each block, mean values followed by different letters are significantly different ($p < 0.05$).

4.3.2 Correlation among variables and effect on implicit responses

A preliminary PLS regression computed with all the variables resulted in a model with one significant component, where the explained variances for components 1 and 2 were equal to 13% and 12% for X and 15% and 3% for Y. Considering all the IATs, variables that resulted significant were *Prospective Taking*, *General Health Interest*, *Natural Product Interest*, *Human-Animal Emotion Similarity*, *Human-Animal Mental Capacity Similarity*, *Pathogen Disgust* and *PROP responsiveness*. The VM-IAT variable resulted more well explained by the model while VD-IAT and DM-IAT variables resulted less explained by the model. For this reasons only VM-IAT was considered as Y variable in the next PLS model. VD-IAT and DM-IAT were included in the model as down-weighted Y variable in order to investigate the association with the PROP responsiveness, the psychological traits, the attitudes and the beliefs. The final PLS regression, computed only with significant variables, resulted in a model with one significant component, where the explained variances for components 1 and 2 were equal to 33% and 13% for X and 25% and 3% for Y. The PLS score plot for the first two components (Figure 4.11a) allowed an exploration of the association among subjects on the basis of the considered variables. The first principal component explained the variability of eating habits, where Omnivores tend to be located in the positive side of the component, while Vegetarians tend to be located in the negative side. Flexitarians tend to be located at the center of the component and partially superimposed on the other two segments, in particular that of Vegetarians.

The PLS correlation loading plot for the first two components (Figure 4.11b) allowed an exploration of the associations among variables. The D-scores of the VM-IAT were positively correlated with the first component, where more subjects were located on the right side of the map (more rapid responses in the second combined task compared to the first one), indicating more positive attitudes toward meat-based dishes. Human-Animal Emotion Similarity, Human-Animal Mental Capacity Similarity, *General Health Interest*, *Natural Product Interest* and *Prospective Taking* measures were correlated with the negative side of the first component, while PROP responsiveness and *Pathogen Disgust* measures were correlated with the positive side. The PLS regression coefficients of the first dimension (Figure 4.12) showed that VM-IAT D-scores significantly decreased when Human-Animal Emotion Similarity, Human-Animal Mental Capacity Similarity, *General Health Interest*, *Natural Product Interest* and *Prospective Taking* measures increased and PROP responsiveness and *Pathogen Disgust* measures decreased. In the case of VD-IAT, the D-scores significantly decreased when Human-Animal Emotion Similarity, Human-Animal Mental Capacity Similarity, *General Health Interest*, *Natural Product Interest* and *Prospective Taking* measures increased and PROP responsiveness decreased. No variables significantly affected the D-scores of the DM-IAT.

a.

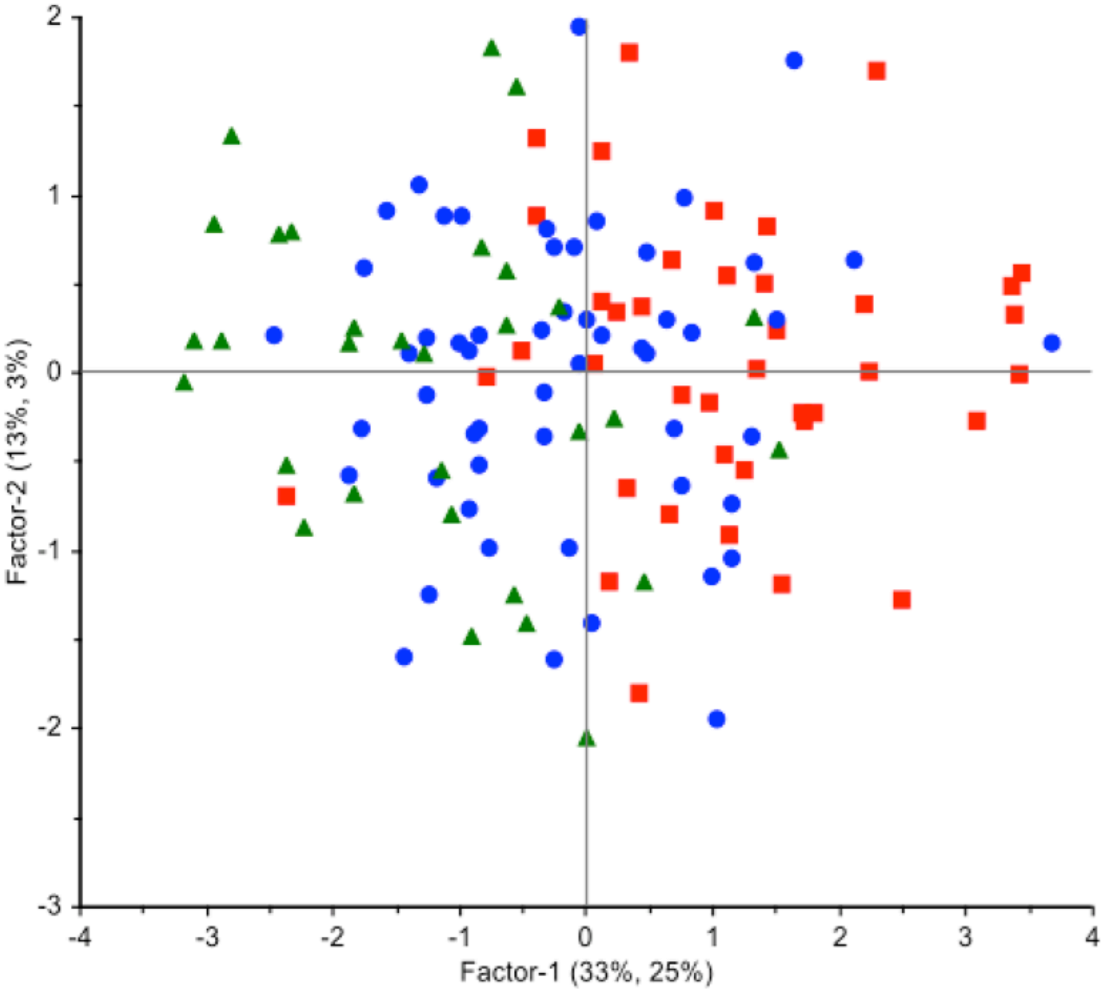


Figure 4.11 PLS regression score plot (a) and correlation loading plot (b) of the D-scores from VM-IAT vs. the following X variables: Prospective Taking (PT-IRI), Pathogen Disgust (PD-TDDS), General Health Interest (GHI-HTA), Natural Product Interest (NPI-HTA), Human-Animal Emotion Similarity (HAES), Human Animal Mental Capacity Similarity (HAMCS) and PROP responsiveness (PROP). Variables in italic were considered as down-weighted. Variance accounted for X and Y for PC1 and PC2 are reported in brackets. Symbols in the score plot represent Omnivores (square), Flexitarians (circle) and Vegetarians (triangle).

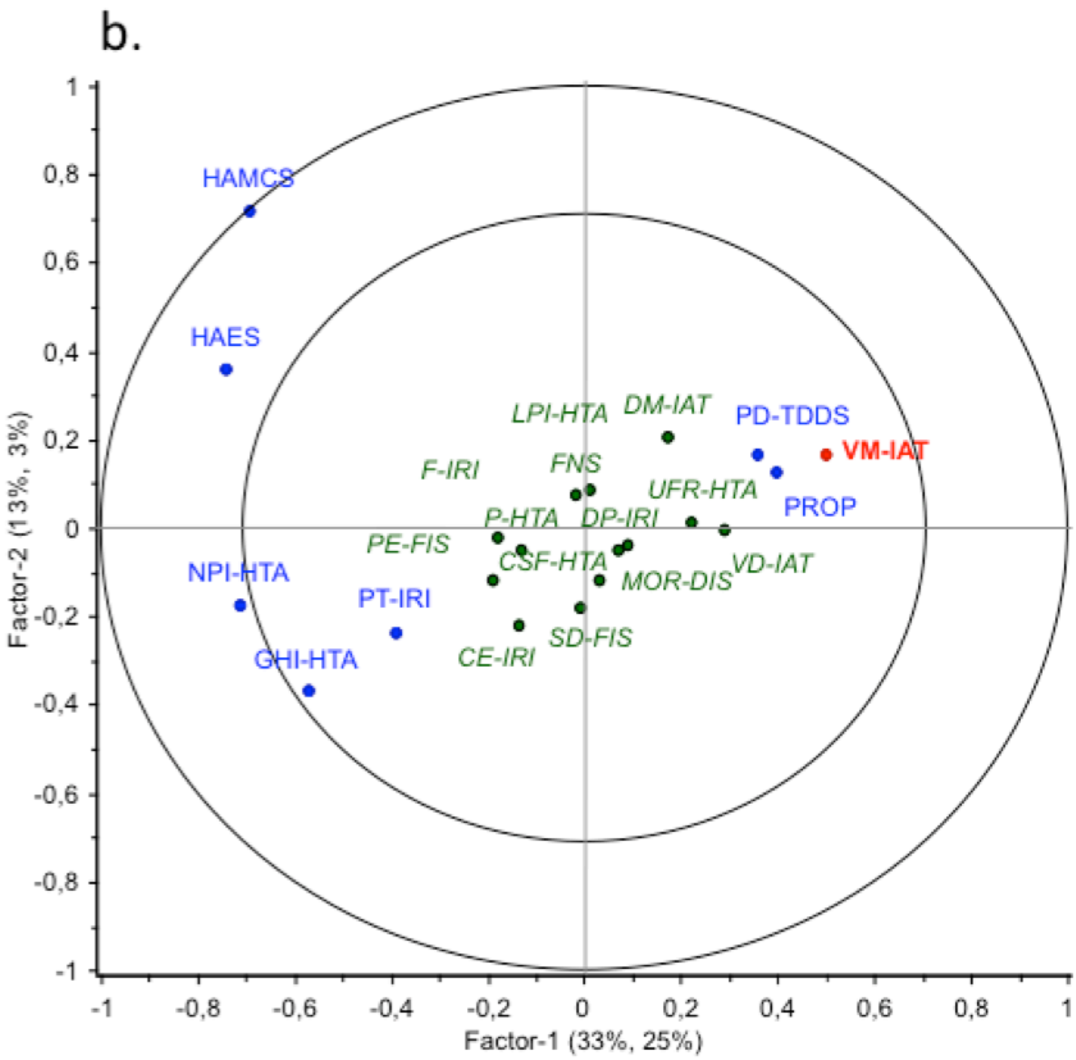


Figure 4.11 Continued

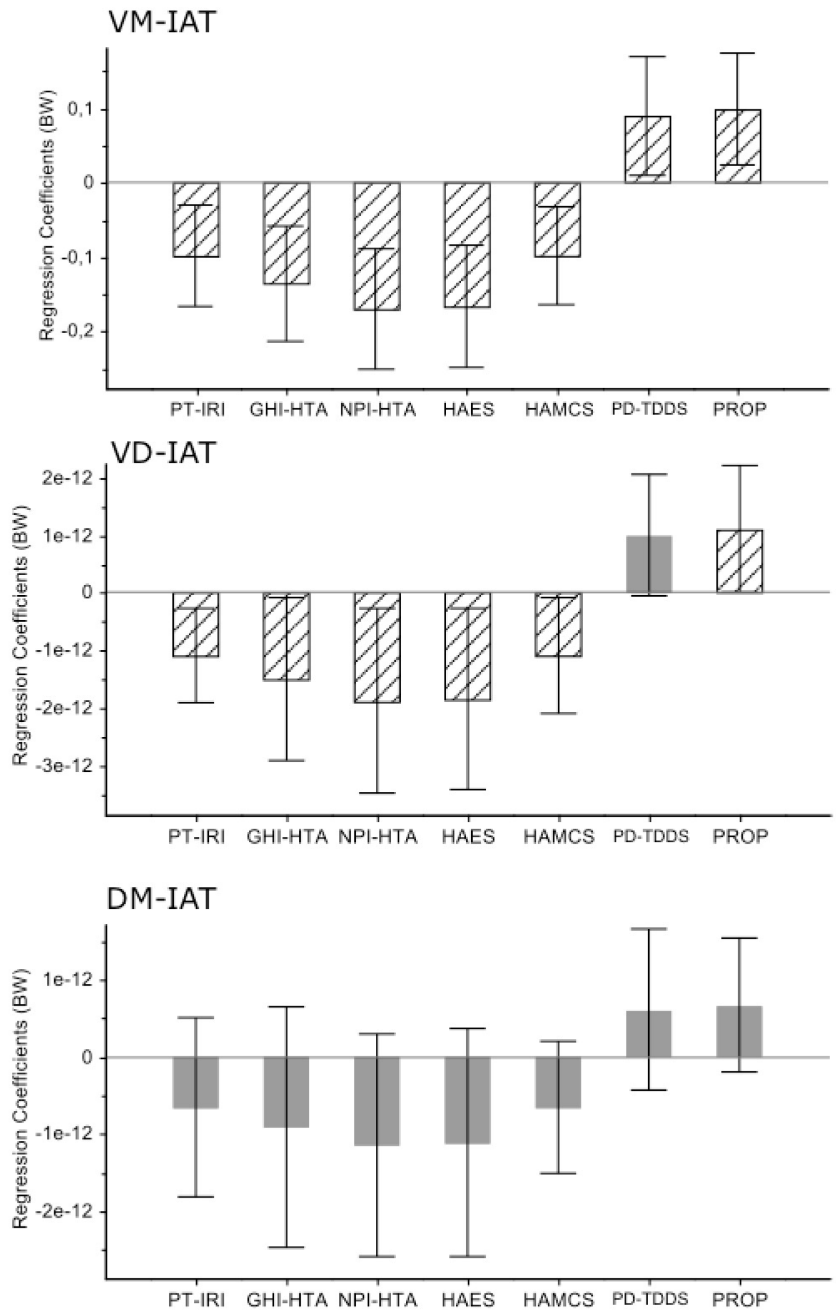


Figure 4.12 PLS weighted regression coefficients displayed with 95% Jack-knife confidence interval for the following X variables: Prospective Taking (PT-IRI), Pathogen Disgust (PD-TDDS), General Health Interest (GHI-HTA), Natural Product Interest (NPI-HTA), Human-Animal Emotion Similarity (HAES), Human Animal Mental Capacity Similarity (HAMCS) and PROP responsiveness (PROP) for the first component of VM-IAT, VD-IAT (down-weighted) and DM-IAT (down-weighted). Variables with interval overlapping 0 (grey bars) are not significant.

5. DISCUSSION

5.1 Study I: Categorization of plant-based dishes and its implications for consumer preferences

5.1.1 Validation of the experimental picture set

In order to study the categorization of plant-based dishes, pictures of culinary preparations of plant-based dishes were selected in order to cover as much variability as possible in the plant-based dish category. The ANOVA validated the graded structure of the category, where the selected pictures varied significantly in typicality, covering all the scale range from neutrality up to maximum typicality. The Check-All-That-Apply procedure validated the sensory variability of the experimental set; the dishes varied significantly for the sensory attributes appropriate to describe them. Taken together these evidences suggest that the pictures included in the study may be representative of the variability of the members of the plant-based dish category in the Italian food culture.

5.1.2 Typicality and family resemblance of the members of the plant-based dish category

The variability in typicality suggests the entity of graded structure that characterizes the category, with some category members more typical than others. The organization of category members in a graded structure has been previously reported for non-food and food items, such as vegetables and fruit (Rosch and Mervis, 1975; Barsalou 1985; Rioux et al., 2016; Smits et al., 2002). The graded typicality of pictures found in this study resulted to be shared among consumers who vary in their levels of familiarity toward vegetables. This aspect suggests that the more and the less typical members were shared among the considered segments. In interpreting this result, it is important to note that the difference in familiarity between the segments was relative. In absolute terms, the segments resulted anyway to share a good basic level of familiarity toward vegetable foods. Considered that the pictures selected for the study represent dishes that belonged to the Italian food culture, with which Italian consumers are generally familiar, the aforementioned considerations can be generalized only for the specific case of dishes that are generally recognized by the consumers.

In order to facilitate the discussion about which plant-based dish can be considered more or less typical of the category, pictures were classified based on the recipe typology they belong. Results indicate that category members belonging to the Salads and Boiled vegetables were considered the most typical of the plant-based dish category. An aspect that can characterize these recipe typologies can be the presence of ingredients characterized by bland tastes or with the predominance of sensory barriers such as the bitter taste (Dinnella et al., 2016). On the other side, category members where vegetables are present as condiment and coupled with starch-based ingredients (e.g. Pasta, Sandwich, Rice, Pizza) were considered as the least typical of the category. Despite not being strictly defined as vegetables, starch-based dishes were included in the category because of the coupling with vegetable ingredients. These results may suggest that the typicality of plant-based dish can be reduced with the inclusion of starch-based ingredients in the dish.

5.1.3 Main features determining typicality

Green, Orange, Bitter and Bland flavor were found to be positive drivers of typicality; this means that when a dish was characterized by these attributes it was associated with a higher typicality - namely, it was perceived as more typical of the category plant-based dish. The importance of color in food categorization has been already highlighted by Macario (1991) and more recently by Rioux et al. (2016), who reported that dark green, orange and red vegetables were associated with higher typicality scores in children 2-6 years old. The bitter taste was reported as a characteristic attribute that describes many foods belonging to the vegetable category (Drewnowski & Gomez-Carneros, 2000) and has been identified as a sensory barrier for the consumption of vegetables (Dinehart et al., 2006). The suggestion to consume more vegetables may be indirectly associated with the suggestion to consume more bitter foods, a possible reason behind the lack of effectiveness of the official dietary recommendations.

Brown and Creamy had the higher negative impact on typicality, independently of the level of familiarity with vegetables. In particular the color brown may be associated to sensory properties that are the result of the non-enzymatic browning (e.g. Maillard reaction) (Hofmann, 2005), reported to enhance taste intensity (Soldo et al., 2003) and to provide a general positive hedonic value.

The terms associated to higher typicality were shared among segments. On the contrary, a lack of consensus was found for the terms associated to lower typicality.

5.1.4 The role of typicality on expected liking

The study of expected liking for members of the category characterized by a specific level of typicality highlighted that in general the more a dish is typical of the plant-based dish category, the less it is liked. This effect was stronger among Lower familiarity consumers compared to Higher familiarity consumers, meaning that the less a consumer is familiar with plant-based dishes, the less is the expected liking when a typical category member is provided. This result seems to contrast with previous studies on categorization that reported a positive relationship between the prototypicality of a category member and the attitude associated with it: more typical items were better liked (see Loken, Barsalou, & Joiner, 2008; Loken & Ward, 1990; Carpenter & Nakamoto, 1996; Folkes & Patrick, 2003). Several explanations for this positive association were provided, mainly related with exposure with the members of the category (exposure increases liking). However, although we observed a less strong relationship in the case of individuals highly familiar with vegetables, we did report a negative relationship with liking even in this case. This result may be specific of food categories, such as the one of plant-based dishes, for which many factors play a role in promoting liking or, inversely, in acting as a barrier to liking, based on individual sensory responses.

A common approach to gain information on the determinants of vegetable preference is based on "between-vegetable" comparisons, based on interview and questionnaire data collection (Jenkis & Horner, 2005; Krølner et al., 2011). Beside this approach, the "within-vegetable" comparison for investigating the hedonic valence of the sensory properties in vegetables has recently gained attention (Dinnella et al., 2016). Considering the "between-vegetable" comparisons, an increase of expected liking may be obtained selecting recipe typologies that were recognized as less typical; for instance starch-based dishes, soups and burgers as highlighted in the present study. Considering the "within-vegetable" comparisons, an increase of expected liking could be obtained by selecting varieties of a plant-based dish characterized by sensory features that are not typical. For instance, wax beans, characterized by the less typical yellow color, might be provided to a vegetables disliker instead of green beans, in order to overcome the sensory barriers that may rise at the moment of vegetables' selection.

5.1.5 The relationships between typicality, liking and healthiness

At a general level, the correlation between typicality and healthiness resulted to be positive while the correlation between typicality and expected liking was found to be negative. This relationships were higher in the Lower familiarity segment compared to the other two, suggesting that among the consumers with a lower familiarity toward vegetables, the more a category member is typical, the more it is perceived as healthy and the least is liked. In addition, the healthiness was negatively correlated with expected liking for all segments, with the exception of the Higher familiarity segment.

These aspects were coherent with the measured attitudes toward healthy foods, where the Lower familiarity segment gave lower importance to health in food choices compared to Intermediate familiarity and Higher familiarity segments. The association between the concept of healthiness and unpleasantness was already documented in the literature, but different associations were reported in different cultures: while in US consumers an implicit association between unhealthy and tastiness was reported (Raghunathan et al., 2006), in French consumers the opposite implicit association (healthy and tastiness) was found (Werle et al. 2013). Our findings may suggest that among Lower familiarity consumers the promotion of vegetables consumption may be not fully effective if based on health reasons, considered that healthiness is associated with disliked foods. A more appealing approach for these consumers may be therefore to motivate consumption through the promotion of hedonic properties of plant-based dishes.

5.2 Study II: Exploring salient dimensions in a free sorting task: a cross-country study within the elderly population

5.2.1 Validation of the vegetable typologies and the experimental sample sets

In order to study the role of sensory and hedonic dimensions in the process of categorization, samples of pea and sweetcorn were selected in order to cover as much sensory space as possible of both vegetable typologies. The DA validated the sensory variability of the experimental sample sets, where the selected samples of pea and sweetcorn varied significantly on the quality and intensity of several descriptors relevant to different sensory modalities.

Pea and sweetcorn products were chosen in order to study the effect of familiarity on the process of categorization. Peas were chosen due to their long presence in European food culture, while sweetcorn was characterized by a recently introduction to the continent. Our results confirmed a high familiarity with peas in each country and age segment considered in the study. Conversely, in the case of sweetcorn, each country and age segment showed a lower familiarity compared to peas. Thus the results confirmed a higher familiarity of pea compared to sweetcorn and a comparable degree of familiarity with the vegetable typologies between the two countries.

Therefore the familiarity toward the tested vegetables resulted generally not affected by the country, probably for an introduction of pea and sweetcorn products in a comparable time frame in both French and Italian food cultures. On the contrary, the age resulted a factor able to affect the familiarity toward the tested vegetables. Considering these assumptions, in order to increase the number of subjects in each age condition we merged French and Italian subjects, allowing a more robust study of the process of categorization during ageing.

5.2.2 Categorization of vegetables across countries and age segments

In the case of the more familiar product, the configuration of samples from FST was comparable between the countries and age segments. The samples were grouped in three main groups in a consistent way among countries and age segments. These evidences suggest that is possible to infer the categorization criteria of a country even using subjects of another country when a comparable level of familiarity is shared. Conversely, in the case of the less familiar product, the similarity between the categorization maps was clearly lower than in the previous case. The samples were grouped in an inconsistent way among countries and age segments, even if tendencies in samples grouping were found. This evidence suggests that different criteria were used to perform the categorization of samples among countries and age segments, where in the latter case the effect may be due to the influence of age on familiarity toward sweetcorn.

5.2.3 The role of sensory and hedonic dimensions in the categorization of vegetables

The study showed that the sensory properties were the main driver of categorization in the case of the more familiar product. In fact the categorization maps depicted the same similarities and differences among vegetable samples described by the trained panel with DA, irrespective of the country and the age segment. The ability of the FST to generate maps comparable with the sensory maps from DA was already reported in adult subjects (Faye *et al.*, 2004; Saint-Eve *et al.*, 2004) and in the present study this was confirmed also in the elderly population in the case of the more familiar product. Considering the less familiar product, the comparison between the categorization maps and the sensory maps highlighted a gradual decrease in similarity with age, thus indicating a reduction in the influence of the sensory dimension in the process of categorization. However this tendency may also mean that the categorization of sweetcorn samples does not reflect differences and similarities in sensory descriptors as perceived by the trained assessors in DA, an aspect that in an elderly respondent may be due to an impaired perception (Schubert *et al.*, 2012) or may be due to the salience of different sensory attributes, such as mouthfeel characteristics (Forde & Delahunty, 2004).

The other potential driver of categorization investigated in the study was the hedonic dimension. The categorization of the more familiar product was more influenced by the sensory dimension than the hedonic one, an aspect already reported in research on foods categorization with adults (Ballester *et al.*, 2008; Chollet & Valentin, 2000). However the hedonic pattern of the samples still partially superimposed the configurations resulting from the FST in each age segment, suggesting that is possible to obtain an indication of the general liking using categorization maps. In the case of the less familiar product, a reduction in similarity between the categorization map and the preference map was detected from Adults to Middle old subjects. In this case, the tendency seems to be due to an issue related to the applicability of the methodology as the internal reliability index of the preference maps decreases with age.

5.2.4 Sensory-cognitive interaction in flavor building

It is noteworthy to consider how in the case of the more familiar product the drivers of sample categorization are shared among Adults and the older age segments, while in the case of the less familiar product they change during ageing. The differences in the categorization of the two vegetables may be due to the use of different processes in products representation. In fact the categorization can be the results of two distinct cognitive paths, namely similarity-based processes (Juslin et al., 2003) and rule-based processes (Ashby et al., 1998). Similarity-based processes rely on exemplar retrieval from memory, where objects are categorized on the basis of their similarity to already known exemplars. On the other hand, rule-based processes are based on the integration of cues (i.e., the characteristics of the objects). Research reports that in categorization tasks, adult subjects tend to rely on similarity-based processes (von Helversen et al., 2010) due to the lower cognitive demand in respect to the rule-based processes. It is possible to hypothesize that consumers may use similarity-based processes when a familiar product is evaluated, with the effect of building the perception of a product on the base of perceptive elements that subjects learned to associate with specific sensory exemplars. An empirical example of this process is provided by Morot et al. (2001), where the red coloration of a white wine led the assessor to elicit smell attributes characteristic of red wines, therefore demonstrating the use of top-down cognitive processes in the building of wine flavor. On the other hand, in the evaluation of an unfamiliar product the absence of previous knowledge may push subjects to use rule-based processes, based on surface properties that are more related to the actual sensory properties of a food. These assumptions therefore suggest that among older adults the lower experience with the less familiar product led to the building of perceptions mainly using surface sensory properties that may change during the ageing due to possible sensory impairments. In the case of the more familiar product the perceptive information was combined with cognitive information from previous experience, thus compensating the eventual perceptive losses that may occur in this population segment.

5.2.5 The applicability of the free sorting task among age segments

In the case of the more familiar product, ageing weakly affected the categorization criteria as indicated by the high level of similarity between the categorization maps among the different age segments. The categorization maps showed a high level of internal reliability in all age segments, suggesting that the ability of categorization remained high during ageing. Furthermore, the high level of similarity between the categorization maps from the Adult reference group and each elderly group suggests that is possible to infer the categorization criteria of a healthy elderly population even using adult subjects when a comparable level of familiarity is shared.

Considering the less familiar product, the map obtained from FST significantly changed across age segments, thus indicating that the criteria used in the classification of samples varied during ageing, possibly because of the lower familiarity with the product. Despite the different spatial FST configurations among age segments, the internal reliability of the maps was high and comparable in each age segment, confirming good capacity in categorizing the samples. Therefore also using a product with a lower familiarity, the FST remains a suitable method for use among healthy older adults. However, the low level of similarity between the categorization map from Adults and the categorization maps from each elderly group indicates that reliable information on categorization criteria can be inferred only by considering the age segment of interest. Overall the results suggest that FST allowed the detection of differences in sample categorization in the different age segments of the elderly population, and so is applicable for older adults. The present research therefore corroborates the good applicability of free sorting methodology with healthy older adults as reported by Withers et al. (2014).

5.3 Study III: The influence of psychological traits, beliefs and taste responsiveness on implicit attitudes toward plant- and animal-based dishes among vegetarians, flexitarians and omnivores

The call for an integrated approach of study has been encouraged in the sensory and consumer science community (Köster, 2009) and a recent example of a multidisciplinary approach in the study on consumers has been provided by the Italian Taste project (Monteleone et al., 2017). Further studied that adopt a similar multidisciplinary approach are therefore needed to better understand the mechanisms involved in eating behaviour. In this context, the main aim of the study was to explore and understand the associations among a selected number of variables in affecting implicit attitudes toward plant-based and animal based-dishes. This question was investigated through a PLS model where the variability in D-scores from three independent IATs was studied in relation to psychological and personality traits, food attitudes, beliefs on food animals and taste responsiveness measures.

5.3.1 The role of food consciousness on implicit attitudes toward plant-based and animal-based dishes

The obtained PLS model highlighted the presence of one main dimension describing the implicit attitudes toward plant-based and animal-based dishes, which we describe as "Food consciousness". This represents the dimension that best describes attitude variability along the first component of the model and was constituted by variables related to health and morality, already reported as drivers of meat and vegetable consumption (Rozin et al., 1997). On the IAT, an increase in the variables related to the Food consciousness resulted in increased positive attitudes toward plant-based dishes and increased negative attitudes toward animal-based dishes, making this dimension the main driver of the considered attitudes.

In addition to the Food consciousness, our model highlighted the influence of psychological traits on implicit attitudes. Empathic responsiveness was found to influence IAT responses, in particular the subscale that measures the ability of the respondent to adopt the perspective of other people. In fact, an increase in this variable resulted in increased positive attitudes toward plant-based dishes and negative attitudes toward animal-based dishes. Our study therefore supports the evidence that subjects with higher empathic responsiveness tend to exclude animal-based foods from their diets (Filippi et al., 2010). A more developed ability to adopt the point of view of "others" may be at the base of an increased consciousness of emotions and mental state experienced by animals, a variable strongly related to negative attitudes toward animal-based dishes.

In line with previous findings (Fessler et al., 2003), we did not find evidence of a relationship between sensitivity to disgust and the specific disgust toward meat highlighted for vegetarians. Our findings showed that subjects did not differ in moral disgust sensitivity, while an increase in pathogen disgust sensitivity was associated with positive attitudes toward meat-based dishes.

Taste responsiveness also influenced implicit attitudes. Our model showed that a higher responsiveness to PROP resulted in negative attitudes toward plant-based dishes and positive attitudes toward animal-based dishes. PROP status was previously examined as a possible explanation for explaining why certain individuals are more likely to become vegetarians (Teller et al., 2011), providing the evidence that moral vegetarians were significantly less sensitive to PROP than non-vegetarians. Therefore these results suggest that bitter sensitivity may influence the adherence to diets rich in plant-based food products, like the vegetarian one. More in general, our findings are coherent with previous research where a higher responsiveness to PROP has been associated with lower vegetables preference (Dinehart et al., 2006) and food choice (Feeney, 2010). PROP responsiveness resulted also positively correlated with pathogen disgust, confirming previous studies that highlighted a relationship between PROP taster status and the visceral components of disgust (Herz, 2011).

Overall these results allow hypothesizing that possible factors that facilitate consumption of plant-based dishes may be a lower responsiveness to bitter taste, a higher knowledge of positive effects of vegetables consumption on health and an increased consciousness of food animals mental state and emotions.

5.3.2 Implicitly measured attitudes toward plant-based and animal-based dishes among declared eating habits

Declared eating habits related to animal food consumption may not reflect actual behavior (Rothgerber, 2014). The measure of attitudes toward plant-based dishes and animal-based-dishes with an implicit measure allowed validating the segments formed on the basis of declared eating habits, through a comparison between declared eating habits and implicitly measured attitudes. In the IAT, where attitudes towards vegetables were studied relatively to attitudes towards meat, the implicit measures agreed with the declared eating habits. In particular, the Vegetarians had more positive attitudes toward plant-based than meat-based dishes to a greater extent than did the Flexitarians, while the Omnivores did not differ in their attitudes. These results thus support previous studies (Barnes-Holmes et al., 2010; De Houwer & De Bruycker, 2007) in showing that the implicit attitudes of vegetarians and non-vegetarians toward meat and vegetables may be detected using the IAT and that implicit attitudes towards vegetables were more positive in vegetarians than in non-vegetarians.

In the IAT in which attitudes towards vegetables were studied relative to the attitudes towards dairy products, the Vegetarians expressed positive attitudes toward plant-based dishes over dairy-based dishes to a greater extent than the other segments, while the Flexitarians and the Omnivores did not show directions in the attitudes. These results suggest that being vegetarian involves a preference toward vegetables over both meat and dairy products, while being flexitarian involves only a preference of vegetables over meat. On the other hand, an omnivorous diet does not imply a preference of one food category over another, suggesting an absence of restrictions in food consumption.

Looking at the individual attitudes, Vegetarians were homogeneous in implicit responses, while Flexitarians and Omnivores showed higher heterogeneity. Differences in D-scores among segments were due to differences in response latencies from the combined-task where the animal category was grouped with positive emotions and the plant category was grouped with negative emotions. Anyway, IAT does not allow saying which one of the two previous pairs was the driver of response latency. A possible suggestion may be derived from De Houwer & De Bruycker (2007), where the use of the Extrinsic Affective Simon Task showed that, compared to non-vegetarians, vegetarians have both a more negative implicit attitude towards meat and a more positive implicit attitude towards vegetables. This evidence therefore indicates that, at least for the IAT where the attitude towards vegetables where studied relatively to the attitude towards meat, both the IAT combinations may be included in the average response latency. Overall, the implicit measures agreed with declared eating habits, therefore validating the segments defined for this study. It is noteworthy that, for the first time, the validity of middle-option consumers such as flexitarians is confirmed not only from an explicit declared measure (Graça et al., 2015) but also by an implicit behavioral measure. These results encourage the use of the IAT as a measure of food preferences.

5.3.3 The role of psycho-attitudinal variables and taste responsiveness on declared eating habits

Our results support the research on cognitive processes that underline the Meat paradox (Loughnan et al., 2010). In fact, as previously reported by Bilewicz et al. (2011), Omnivores fail to recognize food animal's capacity to experience emotion and to posses mental capacities. These data may indicate that, among Omnivores, denying the animals essential psychological characteristics that are commonly perceived as uniquely human solved any cognitive dissonance involved in consuming animals. This may be facilitated by a lower ability to adopt the point of view of the "others" (*Perspective taking*), followed by a lower consciousness of emotions and mental state experienced by food animals compared to the other segments.

In contrast, among Vegetarians, not eating meat is associated with the attribution to animals of more emotions and mental states, while any tendency to dissociate the meat from its origin is limited. Also in this case, aspects that may justify the own diet were highlighted, as suggested by a higher interest in natural products and in general a higher concern about health. The Flexitarians fell between the other two segments, both in terms of empathy toward animals and the strategies to justify meat consumption. The only 'Omnivores strategy' that persisted for this group was the dissociation of meat from its origin. Unlike Omnivores, this segment did not withdraw moral status from animals and therefore in this case, meat consumption, even if limited, was mainly due to denial of the animal origin of meat. Also in this case, the process of limiting meat consumption promoted aspects that justified the consumption of healthier meat substitutes.

Considered together, these results suggest that attitudes toward meat consumption are related to the ability to try to empathize with animals, as a consequence of being able to appreciate the existence of emotions and a mental life of animals. The outcome of this process consists, in different degrees, of limiting meat consumption and in the inclusion in the diet of meat substitutes such as vegetables.

The process of including vegetables in the diet with higher frequency may be influenced not only by ethical aspects or health concerns but also by food taste properties. In this study, the responsiveness to PROP was considered as an index of taste sensitivity. Our results reported that PROP bitterness sensitivity was significantly higher in Omnivores compared to the Vegetarians. Moreover, the Vegetarian group had the highest proportion of PROP non-tasters, while PROP super-tasters were most common among Omnivores. These results are consistent with a recent study

(Monteleone et al., 2017), in which being PROP super-taster was associated with a lower liking and familiarity of bitter vegetables. The results of this study therefore indicate that the sensations experienced eating vegetables may be different among the considered segments, and for Omnivores the bitter perception of some vegetables may be higher compared to the one experienced by Vegetarians. In turn, this suggest that a higher bitter perception may represent a barrier to the inclusion in the diet of meat substitutes such as the vegetables, confirming previous literature on PROP bitterness sensitivity and vegetable consumption (Kaminski et al., 2000).

5.4 General discussion: the contribution of categorization in the study of preference for vegetables

The general aim of this thesis was to explore the contribution of methodologies related to the process of categorization in the study of preference toward vegetable foods among different typologies of consumers.

The representation of the plant-based dish category among consumers was considered of interest in order to obtain a deeper comprehension of how consumers represent the category. This research question was investigated recurring to the prototype theory, in order to evaluate which exemplars of plant-based dishes are more typical of the category, which are the features that characterize the prototype of the category and how these aspects are related to liking of consumers. The study of categorization of plant-based dishes through the prototype theory was useful to highlight the graded typicality of dishes around the prototype. In fact specific recipe typologies (e.g. salads and boiled vegetables) were more typical of the plant-based dish category than others (e.g. soups and burgers). Such information, combined with the valence given to the prototype of the category, can provide an indication of recipe typologies that have more possibility to be accepted by consumers that tend to avoid vegetable foods. For instance, among consumers with lower familiarity toward vegetable, the less the dish is typical the more it is liked, while among subjects with higher familiarity this relation is less evident. Therefore, in addition to liking, knowing the typicality of a plant-based dish can be useful to increase the preference of vegetables dislikers. The prototype theory was also useful for extracting the expected features of the category that may influence the typicality of plant-based dishes. The attributes Bitter, Green and Bland positively influenced typicality, while Brown and Creamy negatively impacted on it. An increase of expected liking may be obtained selecting recipe typologies that were recognized as less typical or, within a recipe typology, selecting culinary preparations with features perceived as less typical of the category. The promotion of consumption of vegetables targeted to vegetables dislikers should therefore consider their representation of the category, in order to limit the exposure to features with a negative hedonic value.

A further research question raised in this thesis was if a categorization-based task, such as free sorting task, could be used among older adults to identify the drivers of categorization of real vegetable foods. Age influenced familiarity toward the tested vegetable typologies, and the level of familiarity was the main factor that affected categorization maps and the information that can be extracted from them. Categorization maps from a familiar product can be potentially used to obtain reliable information of sensory and hedonic dimensions, while maps obtained from a less familiar product depict mainly the sensory variability. This suggests that when older adults are encouraged to elicit sensory and hedonic terms to describe the formed groups of a familiar product, it may be possible to obtain an indication of the sensory properties of the samples and the general direction of liking. Therefore the proposed approach can be useful in overcoming the limits in the use of rating scales in this segment of population, moreover providing an information with high external validity in a rapid and effective way.

A final research question was if the use of both explicit and implicit measurements might be an effective approach to classify with higher reliability consumers' attitudes toward the vegetable foods category and its determining factors. This research question was investigated with the Implicit association test, a method based on categorization that can be used to implicitly measure the attitudes toward specific food categories. The Implicit association test allowed obtaining a behavioral response of attitudes toward plant-based dishes and animal-based dishes categories, used in association with explicit responses to increase the external validity of results. In our research the implicit measures resulted generally in line with declared eating habits, thereby validating the segments considered in the study. This approach can be suggested in particular when considering food products where responses may be influenced by social desirability, which vegetable foods are a good example. The study allowed hypothesizing that factors that facilitate plant-based dishes consumption may be a lower responsiveness to PROP, a lower sensitivity to pathogen disgust, a higher importance of health and natural aspects in the diet and an increased consciousness of food animal mental state and emotions and ability to recognize them. The dimension of food pleasure proved equally important regardless of the eating habits, suggesting the importance of developing and provides plant-based dishes and food products that present a hedonic value comparable to the one experienced with animal-based food sources. The transition from plant-based diet to animal-based diet should therefore embrace multiple aspects, focusing attention on both food sensory properties and consumers' food consciousness.

6. CONCLUSIONS

The aim of this research was to explore the contribution of methodologies related to the process of categorization to study the preference of vegetable foods among different typologies of consumers. For this purpose, methodologies based on prototype theory, real product sorting and implicit measures were considered. All the methodological approaches considered in this thesis resulted able to satisfy the different research questions related to the study of the preference of vegetables, therefore highlighting research opportunities provided by the process of categorization in the study of the preference for vegetables.

The familiarity resulted to play a determinant role on the perception of vegetables and consequent preference. Within vegetables equally familiar among consumers, the perception of them resulted generally comparable, while the valence ascribed to the vegetable category may affect the hedonic responses. Within vegetables not equally familiar, the perception may be different among consumers, with consequent impact on preference. This aspect could be take in consideration when providing new plant-based products or dishes, in order to meet sensory expectations and preference of the targeted segment of consumers.

The results agree on the fact that preference for vegetables resulted to be influenced by the health dimension, while the pleasure dimension, even if important, plays an equal role among vegetables likers and dislikers. Therefore a promotion of the consumption of vegetables could be embracing a double strategy, based on the improvement of communication about health benefits of consumption and based on a consumer-led improvement of sensory properties of vegetables. Considering the latter case, this research highlighted the usability of categorization to obtain useful information regarding the relation between typicality and liking.

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Appendix A. Original papers I-III

Paper I

Cliceri, D., Spinelli, S., Dinnella, C., Ares, G., & Monteleone, E. Categorization of plant- based dishes and its implications for consumer preferences.
In preparation for submission to *Food Research International.*

Categorization of plant-based dishes and its implications for consumer preferences

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Abstract

Beside the suggestion to consume a specific number of portions of vegetables, the comprehension of which items consumers include in the category "vegetable" may be of interest, highlighting possible mismatches between guidelines and consumers. To investigate how consumers categorize vegetables, the study of the "prototype" of the vegetable food category and the features related to the prototype can be of interest. Therefore, the aim of the study was to explore how the plant-based dish category is represented among consumers with a different level of familiarity toward vegetables, in order to investigate the relationships between the typicality of the dishes and of the dish features with expected liking.

One hundred and twenty three consumers with a different level of familiarity toward vegetable foods were considered for the study. Consumers were characterized through two psycho-attitudinal questionnaires: Food Neophobia Scale and Health and Taste Attitudes Questionnaire. A total of 80 pictures of plant-based dishes were evaluated to assess the expected liking, healthiness and preparation level of each dish. Consumers were asked to rate how much each picture was a good example of a plant-based dish in order to evaluate the similarity/difference with the prototype of the category. The sensory features characterizing the prototype were obtained through a features applicability judgment task (Check-All-That-Apply).

The results indicate that specific dishes, such as salads and boiled vegetables, are more typical of the plant-based dish category than others, such as soups and fried vegetables. Typicality affected expected liking for dishes depending on the consumers' level of familiarity toward vegetables. Among consumers with a low level of familiarity toward vegetables, the less a dish is typical the higher the expected liking is. No similar relation was found among consumers with a high level of familiarity. Expected sensory attributes were found to impact on the typicality of a dish. The attributes Bitter, Green and Bland positively impacted on typicality, while Brown, White and Creamy negatively impacted it. The promotion of consumption of vegetables targeted at vegetables dislikers should therefore consider their representation of the category, in order to limit the exposure to features with a negative hedonic value

Key words: Categorization, Typicality, Familiarity, Vegetables, Expectations, Preference

1. Introduction

Besides the suggestion to consume a specific number of portions of vegetables, it is particularly important to understand which items consumers perceive as "vegetables". Comparing dietary guidelines, foods classified as vegetables may be shared or even differ. For instance, the classification of potatoes and tubers, and legumes or pulses as vegetables is controversial (WCRF-AICR, 1997). While potatoes are often considered as vegetables, many dietary guidelines put them together with cereals as starchy foods (Painter et al., 2002). In most cases the legumes are included as vegetables, although sometimes beans are included with meat and fish in the protein-rich foods (Painter et al., 2002). Culinary definitions correspond better to what is understood by consumers (IARC, 2003), highlighting possible mismatches between guidelines and consumers. For instance, children show difficulties in deciding which food items belong to the vegetable group, including chips that are based on corn or potatoes among vegetables (Baranowski et al., 1993; Wind et al., 2005). A deeper understanding of what consumers include in the vegetable foods category may be useful to improve the effectiveness of dietary guidelines and increase the consumption of recognized vegetables.

The categorization is a cognitive process in which objects with common characteristics are grouped and inferences are made about their properties (Rosch & Lloyd, 1978). Storing a category in memory, rather than a complete description of each item, is efficient because fewer bits of information are required to specify the category. In addition, an important advantage of categorizing is a reduced need for learning (Bruner et al., 1956). As a result of the categorization, when a novel item is classified as a member of an existing category, information in that category is transferred to the novel item (Gregan-Paxton 1999; Waldmann, Holyoak, and Fratianne 1995). Prototype theory and Exemplar theory represent two prominent theories of how categories are created in memory (Goldstone et al., 2012). The Prototype theory (Rosch, 1978) assumes that categories are represented by abstract composites, called prototypes. The prototype for a category consists of the most common attribute values associated with the members of the category (Goldstone et al., 2012). Therefore the likelihood of placing an object into a category increases as it becomes more similar to the prototype of the category and less similar to other category prototypes (Rosch & Mervis, 1975). The Exemplar theory (Nosofsky, 1992) assumes that categories are represented by specific, stored instances of the category, rather than by general, abstract prototypes. The new stimulus is assigned to a category based on the greatest number of similarities it holds with the exemplars in that category**.** The two theories are similar in that they emphasize the importance of similarity in categorization, because a new stimulus can be placed into a category only resembling to the prototype or to the exemplars. However, the two theories differ, as the prototype theory suggests that a new stimulus is compared to a single prototype in a category, while exemplar theory suggests that a new stimulus is compared to multiple known exemplars in a category. While a prototype is an abstract average of the members of a category, an exemplar is an actual member of a category. Research suggests that we may use both the exemplar and prototype methods in making category judgments, and they may work together to produce the most accurate conclusions (Mack et al., 2013). Being an abstract concept, a prototype can differ among individuals on the basis of previous exposure and knowledge. In fact, considering the case of plant-based foods, the familiarity toward vegetables has already proved to have an important role in how consumers categorize real samples of vegetables (Cliceri et al., 2017; Rioux et al., 2016). Therefore the study of the prototypes of plant-based dish and the features related to these prototypes can be of interest to investigate how the vegetable food category is defined and organized.

Categories seem to be organized by graded structure (typicality), that means that different members of the same category differ in how typical (or how good an example) they are of the category. Why are some exemplars of the category more typical than others has been a matter of investigation in the last decades. There is now widespread acceptance that an exemplar's typicality depends on its *family resemblance*, that is defined alternatively as an exemplar's average similarity to other category members and its average dissimilarity to member of contrast categories, or as an exemplar similarity to central tendency (Barsalou

1985). Other possible determinants of graded structure have been highlighted: *ideals*, that are characteristic that exemplars should have if they are to best serve a goal associated with their category, *frequency of instantiation*, which is defined as someone's subjective estimate of how often they have experienced an entity as a member of a particular category, and *familiarity*, which is category-independent measure of frequency (Barsalou 1985). While earlier studies found that typicality increased as exemplar become more familiar (Ashcraft 1978; Glass and Meany 1978; Hampton and Gardiner 1983; Malt and Smith 1982), Barsalou (1985) found that familiarity was a much poorer predictor of typicality than frequency of instantiation. The study suggested that familiarity per se does not appear important to graded structure; instead its relation with typicality appears to reflect variance it shares with frequency of instantiation.

The category of vegetables has been investigated in several studies that reported its graded structure (Rosch 1975; Barsalou 1985). A study which compared the categorization of fruits and vegetables in a Dutch sample showed that the knowledge of fruits is represented in a more detailed way than the knowledge of vegetables (Verbeemen et al. 2007). However, because the category of vegetables is within the food category, many factors may contribute in determining the graded structure of the category, associated with the acceptability of the vegetables perceived as food. Acceptability of foods depend on a numbers of factors such as socio-demographics, attitudes and psychological traits, physiological indexes and taste responsiveness (Monteleone et al, 2017). The investigation of individual variables that might affect acceptability can be useful to improve the understanding of consumers' categorization of plant-based dishes. For instance food neophobia (Pliner & Hobden, 1992) has been reported as a psychological trait that may interfere with acceptance of vegetables, considering that neophobia typically results in the rejection of bitter tasting foods (Dovey et al., 2008), of which vegetables are good examples. Also attitudes have been associated with different patterns in preferences for vegetables. People more concerned about health were more prone to include fruits and vegetables in their diet, while avoiding fats and highly processed carbohydrates (Zandstra et al., 2001; Kourouniotis et al., 2016).

Further improvements in the study of the categorization of vegetable foods can be to enhance the external validity of the used stimuli. While previous studies focused on the categorization of vegetables used lists of words (e.g. Smits et al., 2002), the use of pictures of culinary preparation of plant-based dishes can be useful to obtain a more realistic representation of expectations generated during food evaluation. The picture viewing approach has been validated in previous studied in the field of cognitive neuroscience (Wooley & Wooley, 1981; Goldstone et al., 2009), proving to be representative of a natural setting of consumption.

The aim of the study was therefore to explore how the plant-based dish category is represented among consumers with a different level of familiarity toward vegetables. The presented research question was investigated in the context of the prototype theory, in order to evaluate how a number of pictures of plant-based dishes were organized around a prototype. The typicality of each category member was assessed through a question using a Likert scale, while the family resemblance in terms of sensory features between the dishes was measured throughout a features applicability judgment task, using a Check-all-that-apply questionnaire (Adams et al., 2007; Meyners & Castura, 2014). Moreover the study investigated how the expected liking may change for members perceived as more or less typical of the category, and in relation to features characterizing the sensory expectation of the plant-based dish category.

2. Materials and methods

2.1 *Participants*

A total of 123 consumers (females: 66.6%; age: mean = 31.2 years old, SD = 10.1, range = 20 – 67 years old) recruited by means of announcements published on blogs, social networks, emails, pamphlet distribution and word of mouth were involved in the study.

2.2 *Selection of the pictures*

A database of 80 pictures of plant-based dishes was created for this study following the guidelines of Blechert et al. (2014). Pictures of ready to eat dishes were selected by two researchers from open source databases in order to represent the variability of preparations of vegetables in the Italian food culture. To guide the selection, recognized and popular recipes books were consulted (d'Onofrio, 2011; Pedrotti & Pigozzi, 2015). The selection was carried out considering the variability of ingredients, the physical composition and the cooking mode. Only pictures where the food content of the dish was recognizable were considered. Pictures with the presence of meat, fish and dairy products were excluded. The selection included color photographs without symbols or texts and with a minimum resolution of 720 x 540 pixels (72 dpi, RGB format). In order to discard pictures too bright or too dark, only pictures with a grey-scale between 100.000 and 150.000 were considered. After the selection, each picture was modified, removing the surrounding tableware, in order to visualize only the dish content. The evaluation of physical properties of pictures was carried out with ImageJ software (Schneider et al., 2012). The collection of pictures of plant-based dishes resulted in a total of 16 recipe typologies: Boiled vegetables (n = 12), Burgers (n = 1), Couscous (n = 2), Fried vegetables (n = 4), Marinated vegetables (n = 2), Pasta (n = 7), Pizza (n = 1), Purées (n = 5), Rice (n = 6), Roasted vegetables (n = 5), Salads (n = 13), Sandwiches (n = 3), Soups (n = 9), Stewed vegetables (n = 9). A brief description of each picture is reported in Table 1.

2.3 *Pictures evaluation by consumers*

For each picture, consumers were asked to respond to the following sentences in this order:

1. Expected pleasantness of the dish (Expected liking), through the question: "How pleasant would it be to taste this dish?". The answer was provided with a 9-point scale (1 – Not at all pleasant; 9 - Extremely pleasant);
2. Healthiness of the dish (Healthiness), through the question: "How much do you think this dish is healthy?". The answer was provided with a 9-point category scale (1 – Not at all; 9 – Extremely healthy);
3. Level of preparation of the dish (Preparation level), through the question: "How much preparation do you think that this dish needs?". The answer was provided with a 9-point category scale (1 – Little preparation; 9 – A lot of preparation);
4. Typicality of the dish, measured as the extent to which it represented their idea or the category, through the question: "Indicate how much do you agree with the following sentence: this is a plant-based dish". The answer was provided with a 9-point Likert scale (1 – I strongly disagree; 9 – I strongly agree);

5. Family resemblance between the dishes in terms of sensory characteristics. Expected sensory attributes, evaluated through a Check-All-That-Apply questionnaire with 19 terms, presented randomly: 6 related to texture (Firm, Crunchy, Rubbery, Soft, Creamy, Watery), 4 related to taste (Sweet, Sour, Bitter, Salty), 5 related to visual aspects (Green, Yellow, Red, Orange, Brown, White), 2 related to flavor intensity (Tasty, Bland) and 1 related to trigeminal sensations (Pungent).

2.4 *Consumers background*

2.4.1 Socio-demographics

Consumers were asked to declare their own gender, age, height and weight. The Body Mass Index was computed for each respondent and the individual index was used to classify respondents (Underweight: <18.50 kg/m^2; Normal range: 18.50-24.99 kg/m^2; Overweight: 25.00-29.99 kg/m^2; Obese: ≥30.00 kg/m^2) (World Health Organization, 2000).

2.4.2 Familiarity with plant-based foods

A list of 16 vegetables, pulses and cereals (Broccoli, Artichokes, Chicory, Tomatoes, Radishes, Spinach, Zucchini, Cucumbers, Beetroots, Fennels, Asparagus, Chards, Beans, Peas, Sweet corn, Green beans) and 12 plant-based dishes (Grilled eggplant, Eggplant and parmesan cheese, Vegetable soup, Legume soup, Lettuce and valerian salad, Chicory and rocket salad, Cauliflower salad, Carrot salad, Soy sprouts salad, Vegetables crudité, Green olives, Breaded fried olives) was presented. Independently for each item, consumers were asked to indicate the level of familiarity through a 5-point category scale (1: ‘‘I do not recognize the product’’, 2: ‘‘I recognize the product, but I have not tasted it’’, 3: ‘‘I have tasted it, but I do not consume the product’’, 4: ‘‘I occasionally eat the product’’ and 5: ‘‘I regularly eat the product) (Bäckström et al., 2004). An individual index was obtained as the sum of the rating to the twenty-eight items, with the score ranged from 28 to 140, with higher scores reflecting higher familiarity.

2.4.3 Food Neophobia Scale

The trait of food neophobia, defined as the reluctance to try and eat novel foods, was quantified using the Food Neophobia Scale (Pliner & Hobden, 1992). The individual score was computed as the sum of ratings given to the ten statements and ranged from 10 to 70, with higher scores reflecting higher food neophobia levels.

2.4.4 Health and Taste Attitudes Scale

The importance of health and pleasure on food choices was quantified using the Health and Taste Attitudes Scale (Roininen et al., 1999). The Health and Taste Attitudes Scale consists of six subscales: *General Health Interest*, *Light Product Interest*, *Natural Product Interest*, *Craving for Sweet Food*, *Using Food as Reward* and *Pleasure*. For each subscale, the individual score was obtained as the mean of ratings given to the items and ranged from 1 to 7, with higher scores reflecting more positive attitudes.

Table 1. Pictures of plant-based dishes selected for the study: picture code, dish category and brief description of the content. (V = vegetables).

Picture code	*Recipe typology*	*Dish content*	*Picture code*	*Dish category*	*Dish content*
1	Soups	Soup with potatoes, carrots, peas and celery	41	Roasted V	Roasted tomatoes
2	Salads	Salad of broccoli, chickpeas, carrots and valerian	42	Purées	Potatoes purée
3	Purées	Peas pureed soup	43	Marinated V	Marinated artichoke
4	Stewed V	Stewed lentils, carrots and potatoes	44	Salads	Salad with tomatoes, avocado, pepper and radish
5	Sandwiches	Sandwich of salad, avocado, tomatoes and olives	45	Roasted V	Roasted eggplants with tomatoes
6	Stewed V	Stewed beans	46	Soups	Soup with spelt and beans
7	Purées	Pumpkin pureed soup	47	Couscous	Couscous with red peppers and zucchini
8	Salads	Salad with tomatoes, beans, cucumbers, celery	48	Soups	Broth of vegetables with roasted bread
9	Boiled V	Boiled peas and carrots	49	Soups	Soup of spelt and carrots
10	Couscous	Couscous with peas and carrots	50	Boiled V	Boiled broccoli and red peppers
11	Fried V	Fried potatoes	51	Boiled V	Boiled soy sprouts and zucchini
12	Boiled V	Boiled pumpkin	52	Salads	Salad with tomatoes, carrots and radish
13	Stewed V	Boiled Brussels sprouts	53	Stewed V	Stewed peas
14	Soups	Soup of potatoes, tomatoes and carrots	54	Stewed V	Stewed beetroot
15	Purées	Tomato pureed soup	55	Sandwiches	Tomato toast
16	Salads	Salad of rocket, tomatoes, olives and yellow peppers	56	Purées	Pumpkin pureed soup
17	Sandwiches	Tomato toast	57	Pasta	Pasta with asparagus
18	Salads	Salad of cucumbers, green peppers, carrots and salad	58	Salads	Salad with carrots and tomatoes
19	Boiled V	Boiled black cabbage	59	Marinated V	Marinated mushrooms
20	Soups	Soup of chickpeas, mushrooms, rice and cabbage	60	Marinated V	Marinated olives
21	Boiled V	Boiled chard, mushrooms and carrots	61	Stewed V	Boiled broad bean
22	Salads	Salad of carrots, zucchini and almonds	62	Boiled V	Boiled asparagus
23	Salads	Rocket salad with flowers	63	Salads	Salad with chickpeas and radish
24	Soups	Soup of carrots, potatoes and peas	64	Fried V	Chips of vegetables
25	Pasta	Rice pasta with snap peas	65	Pasta	Pasta with tomato and basil
26	Stewed V	Stewed zucchini, snap peas and carrots	66	Burgers	Burgers of vegetables
27	Rice	Risotto with beans	67	Boiled V	Boiled asparagus, peas, celery and carrots
28	Boiled V	Boiled potatoes and green beans	68	Rice	Rice with soy sprouts, broccoli and cauliflowers
29	Soups	Soup of beans, black cabbage and carrots	69	Rice	Risotto with zucchini
30	Boiled V	Boiled carrots	70	Salads	Salad of cucumbers, onion, olives and tomatoes
31	Salads	Salad with tomatoes and avocado	71	Rice	Risotto with mushrooms
32	Pasta	Pasta with tomato sauce	72	Rice	Risotto with peas
33	Stewed V	Stewed carrots	73	Rice	Risotto with pumpkins
34	Salads	Salad of soy sprouts, valerian, carrots and seeds	74	Pasta	Pasta with pesto sauce
35	Boiled V	Boiled potatoes with fennel and celery	75	Pasta	Pasta with tomato and basil
36	Soups	Soup with pasta, chickpeas and carrots	76	Roasted V	Roasted potatoes
37	Boiled V	Boiled broccoli and carrots	77	Pasta	Gnocchi with tomato sauce
38	Stewed V	Stewed chard with seeds	78	Fried V	Fried vegetables
39	Roasted V	Roasted zucchini and mushrooms	79	Fried V	Fried zucchini flowers
40	Roasted V	Grilled onions	80	Pizza	Pizza with broccoli

2.5 *Procedure*

The experimental procedure consisted of three steps carried out in a home test:

1. Q1: socio-demographics and familiarity: At the beginning of the test, Socio-demographics and "familiarity for vegetables" questionnaires were submitted to consumers in an online version. After the conclusion of this part, consumers were involved in the picture evaluation.
2. Q2 - Pictures evaluation: The pictures were evaluated by consumers with an online questionnaire and were provided in two blocks: block 1 (pictures from 1 to 40) and block 2 (pictures from 41 to 80). The order of presentation of blocks and pictures within each block was randomized among participants. Each picture was presented at the beginning of the page, followed by a list of questions (see § 2.3). The evaluation of expected pleasure was always provided before the evaluation of expected sensory properties (Meyners & Castura 2014). The attributes in the Check-All-That-Apply questionnaire were randomized among pictures and consumers. In order to facilitate the evaluation and avoid fatigue, consumers were allowed in each moment to register their progress in the questionnaires, to stop the evaluation and then restart it in a subsequent moment. During the whole test, consumers were asked to carry out the evaluation at least two hours after from the main meals of the day (breakfast, lunch, dinner).
3. Q3 – Attitudes and psychological traits: After the conclusion of pictures evaluation, Food Neophobia Scale and Health and Taste Attitudes Scale questionnaires were submitted to consumers in an online version.

2.6 *Data analysis*

2.6.1 Consumer segments identification and characterization (Familiarity with plant-based foods)

Three segments of consumers were obtained using a cut-off the 33° and 66° percentile computed on the overall distribution of the individual indexes of familiarity toward vegetables. Consumers with an index of familiarity below the 33° percentile were defined as the consumers with a relatively low level of familiarity (Lower familiarity segment), consumers with the index above the 66° percentile were defined as consumers with a relatively higher level of familiarity (Higher familiarity segment), while consumers with the index between the 33° and 66° percentile were defined as consumers with an intermediate level of familiarity (Intermediate familiarity segment). The effect of the consumer segments on age and psycho-attitudinal variables was tested using a 1-way ANOVA and LSD, while the effect of the segment on Body Mass Index was tested using Fisher's exact test.

2.6.2 Characterization of pictures

The effect of the picture on the typicality of the dish and the effect of the familiarity segment on the typicality of each single picture was tested using a 1-way ANOVA (Pictures) and LSD test.

The data produced with Check-All-That-Apply were treated as dichotomous responses (checked term = 1; unchecked term = 0) for each of the terms present in the Check-All-That-Apply ballot. The Cochran's Q test was computed on each attribute in order to identify attributes that do not significantly discriminate among pictures (Meyners & Castura, 2014). Significant attributes were considered for the creation of the overall cross tabulation matrix. Data were scaled and submitted to a Correspondence Analysis (Benzécri, 1973) in order to obtain a perceptive map. Expected liking, typicality, healthiness and preparation level variables were projected on the map as supplementary variables.

The correlation between expected liking, healthiness, preparation level and typicality variables was assessed through Pearson correlation coefficient independently for all the participants and for each segment. Regardless the typology of the recipe represented in the pictures, the influence of expected sensory attributes on typicality and expected liking was tested through a Penalty-lift analysis (Ares et al., 2014). If a rating for each product (e.g. liking; typicality, etc.) is collected along with the Check-All-That-Apply data, Penalty-lift analysis can be used to average the variable across all observations for which the attribute under consideration was elicited and across all observations for which it was not elicited. The difference between these two mean values is an estimate of how much the variable changes when an attribute applies compared to when it doesn't apply (impact). The outcome of Penalty-lift analysis is a score for each attribute, where positive scores represent an increase of the dependent variable due do the attribute and negative scores a decrease of the dependent variable due to the attribute. Data analysis was performed with R Statistics Package version 3.2.3 (R Core Team, 2015).

3. Results

3.1 *Segment characterization*

Socio-demographic and psycho-attitudinal variables for consumers with a relatively lower, higher and with an intermediate level of familiarity are reported in Table 2.

Table 2. Socio-demographic and psycho-attitudinal variables for Lower familiarity, Intermediate familiarity and Higher familiarity segments. Mean values followed by different letters are significantly different ($p < 0.05$).

	Segments			*p-value*
	Lower familiarity	Intermediate familiarity	Higher familiarity	
N	41	31	49	
Age (years)	29.4	33.8	31.4	0.411
Gender (females %)	46.3%	66.0%	69.5%	
Body mass index (kg/m^2) (N)				
Underweight (<18.50)	1	0	3	
Normal range (18.50-24.99)	33	26	37	0.905
Overweight (25.00-29.99)	5	4	6	
Obese (≥30.00)	2	1	3	
Index of familiarity (mean score)	104.8 c	116.7 b	126.5 a	<0.001
Food neophobia (mean score)	27.1 a	25.6 a	24.4 a	0.266
Health and taste attitudes (mean)				
General health interest	4.0 b	4.6 a	4.7 a	<0.001
Light product interest	3.7 a	3.2 b	3.2 b	0.050
Natural product interest	3.7 b	4.1 b	4.9 a	<0.001
Craving for sweet food	5.0 a	4.6 a	4.9 a	0.755
Using food as reward	3.9 a	4.2 a	4.4 a	0.642

3.1.1 Socio-demographics

The three segments were formed by young respondents and did not differ according to age, while a higher presence of females in the Higher familiarity segments compared to the Lower familiarity segment was reported. Normal range consumers mainly characterized the three segments and no significant difference of Body Mass Index distributions was found. Despite the relative differences in familiarity, the three segments shared a good level familiarity toward vegetables foods. In fact, in the Lower familiarity and the Intermediate familiarity segments the overall mode on familiarity scores for the listed vegetables was 4 (I occasionally eat the product), while in the Higher familiarity segment the mode was 5 (I regularly eat the product).

3.1.2 Questionnaires: Food Neophobia Scale and Health and Taste Attitude Scale

The Food neophobia questionnaire was shown to be highly internally consistent, with an alpha of 0.86. The three segments were characterized by a low neophobia score and did not significantly differ for the mean FNS score ($F = 1.27$; $p = 0.266$), suggesting a similar attitude toward the consumption of novel foods.

Light Product Interest, *Craving for Sweet Food* and *Using Food as Reward* domains were shown to be highly internally consistent, with an alpha of 0.86, 0.90, and 0.85 respectively. *General Health Interest* and *Natural Product Interest* domains resulted in an acceptable internal consistence, with an alpha of 0.68 and 0.69 respectively. The *Pleasure* domain resulted in a low internal consistence (alpha = 0.30) and for this reason it was not further considered in the study. Overall the three segments showed positive attitudes toward healthy food consumption, with the exception of *Light Product Interest* domain. The Intermediate familiarity and the Higher familiarity segments were characterized by higher scores in *General Health Interest* compared to the Lower familiarity segment ($F = 15.31$; $p < 0.001$). A significant effect was detected also for the *Natural Product Interest* domain ($F = 25.52$; $p < 0.001$), with a higher interest for the Higher familiarity segment compared to the Intermediate familiarity and Lower familiarity segment. A tendency was found for the *Light Product Interest* domain ($F = 7.12$; $p =0.050$), with a higher interest for the Lower Familiarity segment compared to the Intermediate familiarity and the Higher familiarity segment. Regarding the role of taste on food choices, in general the three segments showed a tendency to positive attitudes toward tasty food consumption with no significant differences between segments (*Craving for Sweet Foods, Using Food as Reward*).

3.2 <u>*Characterization of pictures*</u>

3.2.1 Typicality of dishes (pictures)

The pictures selected for the study varied for typicality, meaning that the level of typicality of the plant-based dish category changed among the considered pictures. The typicality ranged from a minimum reached in picture 32 (mean = 5.57, SD = 2.29) to a maximum reached in picture 50 (mean = 8.79, SD = 0.59). The ANOVA showed that the picture had a significant effect on typicality ($F = 163.6$; $p < 0.001$), with the presence of 54 different groups from LSD test. These results suggest that almost all the variability of positive typicality of the scale was covered.

The ANOVA models computed on typicality scores within each picture did not show any significant effect of segments, with the only exception of picture 7 (Pumpkin pureed soup). Therefore the variability in familiarity among the segments did not affect the typicality of pictures, meaning that overall the dishes were perceived as equally typical of the plant-based dish category.

3.2.2 Typicality for each dish typology

The distribution of the dish typology along the scale of typicality is reported in Table 3. Dish typologies where vegetables are present as an ingredient and coupled with starch-based ingredients (e.g. Pasta, Rice) were present in the first (5.0-5.9) and second (6.0-6.9) scale range. A higher variety of dish typologies was present in the third scale range (7.0-7.9), with a prevalence of starch-free dishes and processed recipes (e.g. Soups, Fried vegetables). Present in the fourth scale range were both dish typologies where the vegetables are cooked (e.g. Boiled and Stewed vegetables) and where the vegetables are raw (e.g. Salads), with the absence of starch-based dishes. The least typical dish resulted starchy-based dish typologies, Burgers and Fried vegetables, while the most typical resulted Boiled vegetables and Salads.

Table 3. Occurrences of dish typologies per scale range and mean of typicality for each dish category.

Recipe typology	*Scale range*				*Typicality*
	5.0-5.9	6.0-6.9	7.0-7.9	8.0-9.0	*(mean)*
Pasta	3	4	1		6.15
Sandwiches		3			6.63
Rice		5	1		6.72
Pizza		1			6.77
Couscous		1	1		7.10
Burgers			1		7.14
Fried vegetables		1	3		7.39
Soups		1	5	3	7.75
Purées		1	1	3	7.84
Marinated vegetables			2	1	7.86
Roasted vegetables			1	4	8.12
Stewed vegetables			2	7	8.15
Boiled vegetables			2	9	8.39
Salads			2	11	8.40

3.2.3 Expected sensory perception of dishes

Results from the Cochran Q test computed on Check-All-That-Apply data showed a significant sample effect for all the 19 attributes ($p < 0.001$) and therefore all the terms were included in data analysis. The representation of the expected perceptive space obtained from Check-All-That-Apply attributes is reported in Figure 1. The first two components of the plot accounted for the 37% of explained variance. In this map it is possible to see how pictures are distributed along the first dimension as function of the occurrences of the descriptors Creamy and Brown at the right side of the map, and the descriptor Crunchy and Bitter at the left side of the map. Along the second dimension, pictures were described as function of the descriptors Red, Spicy and Sour in the positive side of the map and the descriptors Bland, Green and White in the negative side of the map.

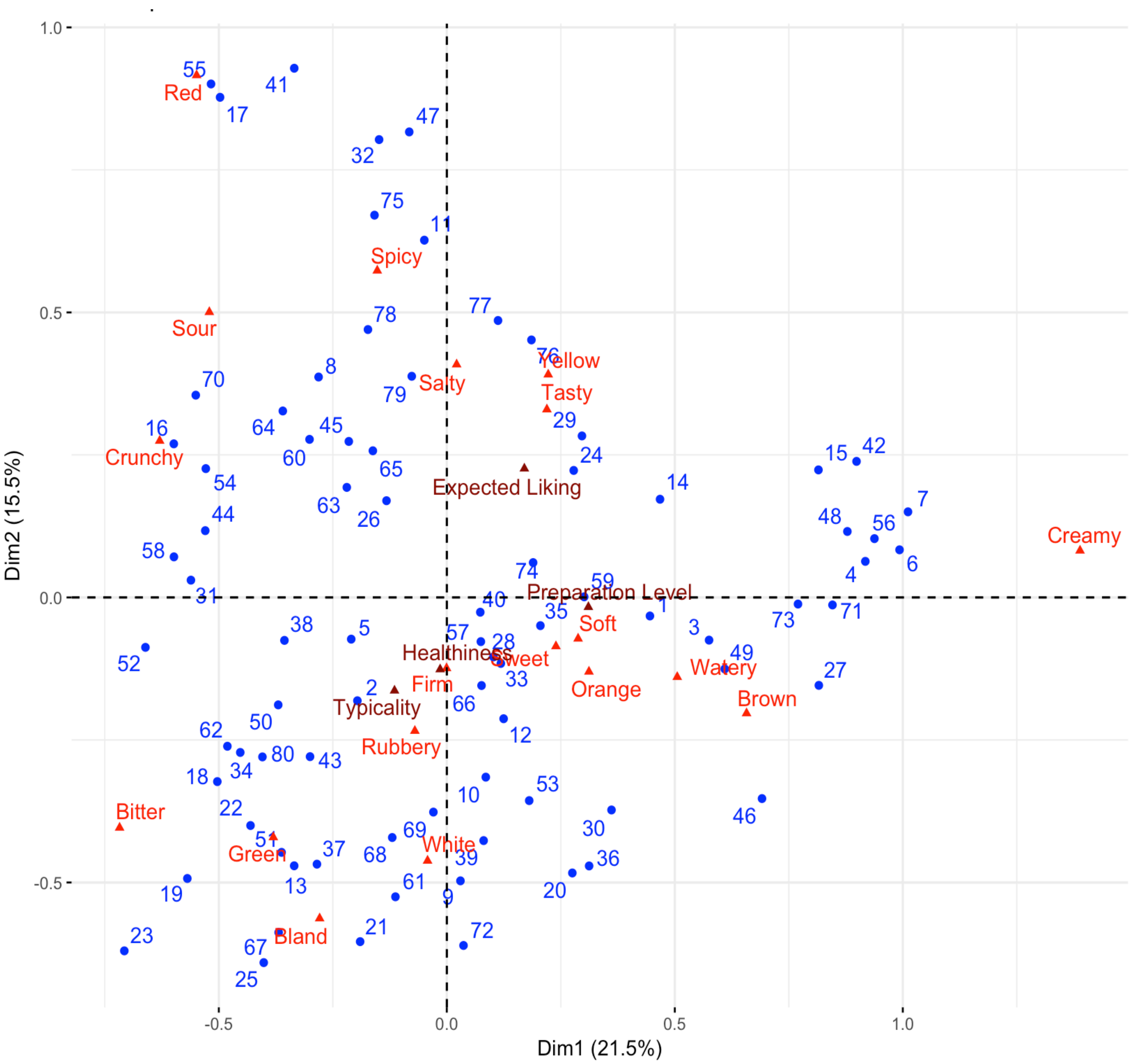

Figure 1. Representation of the terms in the first and second dimensions of the Correspondence Analysis performed on data from the Check-all-that-apply questionnaire.

3.3 *Association between variables describing pictures*

The correlation between the variables used to describe the different dishes is reported in Table 4. For the whole sample of consumers, it is possible to see that typicality was moderately positively related to healthiness and moderately negatively related to expected liking and preparation level. Preparation level was weakly negatively related to healthiness and weakly positively related to expected liking, while expected liking was weakly negatively related to healthiness. Considering the relations within segments, the direction of the correlation follows the same patterns presented for the whole sample of consumers, even if the strength of correlation changes among segments, highlighting an effect of familiarity on the relation among variables. One example is represented by the correlation between typicality and expected liking. This correlation was moderately negative in the Lower familiarity segment, while it was weakly negative among the Higher familiarity segment, with the Intermediate familiarity segment falling between the other two segments. A further example is represented by the correlation between healthiness and expected liking. This correlation was moderately negative in the Lower familiarity segment, weakly negative in the Intermediate familiarity segment, and not significant in the High familiarity segment.

Table 4. Correlation coefficient values between variables describing pictures (healthiness, expected liking, preparation level, typicality) for all consumers and as a function of Lower familiarity, Intermediate familiarity and Higher familiarity segments.

	Preparation level	Expected liking	Healthiness
All consumers			
Typicality	-0.40***	-0.48***	0.49***
Preparation level	1.00	0.27*	-0.24*
Expected liking		1.00	-0.32**
Healthiness			1.00
Lower familiarity			
Typicality	-0.36***	-0.57***	0.58***
Preparation level	1.00	0.30**	-0.23*
Expected liking		1.00	-0.43***
Healthiness			1.00
Intermediate familiarity			
Typicality	-0.30**	-0.45***	0.43***
Preparation level	1.00	0.22	-0.17
Expected liking		1.00	-0.33**
Healthiness			1.00
Higher familiarity			
Typicality	-0.43***	-0.29**	0.45***
Preparation level	1.00	0.25*	-0.26*
Expected liking		1.00	-0.14
Healthiness			1.00

* = p<0.05; ** = p<0.01; *** = p<0.001

3.4 *Impact of* Check-All-That-Apply *attributes on typicality*

The impact of Check-All-That-Apply attributes on typicality is reported in Figure 2. Bitter, Green, Orange and Bland had the higher positive impact on typicality in both the whole sample group and the different segments. Orange, Sweet, Watery and Crunchy also had a positive impact on it. In turn, Brown and Creamy had the higher negative impact on typicality. Yellow, White and Rubbery also seemed to negatively impact on it, even if not in all the segments. The effect of familiarity with vegetables was limited but also in this case was present. For instance, in the Lower familiarity segment the attribute Tasty resulted in a negative impact on typicality, while in the Intermediate familiarity and in the Higher familiarity segments it was not found to have a significant impact. Red, Firm, and Spicy were not found to significantly drive typicality in any segments.

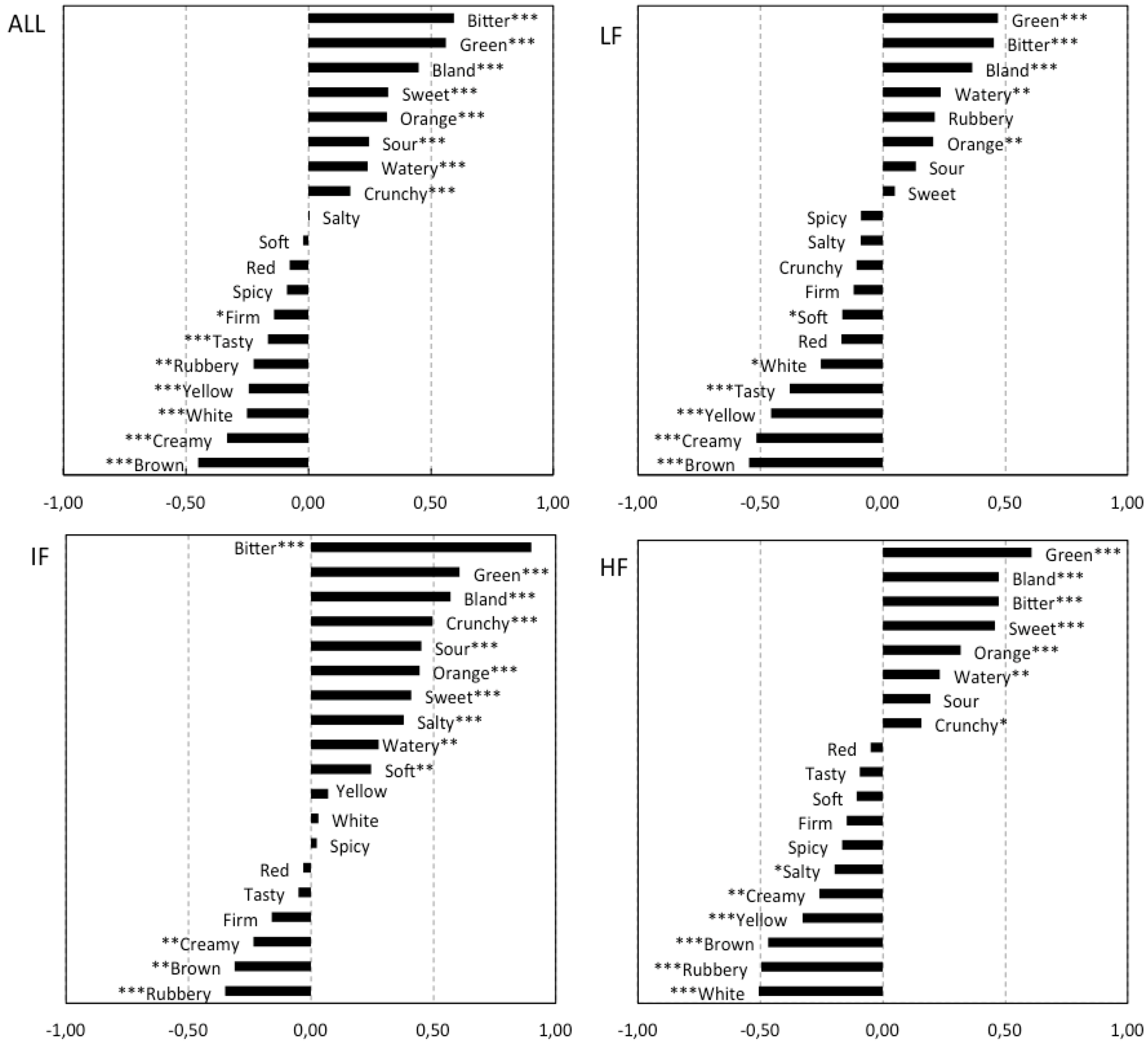

Figure 2. Penalty-lift analysis: impact of Check-All-That-Apply attributes on typicality for all consumers (ALL) and as a function of Lower (LF), Intermediate (IF) and Higher (HF) familiarity segments.

3.5 _Impact of Check-All-That-Apply attributes on expected liking_

The impact of Check-All-That-Apply attributes on expected liking is reported in Figure 3. Considering both the whole sample group and the different segments, Tasty and Creamy are found to be the most important drivers of expected liking. Salty, Sweet, Red, Yellow, and Soft also seemed to positively impact on it. In turn, Bland, Bitter and Rubbery had the highest negative impact on expected liking. Watery and Green also seemed to negatively impact on it. The effect of familiarity on responses can be highlighted also in this case, with a higher variability compared to the case of typicality. For the Lower familiarity segments the attribute Bitter had a stronger negative impact on expected liking, while in the Intermediate familiarity and Higher familiarity segments the relation between Bitter and expected liking seemed weaker. In the Lower familiarity segment the attribute Sour had a negative impact on expected liking, while in the Intermediate familiarity and Higher familiarity segments it had a positive impact. A further example is provided by the attribute Green, that in the Lower familiarity and Intermediate familiarity segments was found to have a negative impact on expected liking, while in the Higher familiarity segment did not significantly impact on it. Brown and White terms were not found to impact significantly the expected liking.

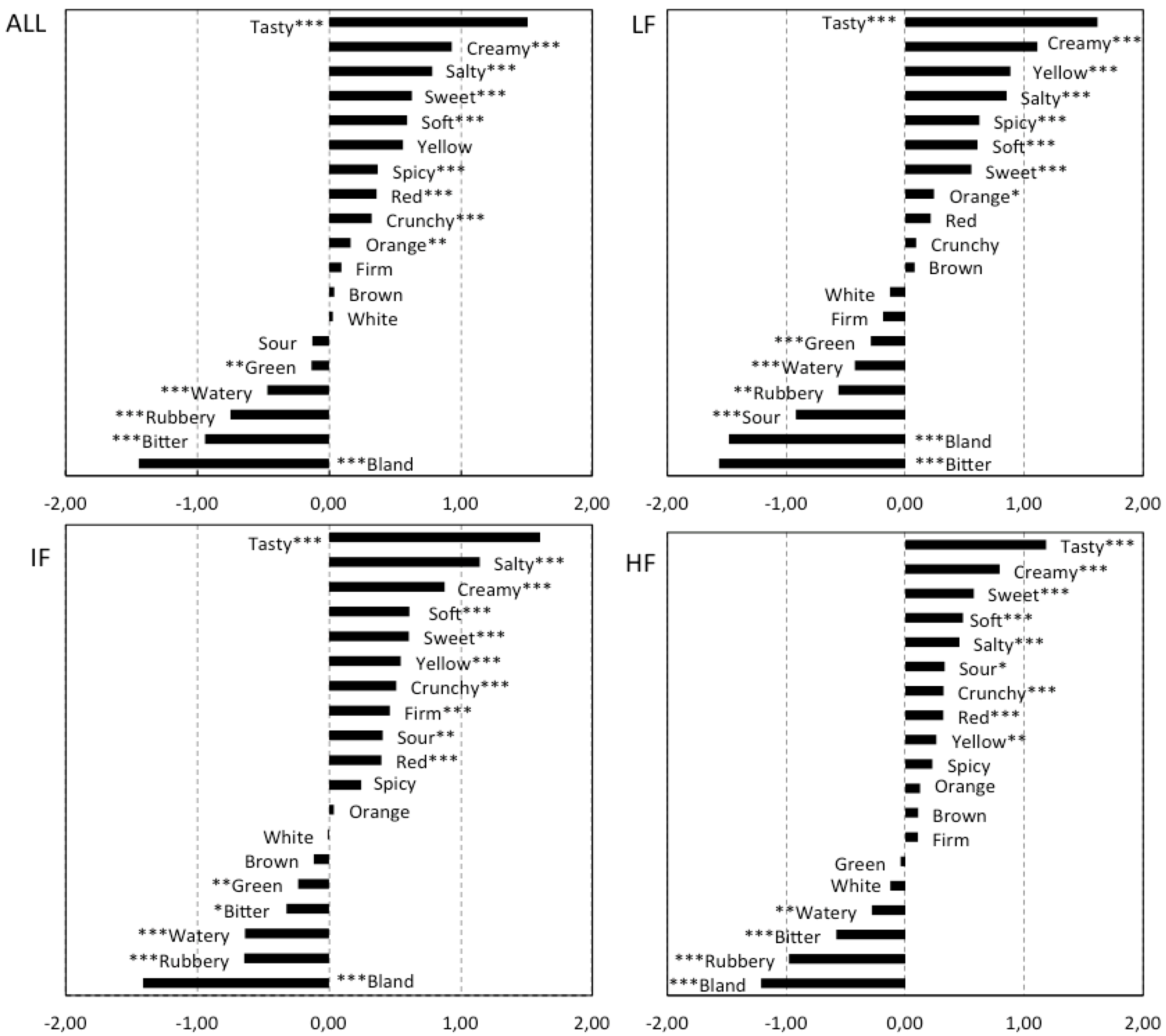

Figure 3. Penalty-lift analysis: impact of Check-All-That-Apply attributes on expected liking for all consumers (ALL) and as a function of Lower (LF), Intermediate (IF) and Higher (HF) familiarity segments.

4. Discussion

4.1 *Validation of the experimental picture set*

In order to study the categorization of plant-based dishes, pictures of culinary preparations of plant-based dishes were selected in order to cover as much variability as possible in the plant-based dish category. The ANOVA validated the graded structure of the category, the selected pictures varying significantly in typicality, covering all the scale range from neutrality up to maximum typicality. The Check-All-That-Apply procedure validated the sensory variability of the experimental set; the dishes varied significantly for the sensory attributes appropriate to describe them. Taken together these evidences suggest that the pictures included in the study may be representative of the variability of the members of the plant-based dish category in the Italian food culture.

4.2 *Typicality and family resemblance of the members of the plant-based dish category*

The variability in typicality suggests the entity of graded structure that characterizes the category, with some category members more typical than other. The organization of category members in a graded structure has been previously reported for non-food and food items, such as vegetables and fruit (Rosch and Mervis, 1975; Barsalou 1985; Rioux et al., 2016; Smits et al., 2002). The graded typicality of pictures found in the study resulted to be shared among consumers who vary in their levels of familiarity toward vegetables. This aspect suggests that the more and the less typical members were shared among the considered segments. In interpreting this result, it is important to note that the difference in familiarity between the segments was relative. In absolute terms, the segments resulted anyway to share a good basic level of familiarity toward vegetable foods. Considered that the pictures selected for the study represent dishes that belonged to the Italian food culture, with which Italian consumers are generally familiar, the aforementioned considerations can be generalized only for the specific case of dishes that are generally recognized by the consumers.

In order to facilitate the discussion about which plant-based dish can be considered more or less typical of the category, pictures were classified based on the recipe typology they belong. Results indicate that category members belonging to the Salads and Boiled vegetables were considered the most typical of the plant-based dish category. An aspect that can characterize these recipe typologies can be the presence of ingredients characterized by bland tastes or with the predominance of sensory barriers such as the bitter taste (Dinnella et al., 2016). On the other side, category members in which vegetables are present as condiment and coupled with starch-based ingredients (e.g. Pasta, Sandwich, Rice, Pizza) were considered as the least typical of the category. Despite not being strictly defined as vegetables, starch-based dishes were included in the category because of the coupling with vegetable ingredients. These results may suggest that the typicality of plant-based dish can be reduced with the inclusion of starch-based ingredients in the dish.

4.3 *Main features determining typicality*

Green, Orange, Bitter and Bland flavor were found to be positive drivers of typicality; this means that when a dish was characterized by these attributes it was associated with a higher typicality - namely, it was perceived as more typical of the category plant-based dish. The importance of color in food categorization has been already highlighted by Macario et al. (1991) and more recently by Rioux et al. (2016), who reported that dark green, orange and red vegetables were associated with higher typicality scores in children 2-6 years old. The bitter taste was reported as a characteristic attribute that describes many foods belonging to the vegetable category (Drewnowski & Gomez-Carneros, 2000) and has been identified as a sensory barrier for the consumption of vegetables (Dinehart et al., 2006). The suggestion to consume more vegetables may be indirectly associated with the suggestion to consume more bitter foods, a possible reason behind the lack of effectiveness of the official dietary recommendations.

Brown and Creamy had the higher negative impact on typicality, independently of the level of familiarity with vegetables. In particular the color brown may be associated to sensory properties that are the result of the non-enzymatic browning (e.g. Maillard reaction) (Hofmann, 2005), reported to enhance taste intensity (Soldo et al., 2003) and to provide a general positive hedonic value.

The terms associated to higher typicality were shared among segments. On the contrary, a lack of consensus was found for the terms associated to lower typicality.

4.4 *The role of typicality on expected liking*

The study of expected liking for members of the category characterized by a specific level of typicality highlighted that in general the more a dish is typical of the plant-based dish category, the less it is liked. This effect was stronger among Lower familiarity consumers compared to Higher familiarity consumers, meaning that the less a consumer is familiar with plant-based dishes, the less is the expected liking when a typical category member is provided. This result seems to contrast with previous studies on categorization that reported a positive relationship between the prototypicality of a category member and the attitude associated with it: more typical items were better liked (see Loken, Barsalou, Joiner 2008, Loken and Ward 1990; Carpenter and Nakamoto 1996; Folkes and Patrick 2003; Simonin and Ruth 1998; Veryzer and Hutchinson 1998). Several explanations for this positive association were provided, mainly related with exposure with the members of the category (exposure increases liking). However, although we observed a less strong relationship in the case of individuals highly familiar with vegetables, we did report a negative relationship with liking even in this case. This result may be specific of food categories, such as the one of plant-based dishes, for which many factors play a role in promoting liking or, inversely, in acting as a barrier to liking, based on individual sensory responses.

A common approach to gain information on the determinants of vegetable preference is based on "between-vegetable" comparisons, based on interview and questionnaire data collection (Jenkis & Horner, 2005; Krølner et al., 2011). Beside this approach, the "within-vegetable" comparison for investigating the hedonic valence of the sensory properties in vegetables has recently gained attention (Dinnella et al., 2016). Considering the "between-vegetable" comparisons, an increase of expected liking may be obtained selecting recipe typologies that were recognized as less typical; for instance starch-based dishes, soups and burgers as highlighted in the present study. Considering the "within-vegetable" comparisons, an increase of expected liking could be obtained by selecting varieties of a plant-based dish characterized by sensory features that are not typical. For instance, wax beans, characterized by the less typical yellow color, might be provided to a vegetables disliker instead of green beans, in order to overcome the sensory barriers that may rise at the moment of vegetables' selection.

4.5 *The relationships between typicality, liking and healthiness*

At a general level, the correlation between typicality and healthiness resulted to be positive while the correlation between typicality and expected liking was found to be negative. This relationships were higher in the Lower familiarity segment compared to the other two, suggesting that among the consumers with a lower familiarity toward vegetables, the more a category member is typical, the more it is perceived as healthy and the least is liked. In addition, the healthiness was negatively correlated with expected liking for all segments, with the exception of the Higher familiarity segment.

These aspects were coherent with the measured attitudes toward healthy foods, where the Lower familiarity segment gave lower importance to health in food choices compared to Intemediate familiarity and Higher familiarity segments. The association between the concept of healthiness and unpleasantness was already documented in the literature, but different associations were reported in different cultures: while in US consumers an implicit association between unhealthy and tastiness was reported (Raghunathan et al., 2006), in French consumers the opposite implicit association (healthy and tastiness) was found (Werle et al. 2013). Our findings may suggest that among Lower familiarity consumers the promotion of vegetables consumption may be not fully effective if based on health reasons, considered that healthyness is associated with disliked foods. A more appealing approach for these consumers may be therefore to motivate consumption through the promotion of hedonic properties of plant-based dishes.

5. Conclusions

In the context of promoting the consumption of vegetables among consumers, this research aimed to explore the categorization of pictures of plant-based dishes and its relation with expected liking, familiarity and sensory properties of the culinary preparations. The study highlighted that specific recipe typologies (e.g. salads and boiled vegetables) were perceived as more typical of the plant-based dish category than others (e.g. soups and burgers). The expected sensory features influenced the typicality of dishes. The attributes Bitter, Green, Orange and Bland positively impacted typicality, while Brown and Creamy impacted it negatively. Among consumers with lower familiarity, the less the dish is typical the more it is liked, while among consumers with higher familiarity this relation is less strong. Therefore an increase of expected liking may be obtained selecting recipe typologies that were recognized as less typical or, within a recipe typology, selecting ingredients and culinary preparations characterized by attributes perceived as less typical of the category. The promotion of consumption of vegetables targeted to vegetables dislikers should therefore consider their representation of the category, in order to limit the exposure to features associated with a negative hedonic value.

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Paper II

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Exploring salient dimensions in a free sorting task: A cross-country study within the elderly population

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ABSTRACT

Free sorting tasks have been widely applied on different age segments to study the categorization of foods. However the method has received little attention in the investigation of older adults' perception. Given the importance of understanding elderly perceptions in order to develop acceptable products, the main objective of this study was to investigate the factors that were able to affect the categorization of samples within different age segments of the healthy elderly consumers. Furthermore, in order to support the obtained configurations, the applicability of a free sorting task within different age segments of elderly population was investigated.

The role of familiarity was considered to better understand the process of food categorization. A free sorting and a liking task were applied on French and Italian elderly to study perception and preference of familiar (peas) and less familiar (sweetcorn) vegetables. Similarities between the categorization maps, the preference maps and the sensory maps from vegetable samples were assessed through the RV coefficient and map visual inspection.

Familiarity with the product was the main factor affecting the categorization among elderly. Categorization maps from a familiar vegetable were found to be suitable to obtain information on sensory and hedonic dimensions, while maps obtained from a less familiar vegetable mainly depicted sensory variability. The free sorting task was found to be a suitable method to use with healthy older adults, that allowed the detection of differences in the categorization of stimuli even among the more aged representatives of the elderly population.

1. Introduction

Population ageing represents one the most important global demographic trends of this century, considering that in 2050 one person in three will be elderly (United Nations, 2015). In order to maintain high levels of health during the lifespan and avoid an excessive burden on health and care services, it is vital to adopt strategies to increase healthy life expectancy. One way to promote a healthy life is undoubtedly to have a balanced diet that satisfies the nutritional requirements of the age segment. Aging is associated with an augmented risk of malnutrition (Hickson, 2006), which can lead to sarcopenia (Cruz-Jentoft et al., 2010) and subsequent frailty and dependency (Roubenoff, 2000). To prevent this negative spiral of inadequate food intake, malnutrition and the onset of disease, in the last years scholars have called for solutions to prevent malnutrition in older adults through the development of foods and modalities of consumption that consider the needs and preferences of the elderly population (Appleton et al., 2016; Giacalone et al., 2016; Nyberg et al., 2015).

The study of elderly consumers requires investigative tools that allow evaluation of the perceptions and preferences of this segment of the population in an effective and reliable way, while the majority of the methods used to study consumers' responses were developed with younger adults, without taking into account the physical and cognitive difficulties that may be present in elderly subjects. In healthy older adults most sensory and consumer methods can be applied (Methven, Jiménez-Pranteda, &

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Lawlor, 2016). However the use of consumer tests with this segment of population should be evaluated carefully, due to the possible presence of difficulties related to the comprehension and use of rating scales (Dermiki et al., 2013), difficulties in the use of introspection processes, and a general tendency to have cognitive and perceptive fatigue with long and complex methodologies (Methven et al., 2016). A methodology with big potential, yet to be fully explored with older adults is the free sorting task (FST).

The free sorting task is a method based on categorization, a natural cognitive process where objects with common characteristics are grouped and inference is made about their properties, in order to obtain considerable information with minimum cognitive effort (Rosch & Lloyd, 1978). The method has been shown to be easily applicable with consumers considering that little training is required, quantitative rating systems are not requested, and in general the method is based on a simple and spontaneous cognitive process. In FST, subjects are provided with a varied number of samples and asked to evaluate and group them on the basis of their subjective criteria. Research involving FST on food products has highlighted the importance of the sensory dimension as categorization criteria, and demonstrated that the maps from FST are often found highly correlated with the sensory maps obtained with descriptive analysis (DA) (Cartier et al., 2006). A further dimension relevant in food product categorization is the hedonic one (Ballester, Patris, Symoneaux, & Valentin, 2008; Chollet & Valentin, 2000), even if only a limited effect on the structuring of similarity space is reported. Moreover different studies have highlighted a role for familiarity in foods categorization, where subjects with previous experience with the tested products tend to use higher-level types of categorization such as those based on the extrinsic properties of food (Ballester et al., 2008; Solomon, 1997). The role of familiarity in the categorization of food products has emerged also in cross-cultural studies, where cultures with different levels of familiarity with the tested products provide different spatial representations of them (Blancher et al., 2007; Chrea et al., 2004). In the domain of consumer research, FST has been used with children (Morizet, Depezay, Combris, Picard, & Giboreau, 2012; Varela & Salvador, 2014), adolescents (Bucher, Collins, Diem, & Siegrist, 2016) and adult respondents (Deegan, Koivisto, Näkkilä, Hyvönen, & Tuorila, 2010; Lawless, Sheng, & Knoops, 1995; Lelièvre, Chollet, Abdi, & Valentin, 2009; Nestrud & Lawless, 2010; Santosa, Abdi, & Guinard, 2010). The only study, of which we are aware, that has investigated the use of FST with food samples in older adults was carried out by Withers and colleagues (Withers et al., 2014). In this research, a variation of the basic sorting task, called Taxonomic free sorting, was coupled with hedonic liking ratings to produce an external preference map from consumer data. The study demonstrated the applicability of sorting methodologies with healthy older adults in general. However, the authors did not explore the applicability among different age segments of the elderly population, while the elderly population, despite often being considered as a single group, contains subjects that may differ considerably in perceptual abilities (Song, Giacalone, Bølling Johansen, Frøst, & Bredie, 2016) and in their familiarity with and liking for different food products (Mingioni et al., 2016). Hence, the variability within older adults may affect the main dimensions driving the categorization of food products.

Given the importance of understanding elderly's perceptions in order to develop acceptable products, the main objective of this study was to investigate the factors that were able to affect the categorization of samples within different age segments of the healthy elderly population. The influence of the sensory dimension on the process of categorization was studied by comparing the categorization map obtained from FST against the sensory map from a conventional DA, while the influence of the hedonic dimension was studied by comparing the categorization map against the preference map obtained from a liking task, considering the same subjects. In order to investigate the role of familiarity on the process of categorization, the study was carried out on food typologies with a different level of familiarity and in two different food cultures, that is the French and Italian one. Furthermore, in order to support the validity of the obtained FST configurations, the applicability of a free sorting task within different age segments of elderly population was investigated.

Considering the importance of promoting the intake of healthy foods, the study was conducted using vegetable products. In order to explore an approach where healthy food consumption is increased through the optimization of healthy foods already present in the diet of older adults (Appleton, 2016), the study was carried out using specific typologies of vegetables, which were pea and sweetcorn.

2. Material and methods

2.1. Products and samples

Pea and sweetcorn were selected as vegetable typologies because of their differential adoption in European food culture, where sweetcorn was introduced only in the second part of the 20th century while pea has been present for several centuries (Pelt, 1993). Canned versions of peas and sweetcorn were chosen because of their large availability in the markets of the countries involved in the study and because they represent a convenient way to promote vegetable intake (Kapica & Weiss, 2012). Ten canned pea (codes: A,B,D,E,F,J,L,O,P,Q) and eight canned sweetcorn (codes: H,R,S,T,U,V,W,Z) samples were considered for the study. The amount of each sample needed for the whole study was purchased from the producer company and from the same production batch, then delivered to the Institutions participating in the study. The samples were selected in order to cover as much as possible of the sensory spaces of peas and sweetcorn (i.e. diversity of size, texture, colour, flavour) and DA (Lawless & Heymann, 2010) was carried out in order to confirm and quantify the sensory variability of samples.

2.1.1. Sensory characterization of pea and sweetcorn samples by descriptive analysis

The evaluation of the samples was carried out with two panels trained at the Sensory Lab of Florence University, as already described in Dinnella et al. (2016). Twelve participants, 3 males and 9 females, mean age 29.8 years, were selected for the DA of the pea samples. Eleven participants, 4 males and 7 females, mean age 30.1 years, were selected for the DA of the sweetcorn samples. After sample familiarization and sensory descriptor elicitation, the calibration and performance evaluation of each panel was assessed in three sessions where four samples were presented. Data were analyzed using Panel Check software (ver 1.4.0, Nofima, Tromso, Norway). Panel calibration was assessed using the multi-block PCA (Tucker-1), while assessor performance was assessed using the p∗MSE plot. (Næs, Brockhoff, & Tomic, 2010). Having completed the training, and after performance validation, panels participated in three evaluation sessions. In each session, ten samples of peas or eight samples of sweetcorn were evaluated in two sub-sets. Samples (25 gr) were presented in a 100 cc plastic cup identified by a 3-digit code. Samples presentation was balanced across participants. Pea samples were evaluated at 54-56 °C, while sweetcorn samples were evaluated at room temperature. Evaluations were performed in individual booths under white light for appearance description and under red light for the rest of the attributes. Data were collected with the software Fizz (ver.2.47. B, Biosystemes, Couternon, France).

Sample differences for each attribute were assessed by a three way ANOVA mixed model using assessor and replicate as random factors, while sample was the fixed factor. Differences and similarities in sensory properties among samples were evaluated on a score plot and a correlation loading plot obtained from a Principal Component Analysis (PCA). PCA models were computed on panel averages of each significant sensory attribute ($p < 0.05$) arising from the ANOVA models. Data were analyzed with the software Fizz (ver.2.47.B, Biosystemes, Couternon, France).

The ANOVA model computed on DA data for the pea samples showed a significant sample effect for 23 of the 26 attributes (Table 1). The first two components of the score plot for the pea samples obtained from PCA accounted for 86% of explained variance (Fig. 1a). Results from the ANOVA model computed on DA data for the sweetcorn samples showed a significant sample effect for 15 of the 19 attributes (Table 1). The first two components of the score plot for sweetcorn obtained from PCA accounted for 82% of explained variance (Fig. 2a). F and p-values in Table 1 confirmed that the size of differences between samples in each product set was comparable.

2.2. Samples evaluation by consumers

2.2.1. Participants

Elderly people were recruited at elderly care institutions and leisure facilities for the elderly in Florence (Italy, IT) and Lille (France, FR). The age of subjects covered different age segments of the elderly population (Forman, Berman, McCabe, Baim, & Wei, 1992), with a segment aged from 65 to 69 years (Young old) and a segment aged from 70 to 79 years (Middle old). Demographic details of the participants as a function of country and age segment are reported in Table 2.

All elderly participants had no medical conditions and were able to independently perform the test. Participants aged from 18 to 64 years (Adults) were also recruited in the Florence area as control segment, respectively for the evaluation of the pea samples (34 females, 21 males, mean age 28.0 years) and sweetcorn samples (38 females, 21 males, mean age 36.3 years). Appropriate health and safety considerations, together with a risk assessment protocol, were carried out prior to the commencement of the research. Individual written informed consent was obtained from participants.

2.2.2. Experimental procedure

Pea and sweetcorn samples were evaluated in two independent sessions. The experiment took place in public spaces such as canteens or common rooms. Tests were conducted individually and social interaction was not allowed. The experimental procedure consisted of three steps: 1. Liking test, 2. Collection of questionnaire data, 3. Sorting task.

2.2.2.1. Liking test.

Participants were provided with individual trays with 11 or 9 three-digit coded pea or sweetcorn samples (10 pea samples plus a replicate; eight sweetcorn samples plus a replicate). Twenty-five grams of product were used for each sample. Peas were presented at 54–56 °C in a foam cup sealed with a plastic top. Sweetcorn samples were presented in a plastic cup at room temperature. Presentation order was randomized across participants. Participants were asked to look at the appearance, and to smell and taste a teaspoon of each sample, then they were asked to rate their liking on a horizontal 9-point category scale (Right label: dislike extremely; central label: neither dislike nor like; left label: like extremely). Participants were asked to rinse their mouth with water before starting the evaluation and after each sample.

2.2.2.2. Questionnaire.

After completing the liking task, participants filled in a questionnaire consisting of two sections: 1. Demographic characteristics (age, gender); 2. Familiarity with pea and sweetcorn products on a 5 point category scale (1: "I do not recognize the product", 2: "I recognize the product, but I have not tasted it", 3: "I

Table 1
Sensory attributes of peas and sweetcorn samples: F and p-values resulted from the three way ANOVA computed for each attributed on assessors scores.

	Peas			Sweetcorn		
	Attribute	F	p	Attribute	F	p
Appearance	Green	14.60	<0.001	Yellow	40.44	<0.001
	Colour uniformity	5.66	<0.001	Seed size	17.40	<0.001
	Seed size	96.58	<0.001	Size uniformity	1.40	0.220
	Size uniformity	4.20	<0.001	Swollen	6.43	<0.001
	Swollen	21.95	<0.001	Damaged	11.67	<0.001
	Damaged	22.45	<0.001			
Aroma	o-Raw peas	1.73	0.092	o-Cooked vegetables	0.80	0.593
	o-Cooked peas	4.15	<0.001	o-Acrid	1.75	0.115
	o-Cooked vegetables	3.98	<0.001			
	o-Acrid	1.68	0.105			
	o-Metallic	2.99	0.005			
	o-Onion	3.96	<0.001			
Flavour	f-Raw peas	1.20	0.306	f-Sweet corn	24.25	<0.001
	f-Cooked peas	13.95	<0.001	f-Cooked vegetables	1.44	0.2084
	f-Cooked vegetables	14.33	<0.001	f-Acrid	4.13	<0.001
	f-Acrid	2.32	0.021	Sweet	20.47	<0.001
	f-Metallic	7.40	<0.001	Salty	10.24	<0.001
	f-Onion	6.69	<0.001	Sour	7.68	<0.001
	Sweet	9.16	<0.001	Bitter	7.49	<0.001
	Bitter	5.55	<0.001	Astringent	2.73	0.018
	Sour	5.40	<0.001			
	Umami	10.46	<0.001			
	Salty	14.55	<0.001			
Texture	Skin hardness	8.16	<0.001	Skin hardness	7.08	<0.001
	Softness	19.22	<0.001	Softness	13.52	<0.001
	Melty	10.57	<0.001	Crunchiness	24.95	<0.001
				Thickness	8.25	<0.001

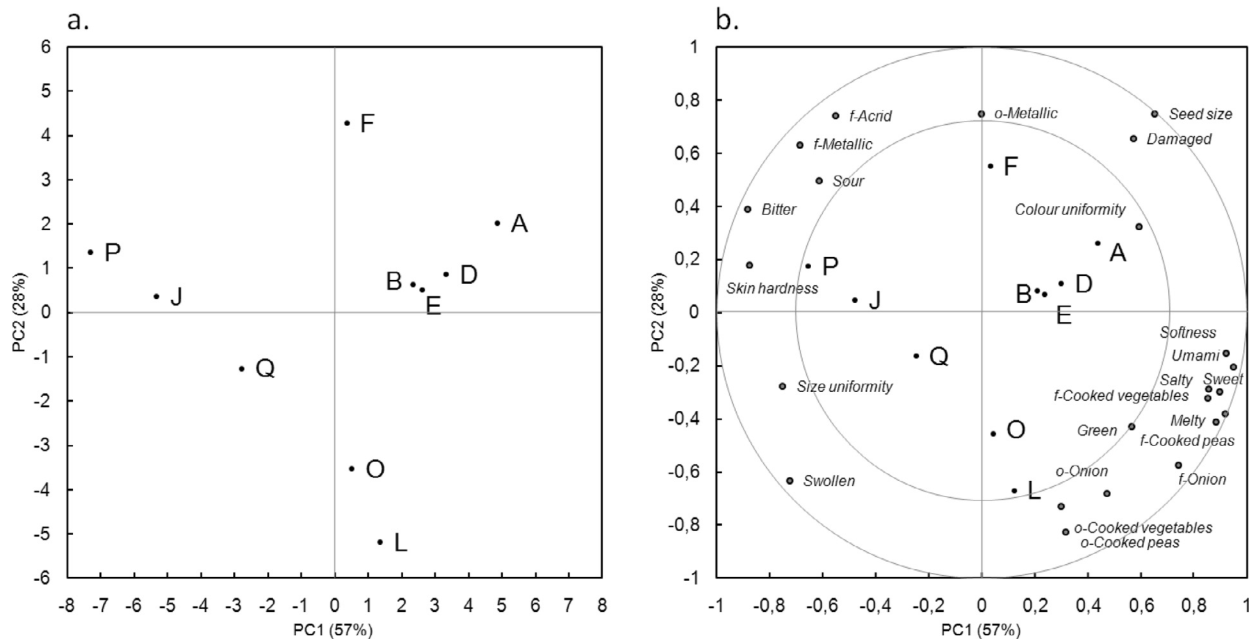

Fig. 1. (a and b). Sensory maps: Score plot (a) and correlation loading plot (b) from PCA on panel averages of each significant attribute ($p < 0.05$) describing the sensory properties of pea samples. In the correlation loading plot outer and inner circles on the map represent 100% and 50% explained variance respectively.

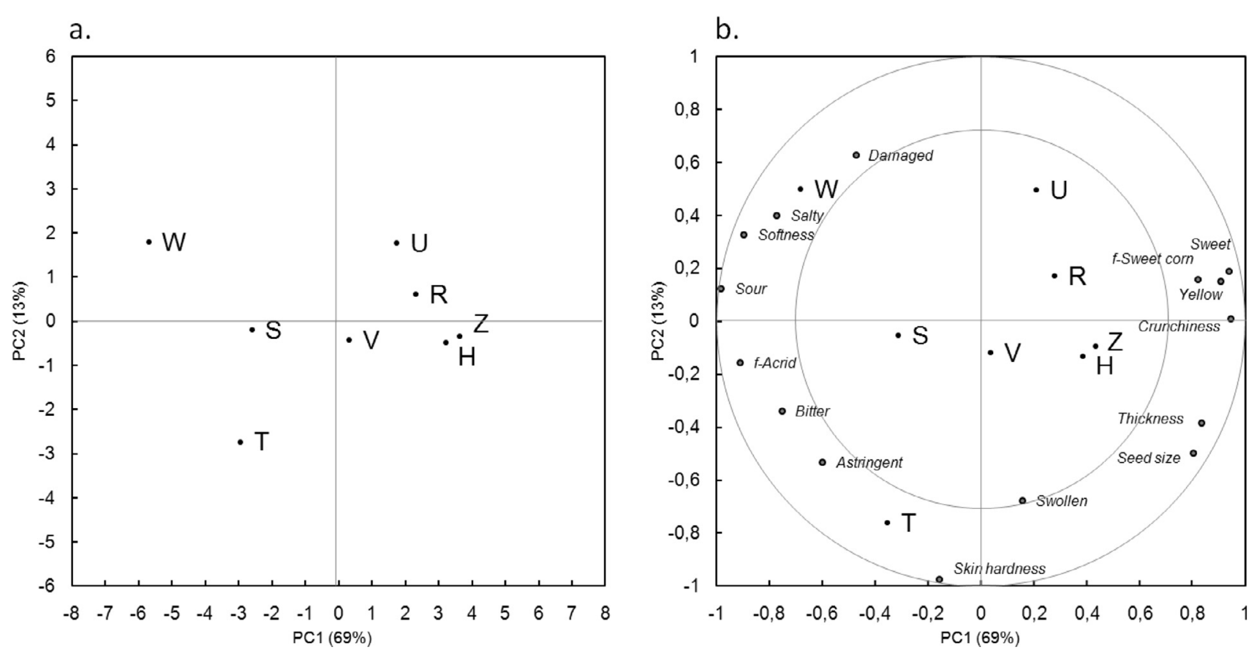

Fig. 2. (a and b). Sensory maps: Score plot (a) and correlation loading plot (b) from PCA on panel averages of each significant attribute ($p < 0.05$) describing the sensory properties of sweetcorn samples. In the correlation loading plot outer and inner circles on the map represent 100% and 50% explained variance respectively.

Table 2
Characteristics of the elderly respondents per product: country, demographics and total number per age segment and country. Values in brackets represent standard deviations.

	Peas					*Sweetcorn*				
	Country		Total	Females	Mean age	Country		Total	Females	Mean age
	France	Italy				France	Italy			
Young old	78	42	120	65.8%	65.7(2.0)	41	41	82	68.3%	65.9(1.9)
Middle old	18	28	46	63.8%	72.8(2.9)	38	28	66	81.8%	73.7(3.0)
Total	96	70	166	65.1%	67.7(3.9)	79	69	148	74.0%	69.4(4.6)
Females	65.7%	61.4%				78.4%	69.5%			
Mean age	67.7(3.2)	68.7(4.8)				69.9(2.7)	69.2(4.9)			

have tasted, but I do not use the product", 4: "I occasionally eat the product" and 5: "I regularly eat the product) (Bäckström, Pirttilä-Backman, & Tuorila, 2004). In this scale, scores increase from lexical/visual knowledge (scores 1 and 2), to a taste experience not associated with consumption (score 3) and to frequency of consumption (scores 4 and 5).

2.2.2.3. Sorting task.
In the last part of the session, subjects were provided with a new tray with 11 or 9 three-digit coded pea or sweetcorn samples (ten pea samples plus a replicate; eight sweetcorn samples plus a replicate). Subjects were asked to observe, smell and taste the samples and then to group them according to their similarities, using their own criteria. Subjects were allowed to taste each sample more than once and were asked to note their groupings, and the characteristics of each group, individually. Subjects were asked to rinse their mouth with water before starting evaluation and after each sample.

2.3. Data analysis

2.3.1. Liking data
Liking data obtained from each product were submitted to a PCA in order to obtain an internal preference map (IPM) for each country and each age segment of participants. Cross-validation (Martens & Martens, 2000) was used to estimate the number of statistically reliable principal components.

As suggested by Lawless & Heymann, 2010 a simple way to check the reliability of a perceptual map is to consider the closeness of blind duplicate samples. These authors specifically suggested this approach to check the reliability of sorting configurations. Considering the several influences on the use of liking rating scale in elderly (Methven et al., 2016), in the present paper the distance between duplicated sample was used to check the internal reliability of internal preference maps computed on liking for pea and sweetcorn samples. In particular here the reciprocal of the percentage ratio of distance (Dr%) was computed. The calculation of Dr% is based on the ratio between the distance of the two replicated samples and the distance of the two most distant samples on the map (Torri et al., 2013).

2.3.2. Questionnaire
The comparison of the familiarity between pea and sweetcorn inside each country was assessed using Wilcoxon rank sum test on scores from the familiarity category scale within each age segment and in total. The comparison of the familiarity with pea and sweetcorn between countries was assessed using Chi-square test on frequencies of each category of the familiarity scale for each age segment and in total.

2.3.3. Sorting data
For each subject a distance matrix was generated, where a value of 0 between a row and a column indicates that the assessor put the samples together, whereas a value of 1 indicates that samples were not put together. Individual distance matrices were submitted to DISTATIS (Abdi, Valentin, Chollet, & Chrea, 2007), a generalization of classical multidimensional scaling that considers individual sorting data. DISTATIS was computed for each country and each age segment, in order to obtain a spatial representation of product similarity in which products are represented by points on a map. The points are arranged in this representation so that the distances between pairs of points reflect the similarities among the pairs of stimuli. The adoption of DISTATIS also allowed consideration of the individual variability in the process of categorization, in this way providing a spatial representation less influenced by assessors that behave differently from others. The internal reliability of the obtained maps was assessed considering the reciprocal of the Dr%. In order to identify groups of samples in each FST configuration, a hierarchical cluster analysis with Ward's criterion was performed on samples coordinates on the first two components (Lelièvre et al., 2009).

2.3.4. Maps comparison
The similarity of the first two dimensions of the maps was assessed considering the RV coefficient (Robert & Escoufier, 1976). The RV coefficient is a measure of the similarity between two factorial configurations, which takes the value of 0 if the configurations are uncorrelated, and the value of 1 if the configurations are homothetic. The minimum RV value that has been considered as an indicator of good agreement between sample configurations ranges from 0.65 to 0.85 (Vidal et al., 2014), therefore a cut-off of 0.75 was considered for this study. With respect to each vegetable, the RV coefficient and its statistical significance was computed for all combinations between the compromise maps from DISTATIS on FST data (categorization maps), the score plots from PCA on DA data (sensory maps) and the score plots from PCA on liking data (preference maps), within each country and age segment. Considering that RV coefficients put particular emphasis on the component with the largest variance, the similarity between maps was assessed also considering a visual evaluation of the configurations as suggested in Tomic, Berget, and Næs (2015).

All analyses on consumer data were conducted with the R Statistics Package version 3.2.1 (R Core Team, 2015) using the FactoMineR package (Le, Josse, & Husson, 2008) and the DistatisR package (Beaton, Fatt, & Abdi, 2013).

3. Results

3.1. Familiarity for pea and sweetcorn products across countries and age segments

In order to evaluate the familiarity for pea and sweetcorn products, familiarity scores from each country and age segments were analyzed independently (Table 3). The sum of scores for each vegetable highlighted that pea typology was in general more familiar than sweetcorn, irrespective to country and age segment. Familiarity with peas was significantly higher than for sweetcorn (rank sum $_{peas}$: 480; rank sum $_{sweetcorn}$: 421; $p < 0.001$) in the Adult control segment too. No significant differences in the distribution of familiarity scores in the scale categories were found for both products when comparing countries, considering the whole sample and within each age segment (Table 4). Irrespective to country and age segment, pea product resulted to be mainly associated with "I regularly eat the product", while sweetcorn resulted mainly associated with "I occasionally eat the product". Overall these results show that pea typology was more familiar than sweetcorn typology, while the familiarity for each vegetable between countries resulted comparable.

3.2. Similarity among categorization, preference and sensory maps

3.2.1. Comparison across countries
The categorization maps obtained from the two countries are shown in Fig. 3. In the case of peas (Fig. 3, a and b), the maps from Italian and French respondents were very similar in terms of relative categorization of the samples. As consequence of the hierarchical cluster analysis performed on samples coordinates on the first two components in each map, three sample groups were identified in both countries (group 1: A, D, B, E, F; group 2: O, L, Q; group 3: J, P). Along the first dimension group 1 was separated from group 2

Table 3
Familiarity with pea and sweetcorn as a function of country and segment for all tasters involved in the evaluation: rank sum of scores and p-values.

	France				Italy		
	Pea	Sweetcorn	p		Pea	Sweetcorn	p
All subjects	812	706	<0.001	*All subjects*	627	506	<0.001
Young old	555	483	<0.001	*Young old*	373	309	<0.001
Middle old	257	223	<0.001	*Middle old*	254	197	<0.001

Table 4
Distribution of subjects' familiarity scores between countries as a function of vegetable product and age segment: occurrences and p-values.

	Pea			Sweetcorn		
	France	Italy	p	France	Italy	p
All subjects						
1	0	0	0.213	1	2	0.220
2	0	1		3	5	
3	6	5		28	52	
4	51	60		100	67	
5	118	74		43	14	
Young old						
1	0	0	0.199	0	0	0.213
2	0	0		2	1	
3	4	2		18	29	
4	32	37		69	44	
5	83	44		30	9	
Middle old						
1	0	0	0.199	0	1	0.265
2	0	0		2	5	
3	2	4		10	23	
4	19	23		31	23	
5	35	30		13	5	

1: "I do not recognize the product", 2: "I recognize the product, but I have not tasted it", 3: "I have tasted, but I do not use the product", 4: "I occasionally eat the product" and 5: "I regularly eat the product".

and 3. The second dimension further separated group 2 from group 3. Furthermore, the replicate samples (O and O') were very close on the maps, meaning that the subjects have frequently sorted them in the same group. The correlation of FST configurations between countries was high for peas (RV = 0.92, $p < 0.001$).

Similarities between the spatial configurations of sweetcorn samples (Fig. 3, c and d) across countries resulted less evident. Sample grouping resulting from the hierarchical cluster analysis showed that in both countries samples W, T and S were clearly separated from the rest. Globally indentified sample groups were the same with the only discrepancy represented by the position of sample V. As consequence the correlation between the maps was lower (RV = 0.62, $p = 0.021$) than the one observed for peas. In both countries the replicate samples (H and H') fell in the same group thus still indicating the internal reliability of the configurations.

The comparison of preference maps from pea samples between countries resulted in a RV coefficient of 0.87 ($p < 0.001$), showing a general agreement on the value of hedonic properties when discriminating between samples. In the case of sweetcorn the comparison between preference maps resulted in a low level of similarity (RV = 0.65, $p = 0.008$), suggesting that different sensory properties may drive the liking for sweetcorn among Italian and French population.

In order to evaluate the weight of sensory and hedonic dimensions on the process of categorization, the categorization map of each country was compared with the relevant sensory and preference maps (Table 5). For the pea samples, the categorization maps from both countries were highly correlated with the sensory maps and also with the corresponding preference map. For sweetcorn, the spatial configuration from FST was poorly correlated with the sensory map, reaching a maximum of the critical RV value of 0.78 ($p = 0.002$) in the French group. This suggests that subjects gave a different weight to the sensory attributes that determinate the dimensions of the categorization map, particularly in the case of the Italians (RV = 0.61, $p = 0.014$). Also the correlation between categorization maps and preference maps revealed a poor correlation between the two configurations in both countries.

3.2.2. Comparison across age segments

Considering that familiarity toward the tested vegetables and sample grouping resulted generally not affected by the country, in order to better investigate the process of categorization during ageing, sorting data and liking data for both countries were merged by age segment and data analysis was carried out independently for each age segment. A characterization of each age segment is reported in Table 2. Categorization and preference maps from the control group of Adults were used as reference.

The categorization maps obtained from the three age segments are shown in Fig. 4. For the pea samples, substantial similarities can be noted across age segments in the FST configurations (Fig. 4, a–c). As consequence of the hierarchical cluster analysis performed on samples coordinates on the first two components in each map, three sample groups were identified (group 1: A, D, B, E, F; group 2: O, L, Q; group 3: J, P). These groups were well separated one from each other in the configurations from Adults, Young old and Middle old subjects.

Fig. 4 (d–f) shows that the spatial configuration of sweetcorn samples varied across age-segments. This is clearly shown by the different sample-groups obtained from the cluster analysis on sample coordinates of the first two dimensions of each map. The influence of age on sample categorization appeared evident in this case even if the opposition among specific samples (H vs. W, S, T) remained constant across age segments. It is worth to note that replicated samples always fell in the same group both for pea

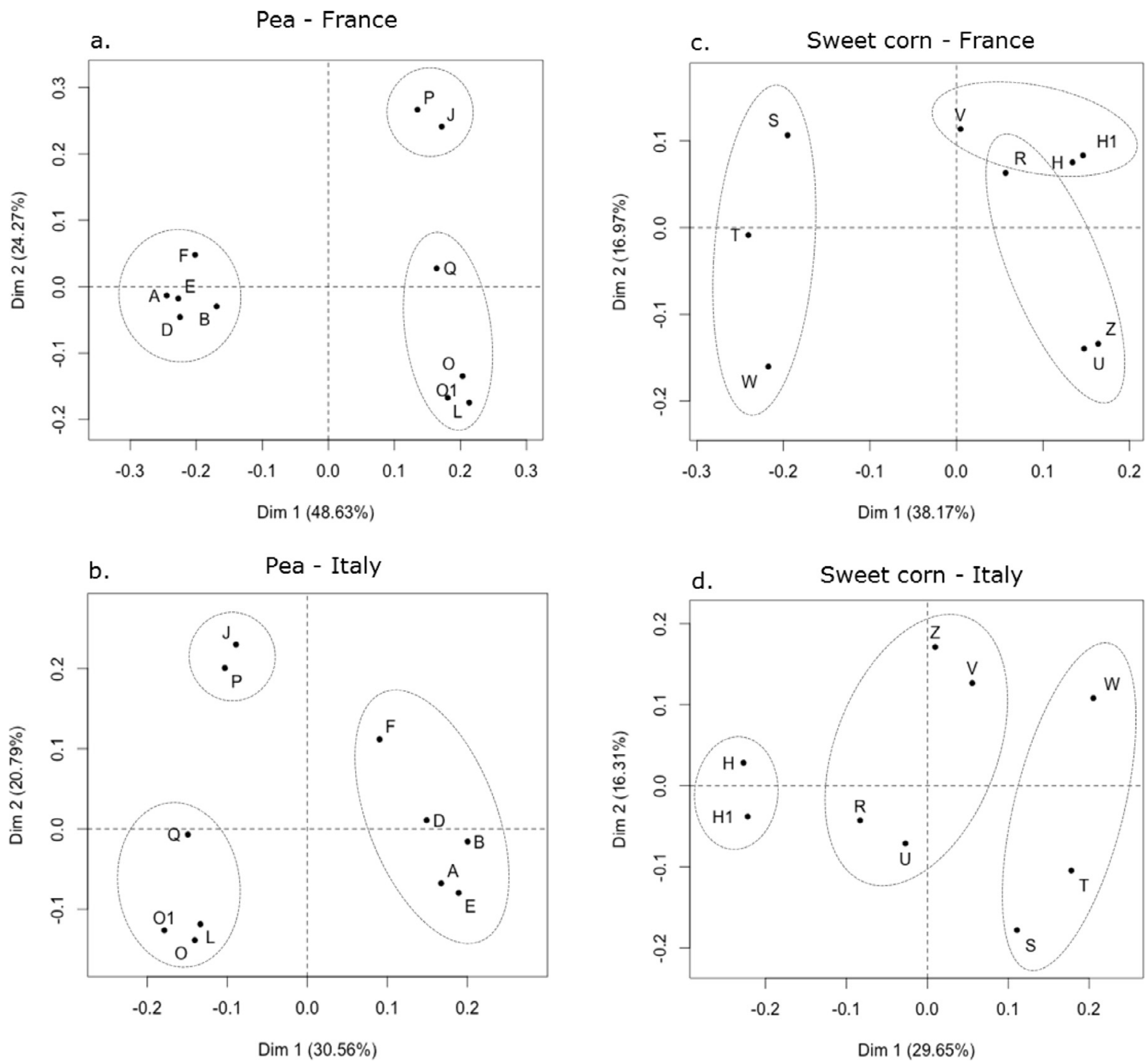

Fig. 3. (a-d). Categorization maps: Compromise map from DISTATIS for pea (left) and sweet corn (right) samples obtained from the free sorting task with French and Italian older adults. The ellipsoids correspond to the clusters identified with hierarchical cluster analysis.

Table 5
RV coefficient values between samples configurations in the first two dimensions of categorization, preference and sensory maps as a function of country and vegetable products.

	Pea					*Sweetcorn*				
	FST Italy	FST France	IPM Italy	IPM France	DA	FST Italy	FST France	IPM Italy	IPM France	DA
FST Italy	1					1				
FST France	0.92***	1				0.62**	1			
IPM Italy	0.68***	0.67***	1			0.60**	0.62**	1		
IPM France	0.76***	0.74***	0.87***	1		0.62**	0.58*	0.65**	1	
DA	0.83***	0.87***	0.78***	0.88***	1	0.61**	0.78**	0.66**	0.76**	1

* = p<0.05.
** = p<0.01.
*** = p<0.001.

and sweetcorn samples irrespective to age, confirming the internal reliability of the configurations. Overall these results clearly show that the influence of age on samples categorization is associated to the level of familiarity toward the tested products.

The level of similarity between categorization, preference and sensory maps as a function of ageing is reported in Fig. 5a for peas and in Fig. 5b for sweetcorn. The following comparisons were considered: 1. The categorization map from the reference segment of Adults versus each categorization map from the two elderly age segment; 2. Categorization maps from Adults and the two elderly age segments versus the sensory map; 3. Categorization maps from Adults and from the two elderly age segment versus the relative preference maps. For all comparisons the RV coefficient computation and the visual inspection were used. The RV values were considered only after visually checking the similarity between two maps.

Considering the pea samples, the correlation between the categorization maps from the Adults and each elderly group was high in the Young old (RV = 0.97, $p < 0.001$) and Middle old segment (RV = 0.97, $p < 0.001$), suggesting a strong similarity in the

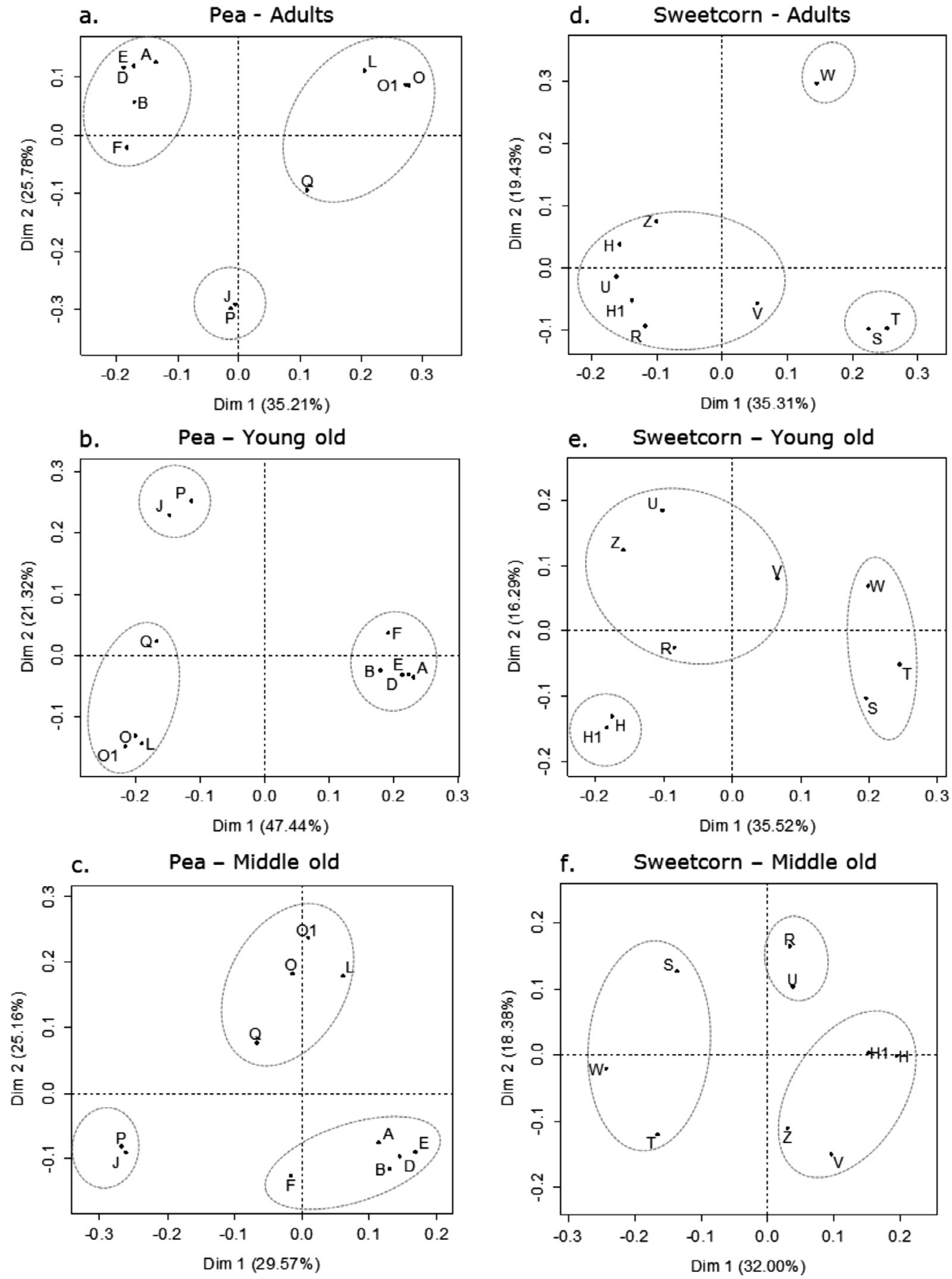

Fig. 4. (a-f). Categorization maps: Compromise map from DISTATIS for pea (left) and sweet corn (right) samples obtained from the free sorting task with Adults, Young old and Middle old segments. The ellipsoids correspond to the clusters identified with hierarchical cluster analysis.

categorization of pea samples. In the case of the sweetcorn samples, the maps follow a different pattern. The correlation between the categorization maps from the Adults and each elderly group decreased from Young old (RV = 0.68, $p = 0.003$) to Middle old (RV = 0.53, $p = 0.024$) segments. This evidence suggests that for this typology of product, the criteria used in categorizing the samples varies during the ageing process, with an overall effect on sorting configuration.

Taking into consideration the similarity between the categorization maps and the sensory map, in the case of peas it is possible to see that the sensory dimension was highly important in each age segment (minimum RV value: Middle old segment (RV = 0.86, $p < 0.001$)). Conversely, in the case of sweetcorn the similarity between the categorization maps and the sensory map was lower and decreases from Adults to Middle old segment, the latter with the minimum level in similarity (RV = 0.68, $p = 0.012$).

Concerning the similarities between the categorization maps and the preference maps, in the case of peas, the results showed little differences in the value of the hedonic dimension in the presented samples from Adults to the Middle old segment. Moreover, the contribution of the hedonic dimension to the

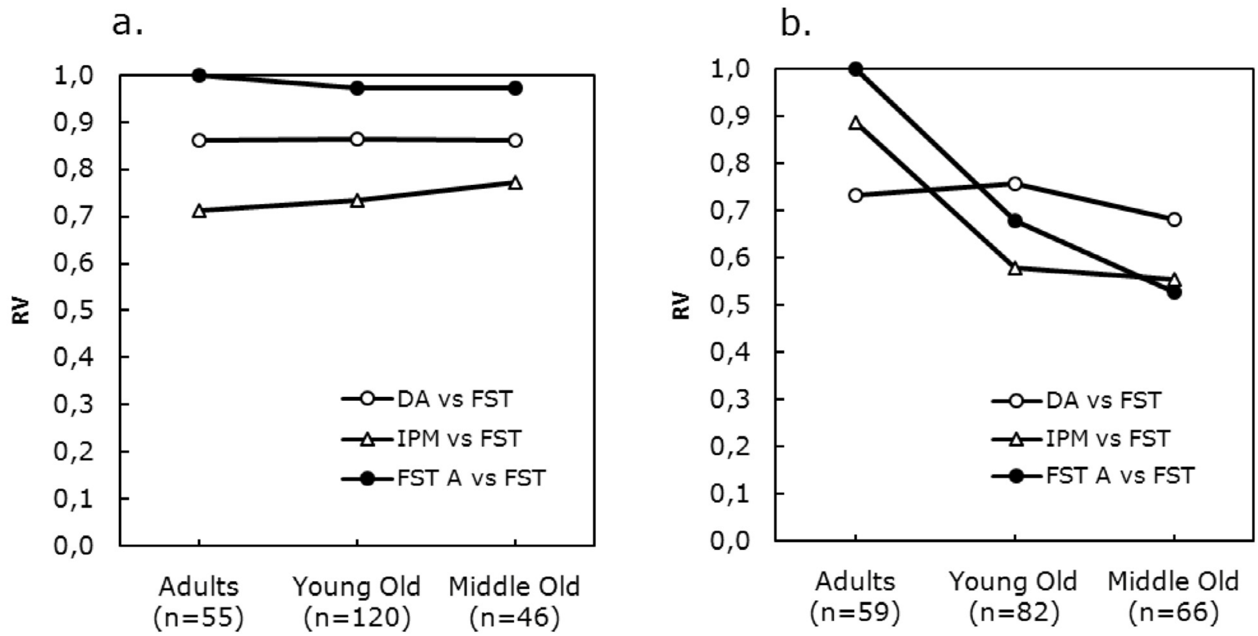

Fig. 5. (a and b). RV coefficient values between samples configurations in the first two dimensions of categorization, preference and sensory maps as a function of the age segments and pea (a) and sweetcorn (b) typologies. FST A indicates categorization maps from Adults.

categorization process remained lower than the sensory dimension in each age segment, with a maximum RV value reached in the Middle old segment (RV = 0.77, $p < 0.001$). A similar tendency was found for sweetcorn, with a minimum similarity reached in the Middle old segment (RV = 0.55, $p = 0.042$).

3.3. Free sorting task reliability within each age segment

The internal reliability of the maps generated with FST during ageing was explored by considering the ratio of distances between the two replicated samples (Dr%). The Dr% of categorization maps and preference maps are reported in Fig. 6 (a and b), respectively for each age class and vegetable category. In these plots, the closer the two replicated samples are on the map the higher the Dr% value and thus the map internal reliability. For the pea samples, both the categorization and preference maps showed a high Dr% in each age segment. For the sweetcorn a high Dr% was found in each age segment only for the categorization maps, while for the preference maps the Dr% value decreased with age. In particular for the pea samples the lowest Dr% of the categorization maps was reached in the Middle old segment, while in the preference maps, the minimum Dr% was reached in the Adults segment. The FST on sweetcorn samples gave highly reliable maps in each age segment. On the contrary, Dr% values associated to the preference maps from the Adults and Young old were higher than the one computed for the Middle old segment.

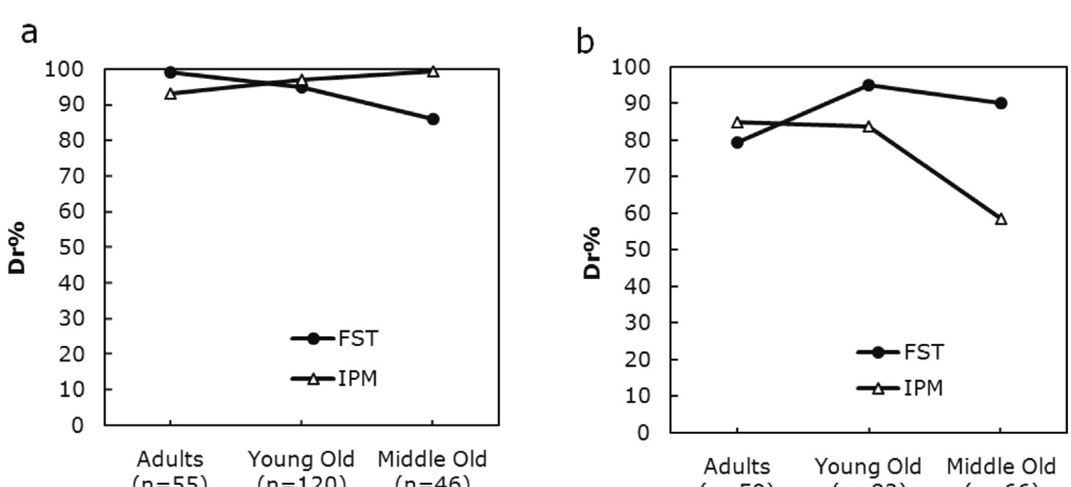

Fig. 6. (a and b). Ratio of distances (%) values for the two replicated samples in the first two dimensions of the categorization and preference maps as a function of the age segments and pea (a) and sweetcorn (b) typologies.

4. Discussion

4.1. Validation of the vegetable typologies and the experimental sample sets

In order to study the role of sensory and hedonic dimensions in the process of categorization, samples of pea and sweetcorn were selected in order to cover as much sensory space as possible of both vegetable typologies. The DA validated the sensory variability of the experimental sample sets, where the selected samples of pea and sweetcorn varied significantly on the quality and intensity of several descriptors relevant to different sensory modalities.

Pea and sweetcorn products were chosen in order to study the effect of familiarity on the process of categorization. Peas were chosen due to their long presence in European food culture, while sweetcorn was characterized by a recently introduction to the continent. Our results confirmed a high familiarity with peas in each country and age segment considered in the study. Conversely, in the case of sweetcorn, each country and age segment showed a lower familiarity compared to peas. Thus the results confirmed a higher familiarity of pea compared to sweetcorn and a comparable degree of familiarity with the vegetable typologies between the two countries.

Therefore the familiarity toward the tested vegetables resulted generally not affected by the country, probably for an introduction of pea and sweetcorn products in a comparable time frame in both French and Italian food cultures. On the contrary, the age resulted a factor able to affect the familiarity toward the tested vegetables. Considering these assumptions, in order to increase the number of subjects in each age condition we merged French and Italian subjects, allowing a more robust study of the process of categorization during ageing.

4.2. Categorization of vegetables across countries and age segments

In the case of the more familiar product, the configuration of samples from FST was comparable between the countries and age segments. The samples were grouped in three main groups in a consistent way among countries and age segments. These evidences suggest that is possible to infer the categorization criteria of a country even using subjects of another country when a comparable level of familiarity is shared. Conversely, in the case of the less familiar product, the similarity between the categorization maps was clearly lower than in the previous case. The samples were grouped in an inconsistent way among countries and age segments, even if tendencies in samples grouping were found. This evidence suggests that different criteria were used to perform the categorization of samples among countries and age segments, where in the latter case the effect may be due to the influence of age on familiarity toward sweetcorn.

4.3. The role of sensory and hedonic dimensions in the categorization of vegetables

The study showed that the sensory properties were the main driver of categorization in the case of the more familiar product. In fact the categorization maps depicted the same similarities and differences among vegetable samples described by the trained panel with DA, irrespective of the country and the age segment. The ability of the FST to generate maps comparable with the sensory maps from DA was already reported in adult subjects (Faye et al., 2004; Saint-Eve, Paçi Kora, & Martin, 2004) and in the present study this was confirmed also in the elderly population in the case of the more familiar product. Considering the less familiar product, the comparison between the categorization maps and the sensory maps highlighted a gradual decrease in similarity with age, thus indicating a reduction in the influence of the sensory dimension in the process of categorization. However this tendency may also mean that the categorization of sweetcorn samples does not reflect differences and similarities in sensory descriptors as perceived by the trained assessors in DA, an aspect that in an elderly respondent may be due to an impaired perception (Schubert et al., 2012) or may be due to the salience of different sensory attributes, such as mouthfeel characteristics (Forde & Delahunty, 2004).

The other potential driver of categorization investigated in the study was the hedonic dimension. The categorization of the more familiar product was more influenced by the sensory dimension than the hedonic one, an aspect already reported in research on foods categorization with adults (Ballester et al., 2008; Chollet & Valentin, 2000). However the hedonic pattern of the samples still partially superimposed the configurations resulting from the FST in each age segment, suggesting that is possible to obtain an indication of the general liking using categorization maps. In the case of the less familiar product, a reduction in similarity between the categorization map and the preference map was detected from Adults to Middle old subjects. In this case, the tendency seems to be due to an issue related to the applicability of the methodology as the internal reliability index of the preference maps decreases with age.

4.4. Sensory-cognitive interaction in flavour building

It is noteworthy to consider how in the case of the more familiar product the drivers of sample categorization are shared among Adults and the older age segments, while in the case of the less familiar product they change during ageing. The differences in the categorization of the two vegetabels may be due to the use of different processes in products representation. In fact the categorization can be the results of two distinct cognitive paths, namely similarity-based processes (Juslin, Olsson, & Olsson, 2003) and rule-based processes (Ashby, Alfonso-Reese, Turken, & Waldron, 1998). Similarity-based processes rely on exemplar retrieval from memory, where objects are categorized on the basis of their similarity to already known exemplars. On the other hand, rule-based processes are based on the integration of cues (i.e., the characteristics of the objects). Research reports that in categorization tasks, adult subjects tend to rely on similarity-based processes (von Helversen, Mata, & Olsson, 2010) due to the lower cognitive demand in respect to the rule-based processes. It is possible to hypothesize that consumers may use similarity-based processes when a familiar product is evaluated, with the effect of building the perception of a product on the base of perceptive elements that subjects learned to associate with specific sensory exemplars. An empirical example of this process is provided by Morot, Brochet, and Dubourdieu (2001), where the red coloration of a white wine led the assessor to elicit smell attributes characteristic of red wines, therefore demonstrating the use of top-down cognitive processes in the building of wine flavour. On the other hand, in the evaluation of an unfamiliar product the absence of previous knowledge may push subjects to use rule-based processes, based on surface properties that are more related to the actual sensory properties of a food. These assumptions therefore suggest that among older adults the lower experience with the less familiar product led to the building of perceptions mainly using surface sensory properties, that may change during the ageing due to possible sensory impairments. In the case of the more familiar product the perceptive information was combined with cognitive information from previous experience, thus compensating the eventual perceptive losses that may occur in this population segment.

4.5. The applicability of the free sorting task among age segments

In the case of the more familiar product, ageing weakly affected the categorization criteria as indicated by the high level of similarity between the categorization maps among the different age segments. The categorization maps showed a high level of internal reliability in all age segments, suggesting that the ability of categorization remained high during ageing. Furthermore, the high level of similarity between the categorization maps from the Adult reference group and each elderly group suggests that is possible to infer the categorization criteria of a healthy elderly population even using adult subjects when a comparable level of familiarity is shared.

Considering the less familiar product, the map obtained from FST significantly changed across age segments, thus indicating that the criteria used in the classification of samples varied during ageing, possibly because of the lower familiarity with the product. Despite the different spatial FST configurations among age segments, the internal reliability of the maps was high and comparable in each age segment, confirming good capacity in categorizing the samples. Therefore also using a product with a lower familiarity, the FST remains a suitable method for use among healthy older adults. However, the low level of similarity between the categorization map from Adults and the categorization maps from each elderly group indicates that reliable information on categorization criteria can be inferred only by considering the age segment of interest. Overall the results suggest that FST allowed the detection of differences in sample categorization in the different age segments of the elderly population, and so is applicable for older adults. The present research therefore corroborates the good applicability of free sorting methodology with healthy older adults as reported by Withers et al. (2014).

5. Conclusions

In the context of better understanding the perception of healthy foods among different age segments of older adults, this research aimed to explore the drivers of categorization of free sorting task methodology among healthy older adults of two European countries, France and Italy.

The level of familiarity was the main factor that affected categorization maps and the information that can be extracted from them. Considering the elderly population, categorization maps from a familiar product can be potentially used to obtain reliable information of sensory and hedonic dimensions, while maps obtained from a less familiar product depict mainly the sensory variability. This suggests that when older adults are encouraged to elicit sensory and hedonic terms to describe the formed groups of a familiar product it may be possible to obtain an indication of the sensory properties of the samples and the general direction of liking. The study suggested that among healthy older adults, familiarity toward a food might play a role in flavour building, where in the case of a familiar product the cognitive information from previous experiences of consumption seems to compensate for the sensory loss that older adults may experience. Moreover the results confirm that the free sorting task is an applicable method with healthy older adults, which is able to detect differences in the categorization of stimuli even among the more aged representative of this segment of population.

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Paper III

Cliceri, D., Spinelli, S., Dinnella, C., Prescott, J., & Monteleone, E. The influence of psychological traits, beliefs and sensory responsiveness on implicit attitudes toward plant- and animal-based dishes among vegetarians, flexitarians and omnivores. *Food Quality and Preference* (Under review).

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Three Implicit Association Tests (IAT) were run on omnivores (39 Ss), flexitarians (55 Ss) and vegetarians (31 Ss) to assess the associative strength between the concepts of positive and negative emotions and the following target concepts: plant-based vs. meat-based dishes (1st IAT), plant-based vs. dairy-based dishes (2nd IAT) and dairy-based vs. meat-based dishes (3rd IAT). Psycho-attitudinal questionnaires were provided: Interpersonal Reactivity Index; Three-Domain Disgust Scale; Food Neophobia Scale; Health and Taste Attitudes Questionnaire; Food Involvement Scale. Moreover the beliefs about food animal mental capacities and emotions where investigated. Taste responsiveness was measured through the bitter intensity assessment of PROP.
Vegetarians and Flexitarians were more inclined to implicitly associate positive emotions to meat-free dishes than omnivores, with vegetarians showing a stronger association than Flexitarians. Our findings showed that positive attitudes toward meat-free dishes were positively and significantly related to the empathic sensitivity toward humans and animals and positive attitudes toward healthy and natural products, while were negatively related to PROP responsiveness and sensitivity toward pathogen disgust. On the contrary food pleasure resulted equally

important among the considered groups, highlighting a higher importance of food consciousness in determining the eating habits considered.

The influence of psychological traits, beliefs and taste responsiveness on implicit attitudes toward plant- and animal-based dishes among vegetarians, flexitarians and omnivores

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Abstract

An increase of animal-based diets to the detriment of plant-based diets has been associated with negative effects on health and environment. A number of consumers' characteristics related to physiological and psycho-attitudinal domains resulted to influence the eating behavior toward animal-based and plant-based foods and should be considered if this dietary transition is to be counteracted. Although these variables were already individually investigated, there is a lack of studies that consider their interaction with the objective of understanding eating behavior. Therefore the aim of the study was to investigate the influence of psychological and personality traits, attitudes, beliefs and taste responsiveness on eating behavior, assessed through implicitly measured attitudes toward plant-based and animal-based dishes.

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Key words Vegetarian, Flexitarian, Empathy, Attitudes, Beliefs, PROP, Implicit association test

1. Introduction

A global dietary transition has occurred in the last few decades as a consequence of food system chain improvement, urbanization and increased incomes (Popkin et al., 2012). A current trend is abandonment of diets rich in grains, legumes and other vegetables and an increasing uptake of a "Western diet", characterized by high intake of refined carbohydrates, added sugars and animal-based food products (Elmadfa, 2009). An increase of animal-based diets to the detriment of plant-based diets has been associated with an greater risk of chronic diseases such as obesity (Wang & Beydoun, 2009), type 2 diabetes (Micha, Michas, & Mozaffarian, 2012) and coronary heart disease (Micha, Wallace, & Mozaffarian, 2010). Eating diets based on animal-source foods were also associated with globally significant increases in greenhouse gas emissions (Tilman & Clark, 2014). Hence, dietary change, in the form of a reduction of the consumption of meat and dairy products, may be one of the main strategies for reducing the impacts of food supply chain on environment (Notarnicola et al., 2017), with positive effects also on health (McEvoy et al., 2012).
Eating habits can be considered as the result of the individual food choices repeated in everyday life. Studying the determinants of food choice may allow identifying drivers and barriers of consumption. The knowledge of these aspects may be therefore useful to promote the dietary change previously presented. Food choice is a complex behavior guided by a number of interacting variables related to the product, the context and the person (Köster, 2009). In order to understand how consumers make decisions about food choices is therefore necessary to understand how these variables interact and what impact they have on eating behaviors. In terms of the person-related dimension, the variables involved in food choices are biological, physiological, psychological and socio-cultural. Therefore these variables have to be considered if the dietary transition that is taking place is to be counteracted.
Individual sensitivity to oral sensations shows considerable variability between individuals, and there is evidence that these variations have significant influence on food preference and consumption (Prescott et al., 2004; Masi et al., 2015). Past studies have provided evidence of heritability factors in food perception (Breen et al., 2006; Pirastu et al., 2012), one of which may be sensitivity to bitter compounds. The genetics of bitter perception has been widely investigated using the compounds phenylthiocarbamide and 6-n-propylthiouracil (PROP), the intensity of which have been considered an index of overall taste sensitivity (Bufe et al., 2005). The relevance of such measures is shown by studies on the genetics of vegetable preferences, which found that greater PROP bitterness sensitivity has been associated with

greater vegetable bitterness sensitivity, in turn resulting in lower vegetable acceptability (Kaminski et al., 2000; Dinehart et al., 2006). These findings suggest, therefore, that bitter sensitivity may modulate the adherence to diets rich in plant-based foods.

Such genetic influences on food choice may play a role in concert with, or modified by, psychological factors. Food-related motivations and attitudes have been associated with different patterns in food preferences. People more concerned about health were more prone to include fruits and vegetables in their diet, while avoiding fats and highly processed carbohydrates (Zandstra et al., 2001; Kourouniotis et al., 2016). Vegetarians resulted to be more health conscious than omnivores (Sabaté et al., 1991) and more concerned about natural content of food products included in the diet (Forestell et al., 2012), aspects that may justify the inclusion in the diet of high quantity, plant-based food products. A further attitude that may influence eating habits toward meat and vegetables may be the role of pleasure in food choices. In studies of omnivores motivation to consume meat, one of the main reasons has been identified in the sensory pleasure derived from consumption (Mullee et al., 2017; Povey et al., 2001). It is possible that omnivores and vegetarians may differ concerning the role of pleasure in determining their respective food choices.

It is known that different cognitive processes based on beliefs influence meat consumption. The "Meat paradox" has been coined in literature to explain the different processes that underlie ambivalence toward meat consumption (Loughnan et al., 2010): the belief that animals are able to experience feelings and deserve moral consideration is in conflict with the fact that we like eating meat. The solution of the conflict may be found in removing either one's beliefs or food behaviours. The removal of the food behaviors means stop eating meat, as carried out among vegetarians. On the other side, the removal of the beliefs means withdrawing moral status from animals and denying their capacity to suffer (Bastian et al., 2012), in order to facilitate meat consumption. A further strategy could be also to deny the origin of meat and separate it from animals (Kunst & Hohle, 2016).

Research studying differences between omnivores and vegetarians found that the two groups differ in psychological aspects that suggest possible motivations for vegetarianism. Compared to omnivores, vegans and vegetarians were found to be higher in empathic responsiveness, defined as the capacity to understand or feel what another person is experiencing (Filippi et al., 2010). In a study that measured a wide range of personality characteristics, it was reported that vegetarians females were more open to new experiences, variety seeking, and less food neophobic than omnivores females (Forestell et al., 2012). Moreover, compared to omnivores, vegetarians tend to develop revulsion toward meat as a consequence of meat avoidance (Fessler et al., 2003). The development of the specific disgust toward meat in vegetarians has been widely documented (Beardsworth & Keil, 1992; Rothgerber, 2015), thus highlighting a possible role of disgust in developing and maintaining potential deterrents of meat consumption.

Among the different approaches to investigate eating behaviour, the use of interviews and questionnaires may be considered as the most common one, thanks to their relative low cost and ease of administration. However, such explicitly measured concepts may suffer important limitations. The most salient of these are voluntary self-presentation strategies (e.g. responding in a way that reflects social desirability), resulting in discrepancies between declared values or attitudes and actual behaviour (Maass et al., 2000). A further limitation is that respondents, even carrying out an accurate introspective effort, may not be able to report their own actual cognitive contents and behaviours (Greenwald & Banaji, 2010). In fact, decision-making and choice may be considered as the result of two different cognitive processes: one that is conscious, slow and deliberative and one that is unconscious, rapid and automatic (Kahneman & Frederick, 2002). Spontaneous and impulsive choices might often be driven by the implicit attitude whereas more deliberate choices are strongly influenced by the explicit attitude, suggesting that food choice is the result of both these processes and that the control over eating habits is not necessarily explicit (Cervellon et al., 2007). The study of eating behavior related to meat consumption may represent an example of the discrepancy between declared and actual behaviour, in that it has been documented that consumers claimed they were vegetarians but then simultaneously acknowledged that they consumed animal flesh (Rothgerber, 2014).

Given these limitations of explicit measures, the measurement of implicit motivations, values and attitudes that influence behaviour may be useful in understanding food choices and behaviours. These can be obtained from a variety of methodological tools developed in cognitive science (De Houwer & Moors, 2010). Among them, the most commonly employed measure has been the Implicit Association Test (IAT; Greenwald et al., 1998). The IAT is designed to measure the strength of associations between concepts and evaluative attributes using a categorization task, a peculiarity that can be used to implicitly study consumer attitudes (Maison et al., 2001). The IAT has already been used in consumer studies (Mai & Hoffmann, 2017; Kraus & Piqueras-Fiszman, 2016; Mai et al., 2015; Piqueras-Fiszman et al., 2012; Craeynest et al., 2007) and to assess implicit attitudes toward eating behaviours (Swanson et al., 2001). It has already been demonstrated that IAT can discriminate between vegetarians and non-vegetarians in their attitudes toward vegetables and meat. Hence, De Houwer & De Bruycker (2007) used the IAT to reveal that relative to meat eaters, vegetarians had a stronger preference for vegetables over meat. Barnes-Holmes et al. (2010) replicated these findings in a study with vegetarians (half pescetarians) and meat eaters, with stroger pro-vegetable and anti-meat attitudes among vegetarians compared to meat eaters. Improvements of these studies may be found in involving middle-option consumers, named semi-vegetarians or flexitarians (De Backer & Hudders, 2015; Forestell et al., 2012), coupled with a more consistent definitions of what constitutes a vegetarian and a non-vegetarian diet. Middle-option consumers have been already detected trough explicit approaches (Graça et al., 2015). The inclusion of these consumers can be useful to understand the set of motivations, values and attitudes that play a role in animal-based foods reduction and, on the other side, which determinate their exclusion from the diet. Concerning the stimulus items used in the implicit measures, further improvement may be found in adopting images of culinary preparations instead of lists of words or images of ingredients. The picture viewing approach has been validated in previous studied in the field of cognitive neuroscience (Wooley & Wooley, 1981; Goldstone et al., 2009), demonstrating to be representative of a natural setting of consumption. The use of pictures of culinary preparation of plant-based dishes can be useful to obtain a more real representation of expectations generated during food evaluation, considering that food ingredients are generally consumed through recipes. Finally, the possibility to involve a larger number of subjects could be of interest in order to study the individual variability.

The aim of this research was therefore to explore and understand the associations among a selected number of variables in affecting implicitly measured attitudes toward plant-based and animal based-dishes among vegetarians, flexitarians and regular meat eaters. These attitudes were measured through three independent IATs, using images of culinary preparations of plant-based, meat-based and dairy-based dishes. A partial least square (PLS) model was then adopted to study the individual variability in the implicit attitudes toward the plant-based and animal-based dishes in relation to psychological and personality traits, general food attitudes, beliefs on food animals and taste responsiveness measures.

2. Materials and methods

2.1 *Subjects*

A total of 125 subjects (females: 72.8%; mean age: 28.6 years old) were recruited in the Florence area (Italy) by means of announcements published on blogs, social networks, emails, pamphlet distribution and word of mouth. The recruitment aimed to cover a wide range of dietary variability for the consumption of animal products, from omnivores to vegetarians. For this reason, part of the recruitment was specifically conducted in social environments attended by vegetarians (vegetarian no profit societies and clubs, restaurants and shops).

2.2 *Experimental procedure*

At the time of recruitment, respondents were given general information about the study aims and individual written informed consent was obtained from participants. In the days preceding the sensory lab session, respondents were asked to complete at home an online questionnaire aimed at collecting data about demographic, social characteristics and general eating habits. In the sensory lab session, participants were introduced to the general organization of the day, which included three IAT measures and the measurement of PROP responsiveness. Tests were conducted individually and social interaction between participants was not allowed. Designated breaks (5 min) between tests were observed. After the sensory lab session, participants were asked to complete at home an online questionnaire aimed at measuring a number of variables on demographics, psychological and personality traits, food attitudes and beliefs on food animals (Table 1).

2.3 *Questionnaires*

2.3.1 Socio-demographics and eating habits

Respondents were asked to declare their own gender, age, height, weight, educational level (Lower secondary school; Upper secondary school; Degree; Post-degree), and the monthly expense for food (Up to 200€; From 201 to 400€; From 401 to 600€; More than 600€). A Body Mass Index (BMI) was computed for each respondent and the individual index was used to classify respondents according to the World Health Organization criteria (Underweight: <18.50 kg/m^2; Normal range: 18.50-24.99 kg/m^2; Overweight: 25.00-29.99 kg/m^2; Obese: ≥30.00 kg/m^2).

Respondents were asked to indicate which statement best represented their own eating habits out of list of nine alternatives (De Backer & Hudders, 2015): 1 - I regularly eat red meat, fish and chicken; 2 – I consciously reduce meat intake, but eating meat now and then; 3 - I don't eat red meat, but I eat fish, chicken and other poultry; 4 – I don't eat red meat nor chicken, but I eat fish and shellfish; 5 – I eat organic and locally grown foods, with a great overlap with foods consumed in a vegetarian diet, yet also including certain kinds of meat; 6 – I don't eat meat or fish, but I eat eggs and dairy products; 7 – I don't eat meat, fish or eggs, but I eat dairy products; 8 - I don't eat meat, fish or dairy products, but I eat eggs; 9 – I don't eat meat and I don't use products of animal origin. Responses to these statements were then grouped into three categories according to published criteria (Dagevos, 2016; De Backer & Hudders, 2015): 1. Omnivores (statement 1), defined as those who do not follow any limitation concerning the consumption of meat and fish; 2. Flexitarians (2, 3, 4 and 5), defined as those who consciously consume a limited quantity of either all types or specific types of meat; 3) Vegetarians (6, 7, 8, and 9), defined as people who totally limit the consumption of meat and fish.

2.3.2 Psychological and personality traits

2.3.2.1 Food neophobia scale

The trait of food neophobia, defined as the reluctance to try and eat novel foods, was quantified using the Italian version of the Food Neophobia Scale (FNS) (Pliner & Hobden, 1992; Laureati et al, submitted). The individual scores were computed as the sum of ratings given to the ten statements and ranged from 10 to 70, with higher scores reflecting higher food neophobia levels.

2.3.2.2 Interpersonal Reactivity Index

In order to explain the psychological bases behind the development of cognitive dissonance toward animal-based foods we measured the empathic responsiveness, defined as the capacity to understand or feel what another person is experiencing. Empathic responsiveness was assessed using the Italian version of the Interpersonal Reactivity Index (IRI) (Albiero et al., 2006; Davis, 1980). The IRI consists of four subscales, each of which reflects a separate aspect of the global concept of "empathy": *Fantasy* (F), defined as the tendency to identify strongly with fictitious characters; *Perspective Taking* (PT), defined as the ability to adopt the perspective, or point of view, of other people; *Empathic Concern* (EC), defined as the tendency to experience compassion and concern for others undergoing negative experiences; and *Personal Distress* (PD), which indicated that the respondent experienced feelings of discomfort and anxiety when witnessing the negative experiences of others. The individual score for each subscale was obtained as the mean of ratings given to the items and ranged from 1 to 5, with higher scores reflecting higher responsiveness.

2.3.2.3 Three-Domain Disgust Scale

Disgust was assessed using two domains of the Three-Domain Disgust Scale (TDDS) (Tybur et al., 2009). The TDDS used in the study consisted of two subscales, each of which reflects a separate aspect of the global concept of "disgust": *Pathogen Disgust (*PD), defined as the tendency to experience disgust for objects that may contain infectious agents; and *Moral Disgust* (MD), defined as the tendency to experience disgust for social transgressions and antisocial activities. The individual score for each subscale was obtained as the mean of ratings given to the items and ranged from 1 to 7, with higher scores reflecting higher disgust.

2.3.3 Attitudes toward foods

2.3.3.1 Health and Taste Attitudes Scale

The importance of health and pleasure on food choices was quantified using the Health and Taste Attitudes Scale (HTA) (Roininen et al., 1999). The HTA consists of six subscales: *General Health Interest* (GHI), *Light Product Interest* (LPI), *Natural Product Interest* (NPI), *Craving for Sweet Food* (CSF), *Using Food as Reward* (FR) and *Pleasure* (P). The individual score for each subscale was obtained as the mean of ratings given to the items and ranged from 1 to 7, with higher scores reflecting more positive attitudes.

2.3.3.2 Food Involvement

Food Involvement, defined as the level of importance of food in a person's life, was measured using the Food Involvement Scale (FIS) (Bell & Marshall, 2003). The FIS consists of two subscales: *Set and Disposal* (SD) and *Preparation and Eating* (PE). The individual score for each subscale was computed as the sum of ratings given to the statements (SD range: 3-21; PE range: 9-63), with higher scores reflecting higher involvement levels.

2.3.4 Beliefs on food animals

2.3.4.1 Human-animal emotional and mental capacity similarity

To assess the extent to which participants believed food animals share emotional states similar to humans, a scale (HAES) was adapted from Bilewicz et al. (2011). Participants were asked to indicate the extent to which they thought a food animal (swine) might experience six primary emotions (rage, surprise, pain, fear, happiness, pleasure) and six secondary emotions (shame, hope, melancholy, love, guilt, tenderness). To assess the extent to which participants thought food animals possessed certain mental capacities, a scale (HAMCS) was adapted from Bastian et al. (2012). Participants were asked to indicate the extent to which they thought a food animal (swine) possessed eight mental capacities (self-control, morality, memory, emotion recognition, planning, communication, thought). The individual score for, respectively, HAES and HAMCS was obtained mediating the items of each scale in order to obtain a score ranging from 1 to 5, with higher scores reflecting higher similarity between human and food animals.

2.3.4.2 Meat eating justification questionnaire

The extent to which participants justified meat consumption was measured using the Meat-eating Justification scale (MEJ) (Rothgerber, 2013). The MEJ consists of nine subscales, each of which taps a separate strategy for justifying eating meat: *Pro-Meat Attitude* (PMA), *Denial* (D), *Hierarchical Justification* (HIJ), *Dichotomization* (DIC), *Dissociation* (DIS), *Religious Justification* (RJ), *Avoidance* (A), *Health Justification* (HEJ), *Human Destiny/fate Justification* (HDJ). The individual score for each subscale was obtained as the mean of ratings given to the items and ranged from 1 to 7, with higher scores reflecting higher justification of meat consumption.

2.4 *PROP responsiveness*

A 3.2mM PROP solution was prepared by dissolving 0.5447 g/L of 6-n-propyl-2-thiouracil (European Pharmacopoeia Reference Standard, Sigma Aldrich, Milano, IT) into deionized water (Prescott et al., 2000). Subjects were presented with two identical samples (10 ml) coded with a three-digit code. Subjects were instructed to hold each sample (10 ml) in their mouth for 10 s, then expectorate, wait 20 s and evaluate the intensity of bitterness using the General Labelled Magnitude Scales (gLMS). Between evaluation of samples, subjects rinsed their mouth with water for 60 seconds. Individual PROP intensity scores were determined using the mean intensity rating across samples, with higher scores reflecting higher responsiveness. Individual PROP taster status was obtained with the arbitrary cut-offs used in previous studies to categorize subjects in PROP non-taster (gLMS score ≤ 17), PROP medium-taster (17 < gLMS score < 53) and PROP super-taster (gLMS ≥ 53) (Fischer et al., 2013; Hayes et al., 2010).

2.5 *Implicit Association Test*

2.5.1 Procedure

Subjects completed three independent seven-block IATs, designed to measure relative associative strength of three concept pairs: Vegetable and Meat (VM-IAT), Vegetable and Dairy

(VD-IAT), and Meat and Dairy (MD-IAT). Ten pictures of dishes (culinary preparations) were used to represent each of the target concepts. Each picture was validated in an independent study (see § 2.5.2). All IATs used positive and negative emotions as attributes, represented by eight words each for the positive emotion (happiness, cheerfulness, enthusiasm, relaxation, satisfaction, joy, pleasure, amusement) and negative emotions (disgust, distress, boredom, annoyance, sadness, dissatisfaction, disappointment, shame) categories. The number of trials in each IAT block was identical for the three IATs: 20 in Blocks 1 (practice on target discrimination), 16 in Block 2 (practice on attribute discrimination), 20 in Block 3 (practice of first combined-task), 36 in Block 4 (test of first combined-task), 40 in Block 5 (practice on reversed target discrimination), 20 in Block 6 (practice of second combined-task), and 36 in Block 7 (test of second combined-task blocks). The task sequence and response keys assignment of the three IATs is reported in Table 2. The additional trials in Block 5 were included to reduce the order effect of the two combined-task conditions, as suggested by Nosek et al. (2007). Concept and attribute trials were alternated on combined-task blocks and respondents were not asked to correct errors. In order to study individual variability, the order of the combined-task blocks within each IAT was not counterbalanced such that within each IAT the order of blocks was done with a fixed order across subjects, as described by Schnabel et al. (2007). The presentation order of the three IATs and the images presented in each IAT were randomized among participants.

2.5.2 Selection of the images for the IAT

The stimulus items for the target concepts for each IAT were selected from a pictures database created for this study following the guidelines of Blechert et al. (2014). The database included 80 pictures of plant-based dishes, 80 pictures of meat-based dishes and 80 pictures of dairy-based dishes. Pictures were selected by two operators from open source databases in order to represent the variability of preparations of the Italian food culture, taking into consideration ingredients and cooking mode. Only pictures where the food content of the dish was fully visible were considered. The selection included color photographs without symbols or texts and with a minimum resolution of 720 x 540 pixels.

2.5.2.1 Picture assessment by consumers

A total of 123 consumers different from those involved in the main study (females: 66.6%; vegetarians: 4.4%; mean age: 31.4 years old) evaluated each picture included in the database through an on-line questionnaire. The order of presentation of blocks and pictures within each block was randomized among participants. Within each block, only pictures of a specific kind of dish category were presented (plant-based, meat-based or dairy-based). Independently for each picture, subjects were asked to answer to the following sentences:

1. How pleasant would it be to taste this dish? (1 – Not at all pleasant; 9 - Extremely pleasant);

2. How pleasant is the appearance of this dish? (1 – Extremely unpleasant; 9 – Extremely pleasant);
3. How much preparation do you think that this dish needs? (1 – Little preparation; 9 – A lot of preparation);
4. Indicate your level of agreement with the following sentence: this is a good example of plant-based (or meat-based, or dairy-based) dish. (1 – I strongly disagree; 9 – I strongly agree).

2.5.2.2 Stimulus selection and target concept validation

A sub-database of pictures to be used as stimulus in the three IAT paradigms was created, selecting pictures that were highly typical of the category of the dish category (Typicality mean score ≥ 8) and that were accepted (Hedonic liking mean score ≥ 5; Visual liking mean score ≥ 5). The images included in the sub-database were assigned in a randomized way to the target categories used in the three IAT measures, for a total of 20 pictures of plant-based dishes (10 for VM-IAT and 10 for VD-IAT), 20 pictures of meat-based dishes (10 for VM-IAT and 10 for MD-IAT), 20 pictures of dairy-based dishes (10 for VD-IAT and 10 for DM-IAT). The pictures selected for each IAT are reported in the Appendix (Figures 6, 7, and 8). The randomized assignation was carried out with the aim of ensuring that the pictures assigned to the two target categories within each IAT resulted non significantly different for hedonic liking, visual liking, preparation level and typicality. The characterization of the pictures used in the three IATs is reported in Table 3.

2.6 *Data analysis*

2.6.1 Questionnaires

Associations between the declared eating habits and, respectively, gender, age, BMI groups, educational level, monthly expense for food, and PROP status was tested using Chi-square tests. The reliability of subscales of each questionnaire was assessed with Cronbach's alpha.

2.6.2 Implicit Association Test

Response latencies from the three IATs were submitted to the D600 algorithm (Schnabel et al., 2007) in order to obtain an individual D-score for each IAT, for a total of three D-scores for each participant. The D-score represents the difference in reaction time between first (block 3 and 4) and second (block 6 and 7) combined-tasks, as a function of the standard deviation of the distribution. D-scores were computed with the R Statistics Package "IAT" version 0.3 following the procedure reported in Nosek et al. (2007). D-scores between -0.15 and 0.15 were considered as arbitrary cut-offs to represent the condition of no differences in association between first and second combined-task (Whitaker et al*.,* 2016), with D-scores below -0.15 indicating a stronger association between concepts in first combined-task compared to second, and with D-scores above 0.15 indicating a stronger association between concepts in second combined-task compared to first. The effect of declared eating habits on psychological and personality traits, attitudes toward foods, beliefs on food animals, taste responsiveness, D-scores and response latencies within each IAT block was tested using a 1-way ANOVA (Eating habit group) and post-hoc Least Significant Difference (LSD) tests. D-scores and univariate data analysis was performed with R Statistics Package version 3.2.3 (R Core Team, 2015).

2.6.3 Partial least square regression model

A preliminary Partial Least Square (PLS) regression model was computed considering the D-scores from VM-IAT (Y) and 18 explanatory variables (X). In particular, we considered the following X variable blocks: seven domains related to psychological traits (FNS; IRI: F, PT, EC, PD; TDDS: PD, MD); eight domains related to attitudes toward foods (FIS: SD, PE; HTA: GHI, LPI, NPI, CSF, FR, P); two domains related to beliefs on food animals (HAES, HAMC); PROP responsiveness. The Uncertainty test was used to estimate the significant X variables for each component of the model while Cross-validation was used to estimate the number of statistically reliable principal components. A final PLS regression model was computed assuming the D-scores from VM-IAT as response variables (Y) and the significant variables from the preliminary PLS regression model as explanatory variables (X). Not significant variables from the preliminary PLS regression model were considered as down-weighted X variables. Uncertainty test was used to estimate the significant X variables for each component of the model while Cross-validation was used to estimate the number of statistically reliable principal components. In both cases, the PLS regression models were computed on standardized variables in order to have unit variance and D-scores from VD-IAT and DM-IAT were considered as down-weighted Y variables. Multivariate data analysis was performed with the software Unscrambler version 10.3 (Camo Software, Norway).

3. Results

Data and responses collected in the study were compared among the three considered consumer segments: Omnivores, Flexitarian and Vegetarians. Results are presented first in relation to specific groups of variables (socio-demographic, psychological traits, questionnaires on attitudes and believes, taste responsiveness and reaction time responses from the IAT study), and then considering the associations among all of them.

3.1 *Characterization of segments based on declared eating habits*

3.1.1 Socio-demographics

The demographic and social characteristics of Omnivores, Flexitarians and Vegetarians are reported in Table 4. The three groups did not differ according to gender, with a higher presence of females in each group. The three segments were formed mainly by young adult respondents (18-30 years old range), even if a significant difference of age group distributions was found, due to a higher presence of adult respondents (31-40 years old range) among Omnivores compared to Vegetarians. Normal range BMI was the most common across the three groups and no significant difference of BMI distributions was found. The variables related to economical wellbeing, such as the educational level and the monthly expense for food, were also not significantly different between groups.

3.1.2 Psychological and personality traits

The psychological and personality traits measures obtained for Omnivores, Flexitarians and Vegetarians segments are reported in Table 5. The internal consistency of the Food Neophobia Scale score, as measured using Cronbach's alpha, was 0.83. The three groups were most commonly low in neophobia and did not significantly differ for the mean Food Neophobia Scale score, suggesting a comparable behavior toward the consumption of novel foods. Concerning the internal consistency of each Interpersonal Reactivity Index domain, *Fantasy* resulted in an alpha of 0.73, *Perspective Taking* resulted in an alpha of 0.73, *Empathic Concern* resulted in an alpha of 0.73 and *Personal Disease* resulted in an alpha of 0.74. With the exception of *Personal Disease* domain, overall the three segments showed a tendency to high scores of cognitive and emotional empathy. The eating habit had a significant effect on the *Perspective Taking* domain ($F = 4.5$; $p = 0.035$), showing a higher capacity to adopt the point of view of other people among Vegetarians as compared to Omnivores, while Flexitarian scores fell between these groups. A tendency, even if not significant, was detected for the *Empathic Concern* domain ($F = 3.1$; $p = 0.085$), suggesting a higher capacity to experience compassion for others undergoing negative experiences in Vegetarians compared to Omnivores, while Flexitarian scores fell between the other two segments. No eating habits effect was found for the domain *Fantasy* and *Personal Disease*. Concerning the internal consistency of each Three-Domain Disgust Scale domain, *Pathogen Disgust* resulted in an alpha of 0.79 and *Moral Disgust* in an alpha of 0.71. The eating habit had a significant effect on the *Pathogen Disgust* domain ($F = 9.0$; $p = 0.003$), showing a higher disgust toward infectious agents in Omnivores and Flexitarians compared to Vegetarians. A tendency, even if not significant, was detected for the *Moral Disgust* domain ($F = 3.2$; $p = 0.007$), showing higher disgust toward antisocial activities in Omnivores and Flexitarians compared to Vegetarians.

3.1.3 Food-related lifestyles and attitudes

The food-related lifestyle and attitude measures obtained for Omnivores, Flexitarians and Vegetarians are reported in Table 5. Concerning the internal consistency of each Health and Taste Attitudes Scale domain, *General Health Interest* and *Light Product Interest* domains were shown to be highly internally consistent, with an alpha of 0.81 and 0.90 respectively. Also *Craving for Sweet Food* and *Using Food as Reward* domains were shown to be highly internally consistent, with an alpha of 0.85 and 0.88 respectively. *Natural Product Interest* domain resulted in an alpha of 0.78, while *Pleasure* resulted in an alpha of 0.46. Concerning the attitudes toward healthy food, with the exception of *Light Product Interest* domain, overall the three segments showed a tendency to positive attitudes toward healthy food consumption. The three groups resulted significantly different concerning the *General Health Interest* domain (F = 21.5; p < 0.001), with a lower interest for Omnivores compared to Flexitarians and Vegetarians. A significant effect was detected also for the *Natural Product Interest* domain (F = 28.1; p < 0.001), with a higher interest among Vegetarians compared to Omnivores, with Flexitarian scores falling between the other two groups. No significant effect was found for the *Light Product Interest*. In general, the three groups showed a tendency to positive attitudes toward tasty food consumption. Eating habits did not affect any of the considered subscales, highlighting a high and comparable importance of taste on food choices (*Craving for Sweet Food*: mean = 5.1, SD = 1.4; *Food as Reward*: mean = 4.5, SD = 1.4; *Pleasure*: mean = 5.1, SD = 0.8).

Concerning the internal consistency of each Food Involvement Scale domain, *Set and Disposal* resulted in an alpha of 0.64 and *Preparation and Eating* resulted in an alpha of 0.44. The involvement with food measured through Food Involvement Scale highlighted a general high level of interest in food in all segments (*Set and Disposal*: mean = 14.7, SD = 3.6; *Preparation and Eating*: mean = 47.7, SD = 7.7). Eating habits had no significant effect on FIS scores, suggesting a high comparable level of importance of food among the considered groups.

3.1.4 Beliefs regarding food animals

The beliefs regarding food animals measures obtained for Omnivores, Flexitarians and Vegetarians are reported in Table 5. Human-Animal Emotions Similarity and Human-Animal Mental Capacity Similarity were shown to be highly internally consistent, with an alpha of 0.88 and 0.82 respectively. In general Omnivores tended to deny the similarity between humans and animals, while Flexitarians and Vegetarians tended to recognize that humans and food animals might experience the same emotions and mental capacities. The three segments significantly differed in the belief that food animals share emotional states and mental capacities similar to humans, with higher scores in Vegetarians compared to Omnivores, and Flexitarians scores falling between the other two segments.

Concerning the internal consistency of each Interpersonal Reactivity Index domain, *Pro-meat attitude*, *Religious Justification* and *Health Justification* domains were shown to be highly internally consistent, with an alpha of 0.89, 0.85 and 0.85 respectively. *Denial* resulted in an alpha of 0.58, *Hierarchical Justification* resulted in an alpha of 0.75, *Dichotomization* resulted in an alpha of 0.48, *Dissociation* resulted in an alpha 0.57, *Avoidance* resulted in an alpha of 0.55 and *Human Destiny Justification* resulted in an alpha of 0.73. The subscales that investigated the different strategies to justify meat consumption resulted to significantly differences between eating habits, with a general higher level of meat eating justification in Omnivores compared to Flexitarians, while Vegetarians obtained lower scores. The only exception is represented by the *Avoidance* domain, indicating that each group similarly tends to avoid thinking about where meat comes from and how it is processed. While for Vegetarians the low scores are the obvious consequence of refusing to eat meat, the scores from Omnivores and Flexitarians depict a more complex situation. Omnivores adopted six of the nine strategies to justify meat consumption (*Pro-meat attitude, Dichotomization, Dissociation, Avoidance, Health Justification* and *Human Destiny Justification*), while Flexitarians tended to positively adopt just three such strategies (*Dichotomization, Dissociation* and *Avoidance*).

3.1.5 Taste responsiveness among declared eating habits

Taste responsiveness measures among declared eating habits are reported in Table 6. Based on an a priori cut-off, in each segment the majority of subjects were PROP medium-tasters (Omnivores: 43.6%; Flexitarians: 54.5%; Vegetarians: 48.4%). 17.9% of Omnivores, 23.6% of Flexitarians and 38.7% of Vegetarians were classified as PROP non-tasters, while 38.5% of Omnivores, 21,8% of Flexitarians and 12,9% of Vegetarians were classified as PROP super-tasters. The three groups did not significantly differed in PROP status distribution, even if a tendency was present ($\chi^2 = 8.25$; $p = 0.082$). However, when PROP was considered as a continuous variable the 1-Way ANOVA model showed that the mean PROP intensity was different among groups, with Vegetarians rating PROP intensity significantly lower (mean = 27.9) than Omnivores (mean = 43.7), and Flexitarians (mean = 37.4) falling between the other two groups, even if not significantly differing from them ($F = 7.34$; $p = 0.008$).

3.1.6 Implicitly measured attitudes within declared eating habits

In the VM-IAT, the lower the D-score, the higher the speed of categorization when category pairings grouped vegetables with positive emotions and meat with negative emotions, compared to the complementary pairing. On average, subjects responded more rapidly when category pairings grouped vegetables with positive emotions and meat with negative emotions, compared to the complementary pairing (mean D-score = -0.30). Examination of eating habits differences in D-scores (Figure 1) showed that, within Omnivores, 50% of respondents resulted in a more rapid categorization vegetables with linked to positive emotions and meat with negative emotions compared to the complementary pairing. For Flexitarians and Vegetarians, however, the corresponding proportion was greater than 75%.

Eating habits had a significant effect on D-scores (Figure 2), with significantly higher scores in Omnivores (mean = -0.07) compared to Vegetarians (-0.63), while Flexitarians scores fell between the other two segments (-0.38) ($F = 36.49$; $p < 0.001$). The analysis of response latencies from VM-IAT (Figure 3) showed that the differences in D-score between segments originates in a significantly different performance of categorization in Block 6 (mean Omnivores = 919.6 ms; mean Flexitarians = 1077.4 ms; mean Vegetarians = 1149.6 ms) ($F = 7.39$; $p = 0.007$) and Block 7 (mean Omnivores = 821.5 ms; mean Flexitarians = 896.6 ms; mean Vegetarians = 971.3 ms) ($F = 8.60$; $p = 0.004$), in which category pairings grouped meat with positive emotions and vegetable with negative emotions. In contrast, no significant differences were found in either Block 3 (mean Omnivores = 890.0 ms; mean Flexitarians = 883.3 ms; mean Vegetarians = 781.3 ms) ($F = 3.48$; $p = 0.064$) or Block 4 (mean Omnivores = 781.7 ms; mean Flexitarians = 774.2 ms; mean Vegetarians = 695.9 ms) ($F = 3.61$; $p = 0.060$), in which category pairings grouped vegetable with positive emotions and meat with negative emotions.

In the VD-IAT, the lower the D-score, the higher the speed of categorization when vegetables were paired with positive emotions and dairy products with negative emotions, compared to the complementary pairing. On average, this pairing led to lower D-scores (mean = -0.13). Across groups, this was true for 25% of Omnivores and 50% and 75% of Flexitarians and Vegetarians, respectively. Mean D-scores are shown in Figure 2. Omnivores (mean = -0.01) and Flexitarians (mean = -0.14) had significantly higher scores than Vegetarians (mean = -0.41) ($F = 18.43$; $p < 0.001$), while between Omnivores and Flexitarians no significant differences were found.

The analysis of response latencies from VD-IAT (Figure 3) showed that the differences in D-scores between groups arises from significantly different performance of categorization in Block 6 (mean Omnivores = 879.1 ms; mean Flexitarians = 1004.1 ms; mean Vegetarians = 1144.7 ms) ($F = 12.91$; $p < 0.001$) and Block 7 (mean Omnivores = 823.8 ms; mean Flexitarians = 913.1 ms; mean Vegetarians = 915.6 ms) ($F = 4.52$; $p = 0.035$), in which category pairings grouped dairy with positive emotions and vegetable with negative emotions. No significant group performance differences were seen in either Block 3 (mean Omnivores = 926.2 ms; mean Flexitarians = 983.1 ms; mean Vegetarians = 878.1 ms) ($F = 0.264$; $p = 0.609$) or Block 4 (mean Omnivores = 804.5 ms; mean Flexitarians = 828.1 ms; mean Vegetarians = 758.4 ms) ($F = 0.78$; $p = 0.378$), in which category pairings grouped vegetable with positive emotions and dairy with negative emotions.

In the DM-IAT, the lower was the D-score, the higher the speed of categorization when category pairings grouped dairy products with positive emotions and meat with negative emotions, compared to the complementary pairing. On average, this pairing produced generally more rapid performance compared to the complementary pairing (mean D-score = -0.17). Across groups, this was true for 25% of Omnivores and 50% and 75% of Flexitarians and Vegetarians, respectively. Mean D-scores are shown in Figure 2, with significantly higher scores in Omnivores (mean = -0.10) compared to Vegetarians (mean = -0.40), with Flexitarians scores (mean = -0.24) falling between the other two groups, even if not significantly differing by them ($F = 18.43$; $p <0.001$).

Inspection of response latencies from DM-IAT (Figure 3) showed that the differences in D-score between arises from a significantly different performance of categorization in Block 6 (mean Omnivores = 903.8 ms; mean Flexitarians = 1020.4 ms; mean Vegetarians = 1050.1 ms) ($F = 4.76$; $p = 0.031$), in which category pairings grouped dairy with positive emotions and meat with negative emotions, while performance between groups was not significantly different in Block 7 (mean Omnivores = 823.4 ms; mean Flexitarians = 921.6 ms; mean

Vegetarians = 921.6 ms) (F = 3.23; p = 0.074), Block 3 (mean Omnivores = 897.3 ms; mean Flexitarians = 973.2 ms; mean Vegetarians = 887.4 ms) (F = 0.01; p = 0.417) or Block 4 (mean Omnivores = 804.5 ms; mean Flexitarians = 828.1 ms; mean Vegetarians = 758.4 ms) (F = 0.784; p = 0.378), in which category pairings grouped meat with positive emotions and dairy with negative emotions.

3.2 *Correlation among variables and effect on implicit responses*

A preliminary PLS regression computed with all the variables resulted in a model with one significant component, where the explained variances for components 1 and 2 were equal to 13% and 12% for X and 15% and 3% for Y. Considering all the IATs, variables that resulted significant were *Prospective Taking*, *General Health Interest*, *Natural Product Interest*, *Human-Animal Emotion Similarity*, *Human-Animal Mental Capacity Similarity*, *Pathogen Disgust* and *PROP responsiveness*. The VM-IAT variable resulted more well explained by the model while VD-IAT and DM-IAT variables resulted less explained by the model. For this reasons only VM-IAT was considered as Y variable in the next PLS model. VD-IAT and DM-IAT were included in the model as down-weighted Y variable in order to investigate the association with the PROP responsiveness, the psychological traits, the attitudes and the beliefs. The final PLS regression, computed only with significant variables, resulted in a model with one significant component, where the explained variances for components 1 and 2 were equal to 33% and 13% for X and 25% and 3% for Y. The PLS score plot for the first two components (Figure 4.a) allowed an exploration of the association among subjects on the basis of the considered variables. The first principal component explained the variability of eating habits, where Omnivores tend to be located in the positive side of the component, while Vegetarians tend to be located in the negative side. Flexitarians tend to be located at the center of the component and partially superimposed on the other two segments, in particular that of Vegetarians.

The PLS correlation loading plot for the first two components (Figure 4.b) allowed an exploration of the associations among variables. The D-scores of the VM-IAT were positively correlated with the first component, where more subjects were located on the right side of the map (more rapid responses in the second combined task compared to the first one), indicating more positive attitudes toward meat-based dishes. Human-Animal Emotion Similarity, Human-Animal Mental Capacity Similarity, *General Health Interest*, *Natural Product Interest* and *Prospective Taking* measures were correlated with the negative side of the first component, while PROP responsiveness and *Pathogen Disgust* measures were correlated with the positive side. The PLS regression coefficients of the first dimension (Figure 5) showed that VM-IAT D-scores significantly decreased when Human-Animal Emotion Similarity, Human-Animal Mental Capacity Similarity, *General Health Interest*, *Natural Product Interest* and *Prospective Taking* measures increased and PROP responsiveness and *Pathogen Disgust* measures decreased. In the case of VD-IAT, the D-scores significantly decreased when Human-Animal Emotion Similarity, Human-Animal Mental Capacity Similarity, *General Health Interest*, *Natural Product*

Interest and *Prospective Taking* measures increased and PROP responsiveness decreased. No variables significantly affected the D-scores of the DM-IAT.

4. Discussion

The call for an integrated approach of study has been encouraged in the sensory and consumer science community (Köster, 2009) and a recent example of a multidisciplinary approach in the study on consumers has been provided by the Italian Taste project (Monteleone et al., 2017). Further studied that adopt a similar multidisciplinary approach are therefore needed to better understand the mechanisms involved in eating behaviour. In this context, the main aim of the study was to explore and understand the associations among a selected number of variables in affecting implicit attitudes toward plant-based and animal based-dishes. This question was investigated through a PLS model where the variability in D-scores from three independent IATs was studied in relation to psychological and personality traits, food attitudes, beliefs on food animals and taste responsiveness measures.

4.1 *The role of food consciousness on implicit attitudes toward plant-based and animal-based dishes*

The obtained PLS model highlighted the presence of one main dimension describing the implicit attitudes toward plant-based and animal-based dishes, which we describe as "Food consciousness". This represents the dimension that best describes attitude variability along the first component of the model and was constituted by variables related to health and morality, already reported as drivers of meat and vegetable consumption (Rozin et al., 1997). On the IAT, an increase in the variables related to the Food consciousness resulted in increased positive attitudes toward plant-based dishes and increased negative attitudes toward animal-based dishes, making this dimension the main driver of the considered attitudes.

In addition to the Food consciousness, our model highlighted the influence of psychological traits on implicit attitudes. Empathic responsiveness was found to influence IAT responses, in particular the subscale that measures the ability of the respondent to adopt the perspective of other people. In fact, an increase in this variable resulted in increased positive attitudes toward plant-based dishes and negative attitudes toward animal-based dishes. Our study therefore supports the evidence that subjects with higher empathic responsiveness tend to exclude animal-based foods from their diets (Filippi et al., 2010). A more developed ability to adopt the point of view of "others" may be at the base of an increased consciousness of emotions and mental state experienced by animals, a variable strongly related to negative attitudes toward animal-based dishes.

In line with previous findings (Fessler et al., 2003), we did not find evidence of a relationship between sensitivity to disgust and the specific disgust toward meat highlighted for vegetarians. Our findings showed that subjects did not differ in moral disgust sensitivity, while an increase in pathogen disgust sensitivity was associated with positive attitudes toward meat-based dishes.

Taste responsiveness also influenced implicit attitudes. Our model showed that a higher responsiveness to PROP resulted in negative attitudes toward plant-based dishes and positive attitudes toward animal-based dishes. PROP status was previously examined as a possible explanation for explaining why certain individuals are more likely to become vegetarians (Teller et al., 2011), providing the evidence that moral vegetarians were significantly less sensitive to PROP than non-vegetarians. Therefore these results suggest that bitter sensitivity may influence the adherence to diets rich in plant-based food products, like the vegetarian one. More in general, our findings are coherent with previous research where a higher responsiveness to PROP has been associated with lower vegetables preference (Dinehart et al., 2006) and food choice (Feeney, 2010). PROP responsiveness resulted also positively correlated with pathogen disgust, confirming previous studies that highlighted a relationship between PROP taster status and the visceral components of disgust (Herz, 2011).

Overall these results allow hypothesizing that possible factors that facilitate consumption of plant-based dishes may be a lower responsiveness to bitter taste, a higher knowledge of positive effects of vegetables consumption on health and an increased consciousness of food animals mental state and emotions.

4.2 *Implicitly measured attitudes toward plant-based and animal-based dishes among declared eating habits*

Declared eating habits related to animal food consumption may not reflect actual behavior (Rothgerber, 2014). The measure of attitudes toward plant-based dishes and animal-based-dishes with an implicit measure allowed validating the segments formed on the basis of declared eating habits, through a comparison between declared eating habits and implicitly measured attitudes. In the IAT, where attitudes towards vegetables were studied relatively to attitudes towards meat, the implicit measures agreed with the declared eating habits. In particular, the Vegetarians had more positive attitudes toward plant-based than meat-based dishes to a greater extent than did the Flexitarians, while the Omnivores did not differ in their attitudes. These results thus support previous studies (Barnes-Holmes et al., 2010; De Houwer & De Bruycker, 2007) in showing that the implicit attitudes of vegetarians and non-vegetarians toward meat and vegetables may be detected using the IAT and that implicit attitudes towards vegetables were more positive in vegetarians than in non-vegetarians.

In the IAT in which attitudes towards vegetables were studied relative to the attitudes towards dairy products, the Vegetarians expressed positive attitudes toward plant-based dishes over dairy-based dishes to a greater extent than the other segments, while the Flexitarians and the Omnivores did not show directions in the attitudes. These results suggest that being vegetarian involves a preference toward vegetables over both meat and dairy products, while being flexitarian involves only a preference of vegetables over meat. On the other hand, an omnivorous diet does not imply a preference of one food category over another, suggesting an absence of restrictions in food consumption.

Looking at the individual attitudes, Vegetarians were homogeneous in implicit responses, while Flexitarians and Omnivores showed higher heterogeneity. Differences in D-scores among segments were due to differences in response latencies from the combined-task where the animal category was grouped with positive emotions and the plant category was grouped with negative emotions. Anyway, IAT does not allow saying which one of the two previous pairs was the driver of response latency. A possible suggestion may be derived from De Houwer & De Bruycker (2007), where the use of the Extrinsic Affective Simon Task showed that, compared to non-vegetarians, vegetarians have both a more negative implicit attitude towards meat and a more positive implicit attitude towards vegetables. This evidence therefore indicates that, at least for the IAT where the attitude towards vegetables where studied relatively to the attitude towards meat, both the IAT combinations may be included in the average response latency. Overall, the implicit measures agreed with declared eating habits, therefore validating the segments defined for this study. It is noteworthy that, for the first time, the validity of middle-option consumers such as flexitarians is confirmed not only from an explicit declared measure (Graça et al., 2015) but also by an implicit behavioral measure. These results encourage the use of the IAT as a measure of food preferences.

4.3 *The role of psycho-attitudinal variables and taste responsiveness on declared eating habits*

Our results support the research on cognitive processes that underline the Meat paradox (Loughnan et al., 2010). In fact, as previously reported by Bilewicz et al. (2011), Omnivores fail to recognize food animal's capacity to experience emotion and to posses mental capacities. These data may indicate that, among Omnivores, denying the animals essential psychological characteristics that are commonly perceived as uniquely human solved any cognitive dissonance involved in consuming animals. This may be facilitated by a lower ability to adopt the point of view of the "others" (*Perspective taking*), followed by a lower consciousness of emotions and mental state experienced by food animals compared to the other segments.

In contrast, among Vegetarians, not eating meat is associated with the attribution to animals of more emotions and mental states, while any tendency to dissociate the meat from its origin is limited. Also in this case, aspects that may justify the own diet were highlighted, as suggested by a higher interest in natural products and in general a higher concern about health. The Flexitarians fell between the other two segments, both in terms of empathy toward animals and the strategies to justify meat consumption. The only 'Omnivores strategy' that persisted for this group was the dissociation of meat from its origin. Unlike Omnivores, this segment did not withdraw moral status from animals and therefore in this case, meat consumption, even if limited, was mainly due to denial of the animal origin of meat. Also in this case, the process of limiting meat consumption promoted aspects that justified the consumption of healthier meat substitutes.

Considered together, these results suggest that attitudes toward meat consumption are related to the ability to try to empathize with animals, as a consequence of being able to appreciate the existence of emotions and a mental life of animals. The outcome of this process consists, in different degrees, of limiting meat consumption and in the inclusion in the diet of meat substitutes such as vegetables.

The process of including vegetables in the diet with higher frequency may be influenced not only by ethical aspects or health concerns but also by food taste properties. In this study, the responsiveness to PROP was considered as an index of taste sensitivity. Our results reported that PROP bitterness sensitivity was significantly higher in Omnivores compared to the Vegetarians. Moreover, the Vegetarian group had the highest proportion of PROP non-tasters, while PROP super-tasters were most common among Omnivores. These results are consistent with a recent study (Monteleone et al., 2017), in which being PROP super-taster was associated with a lower liking and familiarity of bitter vegetables. The results of this study therefore indicate that the sensations experienced eating vegetables may be different among the considered segments, and for Omnivores the bitter perception of some vegetables may be higher compared to the one experienced by Vegetarians. In turn, this suggest that a higher bitter perception may represent a barrier to the inclusion in the diet of meat substitutes such as the vegetables, confirming previous literature on PROP bitterness sensitivity and vegetable consumption (Kaminski et al., 2000).

5. Conclusions

Overall the implicit measures resulted in line with declared eating habits, allowing the validation of the segments considered in the study. In this context, the flexitarianism was confirmed as a defined eating behavior, not only on the basis of an explicit declared measure but also for the first time also using an implicit behavioral measure.

The results allows hypothesizing that possible factors that facilitate plant-based dishes consumption may be a lower responsiveness to PROP, a lower sensitivity to pathogen disgust, an higher importance of health and natural aspects in the diet and an increased consciousness of food animal mental state and emotions and ability to recognize them. The dimension of food pleasure resulted equally important regardless of the eating habits, suggesting the importance to develop and provide plant-based dishes and food products that present a hedonic value comparable to the one experienced with animal-based food sources. The transition from plant-based diet to animal-based diet should therefore embrace multiple aspects, focusing attention on both food sensory properties and consumers' food consciousness.

6. References

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Figure captions

Figure 1. Box plot. Differences in D-scores within VM-IAT, VD-IAT and MD-IAT for Omnivores (O), Flexitarians (F) and Vegetarians (V) segments. D-scores within horizontal lines represent a condition of no preference between combinations.

Figure 2. D-scores values within VM-IAT, VD-IAT and MD-IAT for Omnivores (O), Flexitarians (F) and Vegetarians (V) segments: mean values. Within each IAT, mean values followed by different letters are significantly different ($p < 0.05$). D-scores above the horizontal line represent a condition of no preference between combinations.

Figure 3. Response latency for Block 3, 4, 6 and 7 within VM-IAT, VD-IAT and MD-IAT obtained for Omnivores, Flexitarians and Vegetarians segments: mean values. Within each block, mean values followed by different letters are significantly different ($p < 0.05$).

Figure 4. PLS regression score plot (a) and correlation loading plot (b) of the D-scores from VM-IAT vs. the following X variables: Prospective Taking (PT-IRI), Pathogen Disgust (PD-TDDS), General Health Interest (GHI-HTA), Natural Product Interest (NPI-HTA), Human-Animal Emotion Similarity (HAES), Human Animal Mental Capacity Similarity (HAMCS) and PROP responsiveness (PROP). Variables in italic were considered as down-weighted. Variance accounted for X and Y for PC1 and PC2 are reported in brackets. Symbols in the score plot represent Omnivores (square), Flexitarians (circle) and Vegetarians (triangle).

Figure 5. PLS weighted regression coefficients displayed with 95% Jack-knife confidence interval for the following X variables: Prospective Taking (PT-IRI), Pathogen Disgust (PD-TDDS), General Health Interest (GHI-HTA), Natural Product Interest (NPI-HTA), Human-Animal Emotion Similarity (HAES), Human Animal Mental Capacity Similarity (HAMCS) and PROP responsiveness (PROP) for the first component of VM-IAT, VD-IAT (down-weighted) and DM-IAT (down-weighted). Variables with interval overlapping 0 (grey bars) are not significant.

Figure 6. Stimuli used in the VM-IAT for the plant-based dish category (a) and the meat-based dish category (b).

Figure 7. Stimuli used in the VD-IAT for the plant-based dish category (a) and the dairy-based dish category (b).

Figure 8. Stimuli used in the DM-IAT for the dairy-based dish category (a) and the meat-based dish category (b).

Table 1. Psychological and personality traits, food attitudes and beliefs on food animal measurements: questionnaires and their relative acronym, items and domains, rating scale and references.

Questionnaire	Items/Domains	Scale	Sample items
Food Neophobia Scale (FNS) (Pliner & Hobden, 1992)	10 items	7 point Likert scale (1=disagree strongly; 7=agree strongly)	‟I don’t trust new foods’’; ‟I will eat almost everything”.
Interpersonal Reactivity Index (IRI) (Davis, 1980)	28 items, 4 domains: - Fantasy (F) - Perspective Taking (PT) - Empathic Concern (EC) - Personal Distress (PD)	5 point Likert scale (1=never true; 5=always true)	‟I try to look at everybody's side of a disagreement before I make a decision”; ‟I am often quite touched by things that I see happen”.
Three-Domain Disgust Scale (TDDS) (Tybur et al., 2009)	14 items, 2 domains: - Pathogen Disgust (PD) - Moral Disgust (MD)	7 point Likert scale (1=not at all disgusting; 7=extremely disgusting)	“Accidentally touching a person’s bloody cut”; “Stealing from a neighbor”
Health and Taste Attitudes Scale (HTA) (Roininen et al., 1999)	38 items, 6 domains: - General Health Interest (GHI) - Light Products Interest (LPI) - Natural Products Interest (NPI) - Craving for Sweet Foods (CSF) - Food as a Reward (FR) - Pleasure (P)	7 point Likert scale (1=disagree strongly; 7=agree strongly)	‟I would like to eat only organically grown vegetable”; ‟I reward myself by buying something really tasty”.
Food Involvement Scale (FIS) (Bell & Marshall, 2003)	12 items, 2 domains: - Set and Disposal (SD) - Preparation and Eating (PE)	7 point Likert scale (1=disagree strongly; 7=agree strongly)	‟Talking about what I ate or am going to eat is something I like to do’’; ‟I do most or all of my own food shopping”.
Human-animal emotions similarity (HAES) (Bilewicz et al., 2011)	12 items	5 point Likert scale (1 = highly unlikely; 5 = highly likely)	
Human-animal mental capacity similarity (HAMCS) (Bastian et al., 2012)	7 items	5 point Likert scale (1 = definitely does not possess; 5 =definitely does possess)	
Meat Eating Justification (MEJ) (Rothgerber, 2013)	27 items, 9 domains: - Pro-meat attitude (PMA) - Denial (D) - Hierarchical justification (HIJ) - Dichotomization (DIC) - Dissociation (DIS) - Religious justification (RJ) - Avoidance (A) - Health justification (HEJ), - Human destiny justification (HDJ)	7 point Likert scale (1=disagree strongly; 7=agree strongly)	“Meat is essential for strong muscles”; “Animals do not feel pain the way humans do”.

Table 2. Task sequence and response key assignment of the three Implicit Association Test measures: VM-IAT, VD-IAT and DM-IAT.

VM-IAT

Block	*No. Trials*	*Task*	Response key assignement	
			Left key	*Right key*
1	20	Practice target	Vegetables	Meat
2	16	Practice attribute	Positive emotions	Negative emotions
3	20	Practice combined-task	Vegetables, Positive emotions	Meat, Negative emotions
4	36	Test combined-task	Vegetables, Positive emotions	Meat, Negative emotions
5	40	Practice on reversed target	Meat	Vegetables
6	20	Practice combined-task	Meat, Positive emotions	Vegetables, Negative emotions
7	36	Test combined-task	Meat, Positive emotions	Vegetables, Negative emotions

VD-IAT

Block	*No. Trials*	*Task*	Response key assignement	
			Left key	*Right key*
1	20	Practice target	Vegetables	Dairy
2	16	Practice attribute	Positive emotions	Negative emotions
3	20	Practice combined-task	Vegetables, Positive emotions	Dairy, Negative emotions
4	36	Test combined-task	Vegetables, Positive emotions	Dairy, Negative emotions
5	40	Practice on reversed target	Dairy	Vegetables
6	20	Practice combined-task	Dairy, Positive emotions	Vegetables, Negative emotions
7	36	Test combined-task	Dairy, Positive emotions	Vegetables, Negative emotions

DM-IAT

Block	*No. Trials*	*Task*	Response key assignement	
			Left key	*Right key*
1	20	Practice target	Dairy	Meat
2	16	Practice attribute	Positive emotions	Negative emotions
3	20	Practice combined-task	Dairy, Positive emotions	Meat, Negative emotions
4	36	Test combined-task	Dairy, Positive emotions	Meat, Negative emotions
5	40	Practice on reversed target	Meat	Dairy
6	20	Practice combined-task	Meat, Positive emotions	Dairy, Negative emotions
7	36	Test combined-task	Meat, Positive emotions	Dairy, Negative emotions

Table 3. Characterization of the pictures referred to the target concepts in the three Implicit Association Test measures: VM-IAT, VD-IAT and DM-IAT.

	VM-IAT			VD-IAT			DM-IAT		
	Concepts		*p value*	*Concepts*		*p value*	*Concepts*		*p value*
	Vegetables	Meat		Vegetables	Dairy		Dairy	Meat	
Q1	6.1	6.3	0.135	6.3	6.5	0.248	6.3	6.3	0.822
Q2	6.0	6.4	0.204	6.1	6.2	0.734	6.2	6.4	0.279
Q3	4.2	4.4	0.741	4.2	2.8	0.012	3.3	4.2	0.057
Q4	8.4	8.4	0.893	8.4	8.3	0.166	8.3	8.4	0.591

Q1: How much would be pleasant to taste the dish?
Q2: How do you evaluate the visual presentation of the dish?
Q3: How much preparation do you think that the dish needs?
Q4: Indicate your level of agreement with the following sentence: this is a plant-based dish (or meat-based, or dairy-based).

Table 4. Demographic and social characteristics of the respondents per category of eating habits.

	Omnivores (n=39) %	Flexitarians (n=55) %	Vegetarians (n=31) %	p-value
Gender				
Males	35.9	23.6	22.6	0.354
Females	64.1	76.4	77.4	
Age (years)				
18-30	89.7	72.7	51.6	
31-40	7.7	21.8	38.7	0.008
41-50	2.6	5.5	9.7	
Body mass index (kg/m^2)				
Underweight (<18.50)	7.7	9.1	12.9	
Normal range (18.50-24.99)	69.2	83.6	83.9	0.238
Overweight (25.00-29.99)	15.4	5.5	3.2	
Obese (≥30.00)	7.7	1.8	0.0	
Educational level				
Lower secondary school	0.0	1.8	3.2	
Upper secondary school	48.7	30.9	45.2	0.521
Degree	43.6	54.5	45.2	
Post-degree (MSc, PhD)	7.7	12.7	6.5	
Monthly expense for food (euro)				
Up to 200	35.9	32.7	32.3	
From 201 to 400	30.8	50.9	54.8	0.263
From 401 to 600	20.5	12.7	9.7	
More than 600	12.8	3.6	3.2	

Table 5. Psychological and personality traits, food attitudes and beliefs on food animal measurements per category of eating habits: mean values. Mean values followed by different letters are significantly different ($p < 0.05$).

	Omnivores (n=39)	Flexitarians (n=55)	Vegetarians (n=31)	p-value	Cronbach's alpha
Food Neophobia Scale	26.6	28.1	31.2	0.112	0.83
Interpersonal Reactivity Index					
Fantasy	3.5	3.7	3.6	0.559	0.73
Perspective Taking	3.7 b	3.9 ab	4.0 a	0.035	0.58
Empathic Concern	3.4	3.6	3.7	0.085	0.73
Personal Disease	2.8	2.9	2.7	0.333	0.74
Three-Domain Disgust Scale					
Pathogen Disgust	4.8 a	4.7 a	4.0 b	0.003	0.79
Moral Disgust	5.5	5.4	5.0	0.074	0.71
Health and Taste Attitudes Scale					
General Health Interest	4.3 b	5.1 a	5.3 a	<0.001	0.81
Light Product Interest	2.9	3.2	2.9	0.969	0.90
Natural Product Interest	4.2 c	4.9 b	5.5 a	<0.001	0.78
Craving for Sweet Food	5.1	5.1	4.9	0.542	0.88
Using Food as Reward	4.6	4.5	4.1	0.143	0.85
Pleasure	4.9	5.1	5.1	0.620	0.46
Food Involvement Scale					
Set and Disposal	14.9	15.2	13.4	0.061	0.64
Preparation and Eating	46.2	47.1	49.1	0.186	0.44
Human-Animal Emotion Similarity	3.0 c	3.5 b	3.9 a	<0.001	0.88
Human-Animal Mental Capacity Similarity	2.7 c	3.1 b	3.4 a	<0.001	0.82
Meat Eating Justification					
Pro-meat Attitude	5.2 a	3.1 b	1.0 c	<0.001	0.89
Denial	3.1 a	1.9 b	1.1 c	<0.001	0.58
Hierarchical Justification	3.9 a	2.3 b	1.1 c	<0.001	0.75
Dichotomization	4.8 a	4.0 b	2.6 c	<0.001	0.48
Dissociation	4.8 a	4.2 a	3.0 b	<0.001	0.57
Religious Justification	3.1 a	2.0 b	1.6 c	<0.001	0.85
Avoidance	5.2	5	4.3	0.158	0.55
Health Justification	5.5 a	3.6 b	1.2 c	<0.001	0.85
Human Destiny Justification	5.5 a	3.6 b	1.2 c	<0.001	0.73

Table 6. PROP status and PROP bitter intensity per category of eating habits. Mean values followed by different letters are significantly different ($p < 0.05$).

	Omnivores (n=39)	Flexitarians (n=55)	Vegetarians (n=31)	p-value
PROP status (%)				
No Taster	17.9	23.6	38.7	
Medium Taster	43.6	54.5	48.4	0.082
Super Taster	38.5	21.8	12.9	
PROP bitter intensity (mean)	43.7 a	37.4 ab	27.9 b	0.008

Figure 1

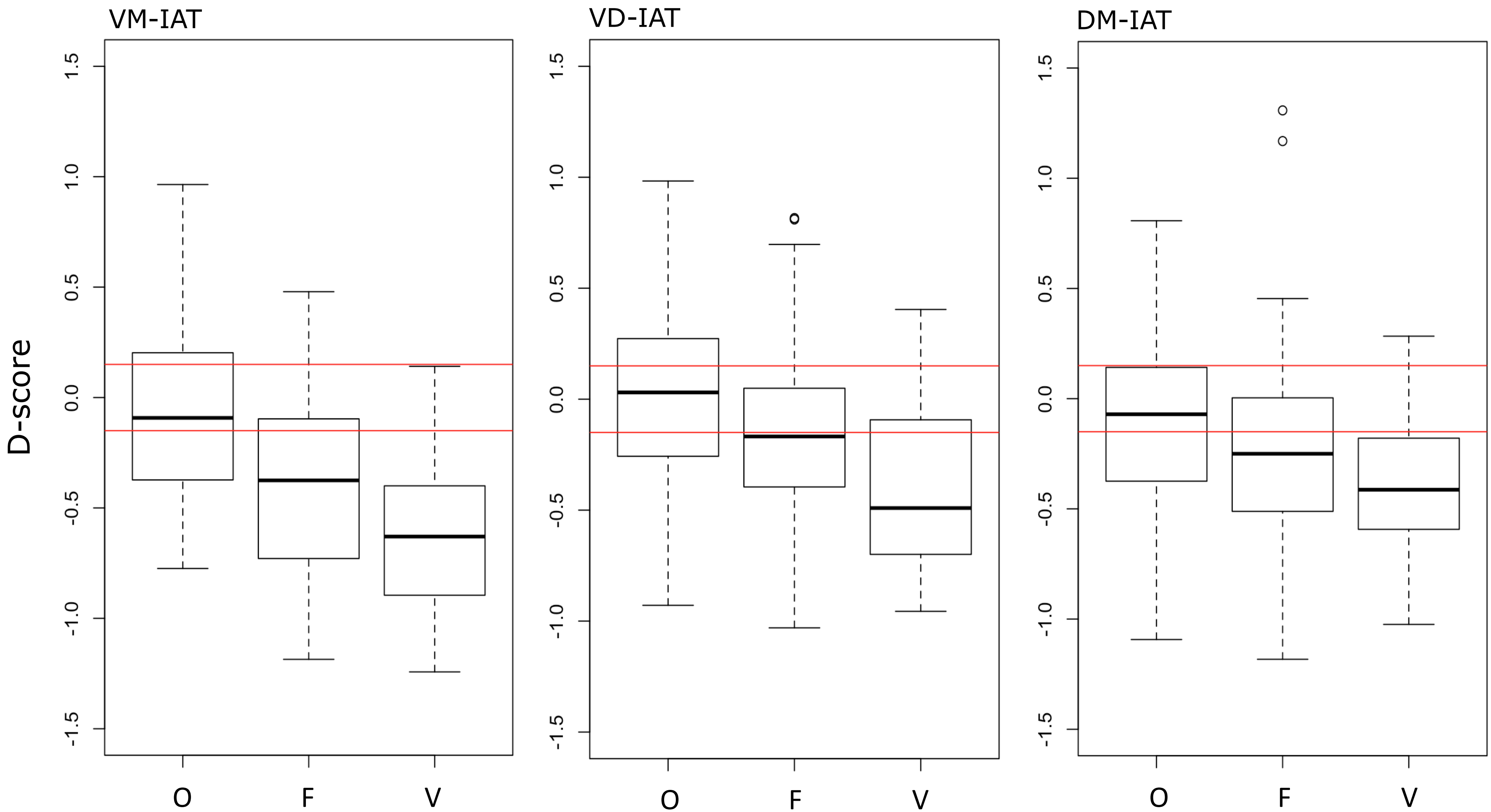
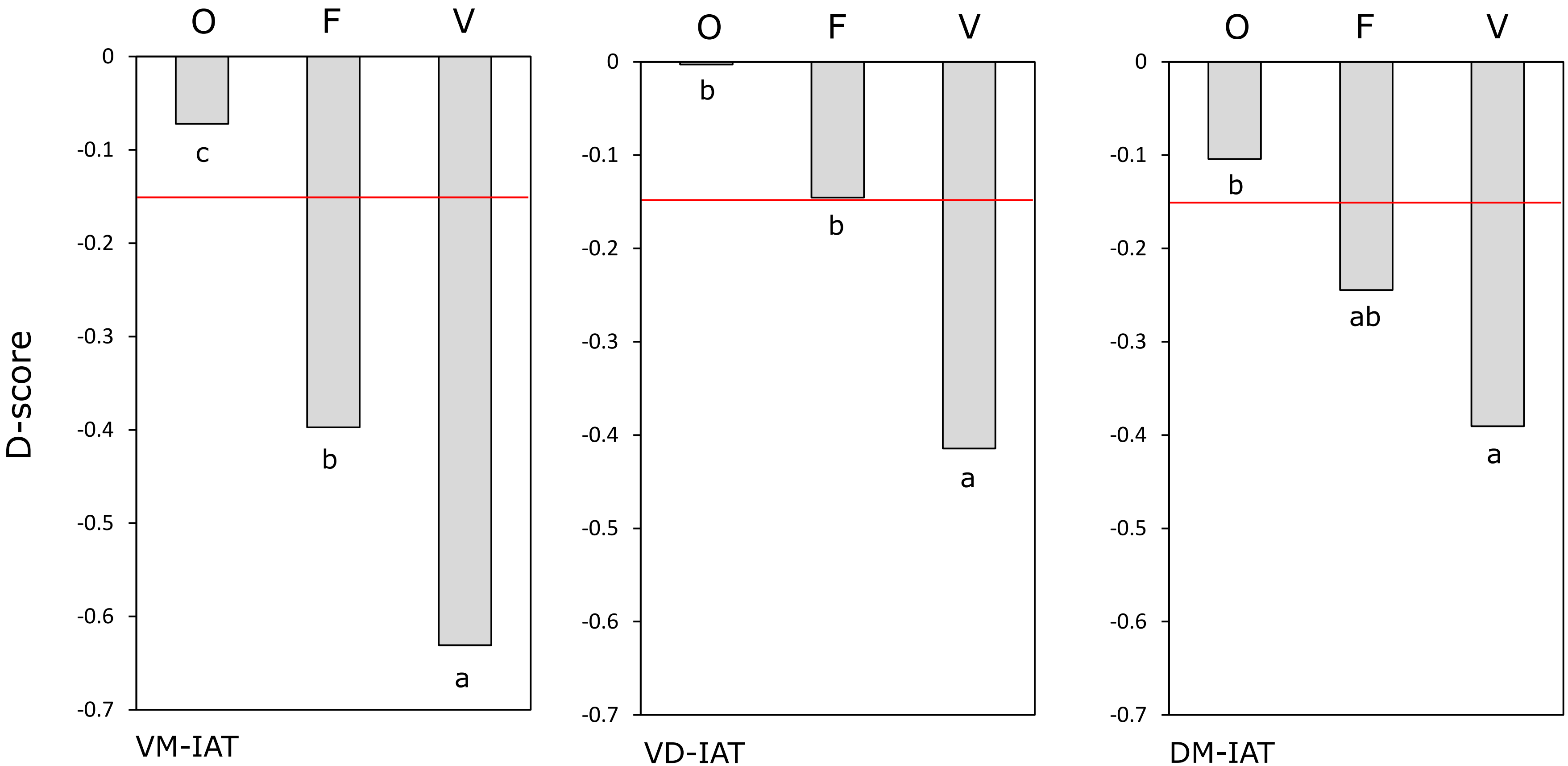
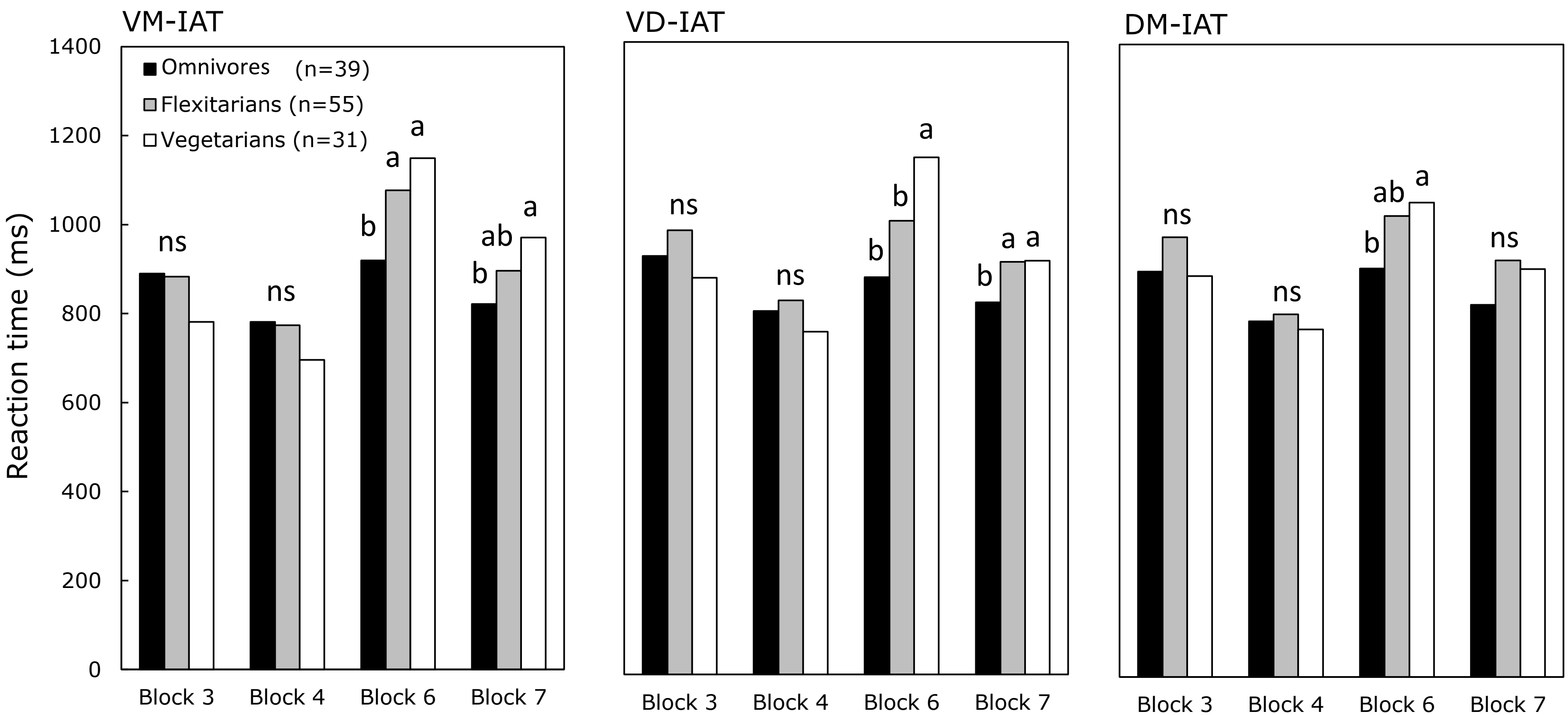


Figure 2



D-score
O
F
V
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
c
b
a
VM-IAT
O
F
V
b
b
a
VD-IAT
O
F
V
b
ab
a
DM-IAT

Figure 3



VM-IAT
VD-IAT
DM-IAT
Reaction time (ms)
1400
1200
1000
800
600
400
200
0
Omnivores (n=39)
Flexitarians (n=55)
Vegetarians (n=31)
ns
ns
b
a
a
b
ab
a
ns
ns
b
b
a
b
a
a
ns
ns
b
ab
a
ns
Block 3
Block 4
Block 6
Block 7

Figure 4

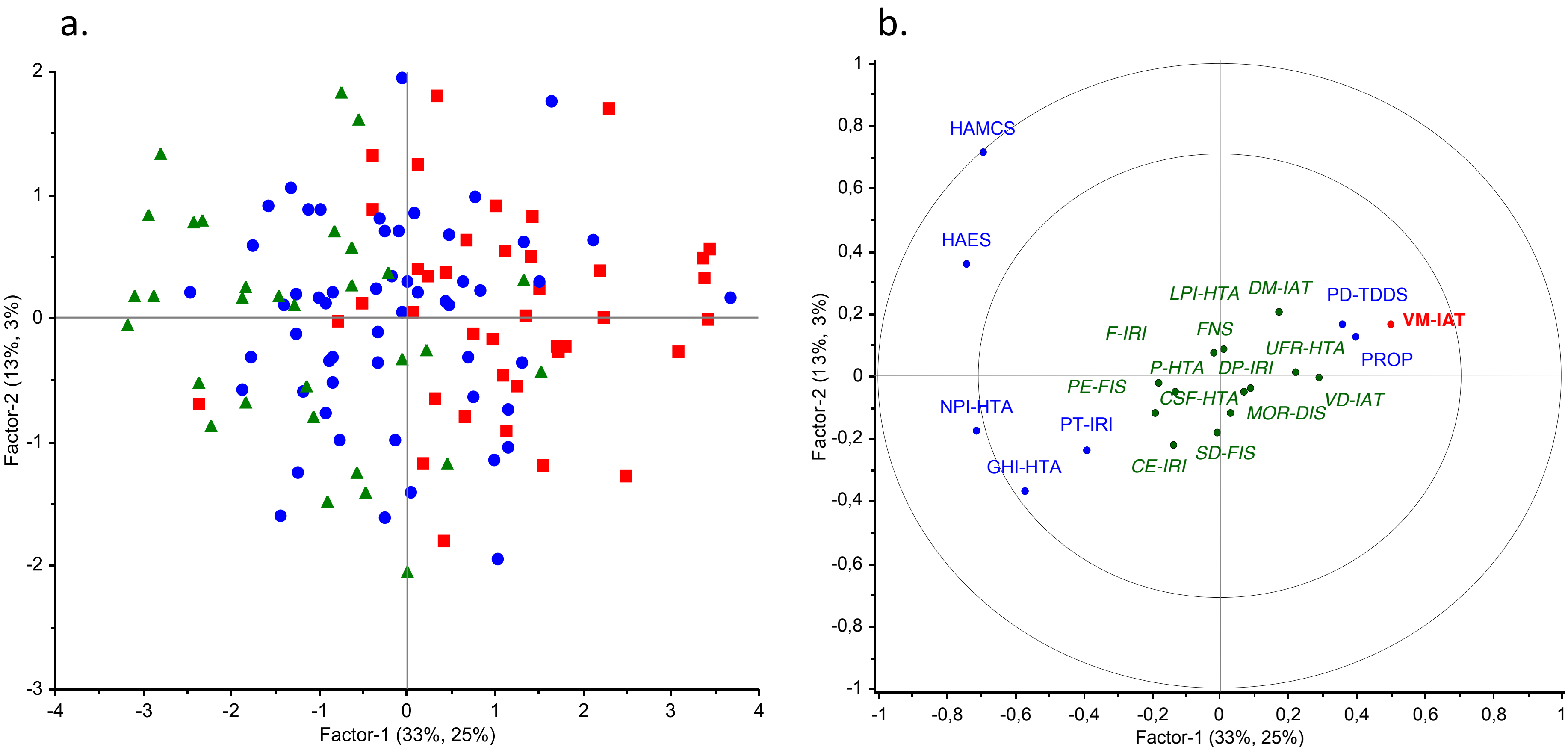
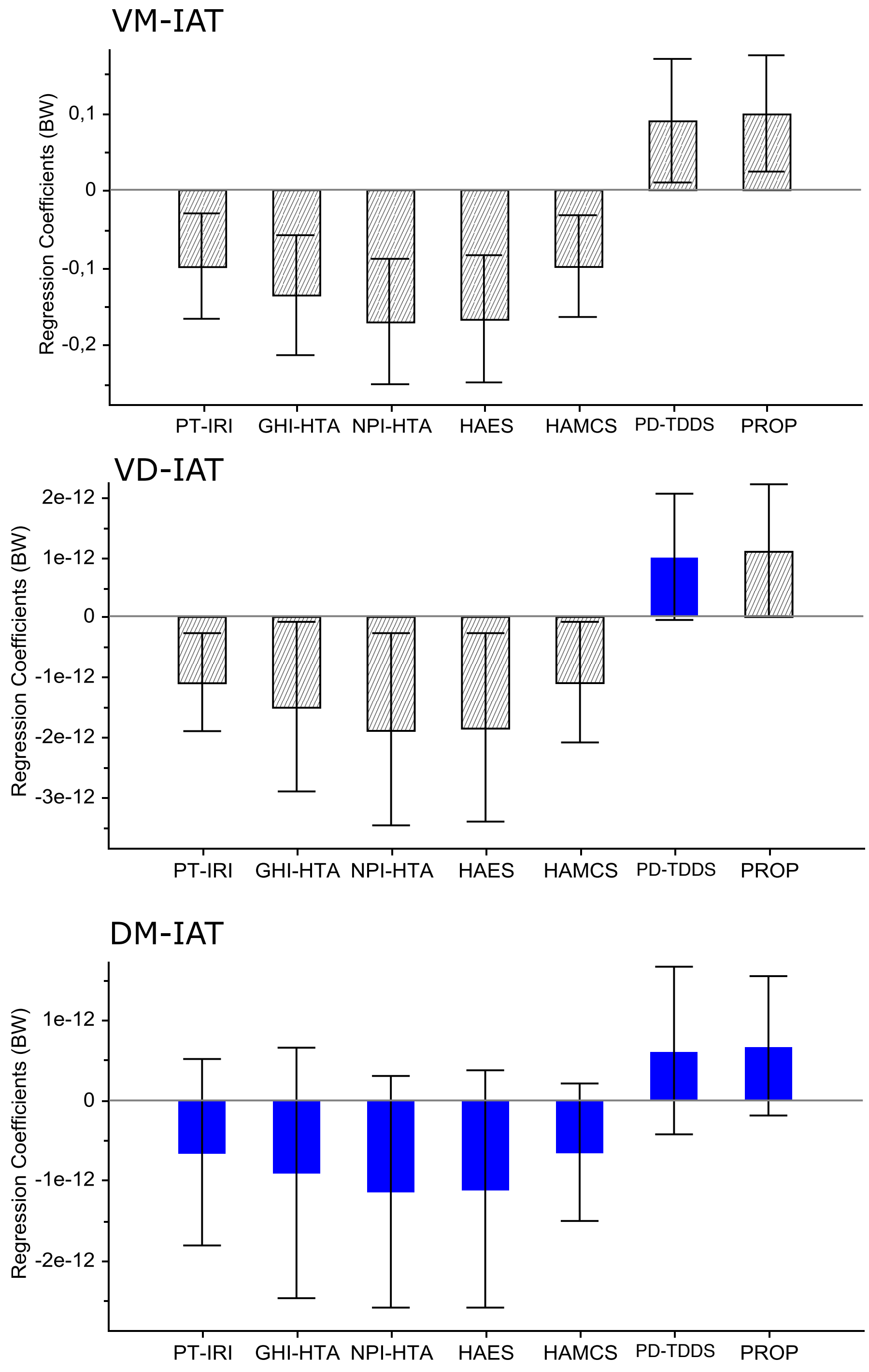

a.
b.
Factor-1 (33%, 25%)
Factor-2 (13%, 3%)
HAMCS
HAES
NPI-HTA
PT-IRI
GHI-HTA
LPI-HTA
DM-IAT
PD-TDDS
VM-IAT
F-IRI
FNS
UFR-HTA
PROP
P-HTA
DP-IRI
PE-FIS
CSF-HTA
VD-IAT
MOR-DIS
SD-FIS
CE-IRI

Figure 5



VM-IAT
Regression Coefficients (BW)
0,1
0
-0,1
-0,2
PT-IRI
GHI-HTA
NPI-HTA
HAES
HAMCS
PD-TDDS
PROP
VD-IAT
Regression Coefficients (BW)
2e-12
1e-12
0
-1e-12
-2e-12
-3e-12
PT-IRI
GHI-HTA
NPI-HTA
HAES
HAMCS
PD-TDDS
PROP
DM-IAT
Regression Coefficients (BW)
1e-12
0
-1e-12
-2e-12
PT-IRI
GHI-HTA
NPI-HTA
HAES
HAMCS
PD-TDDS
PROP

Figure 6

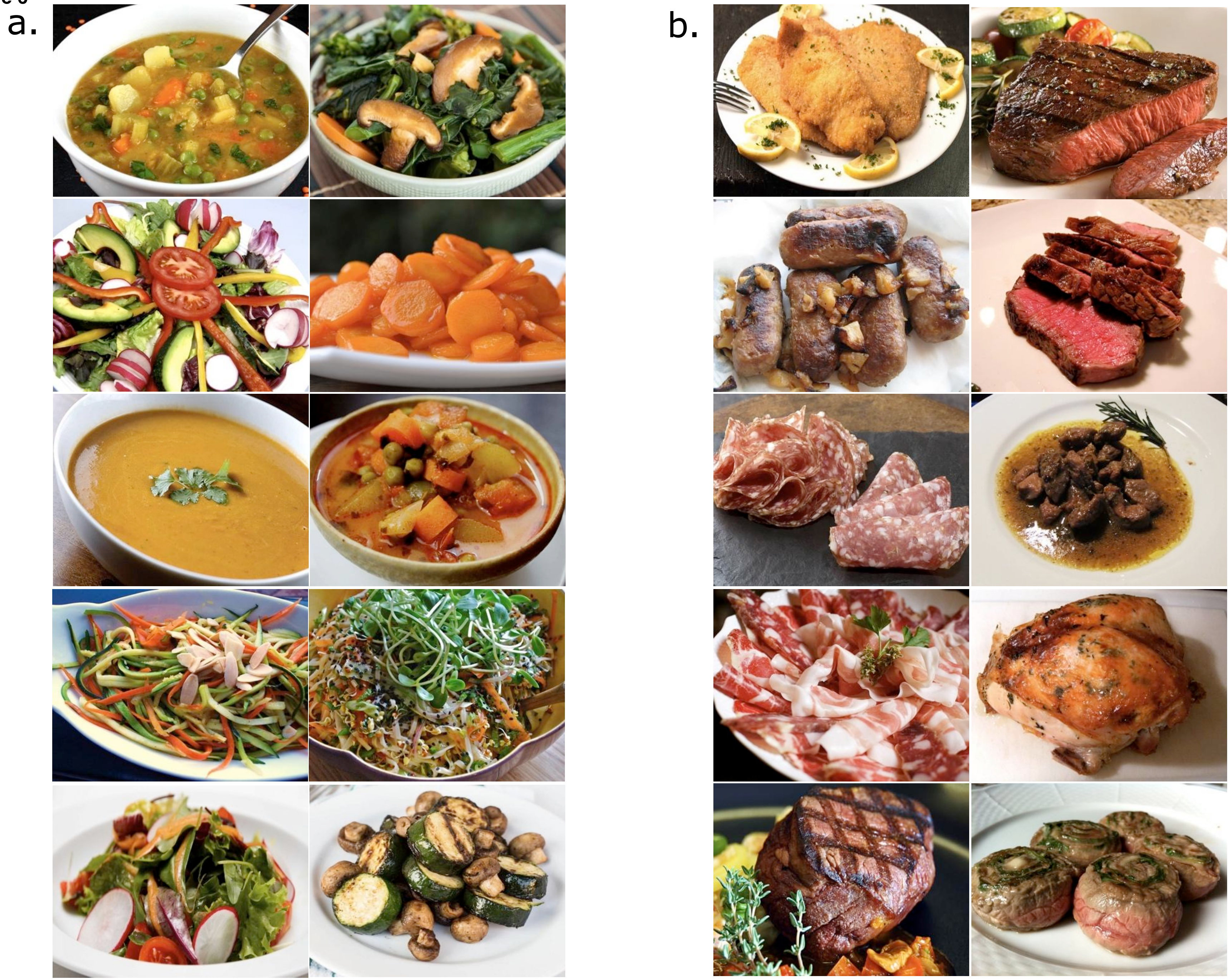


Figure 7

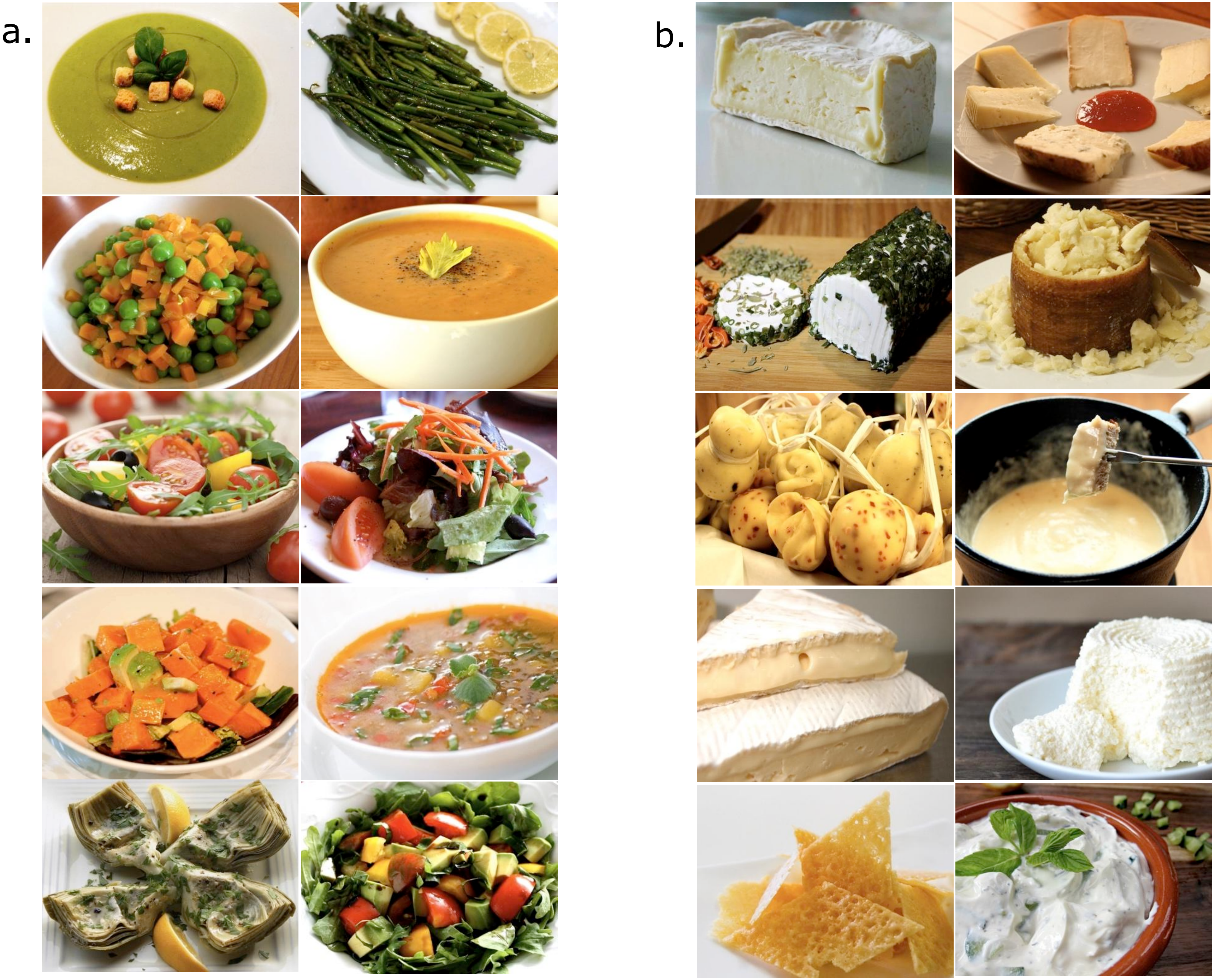


Figure 8