Exploring influences on food choice in a large population sample: The Italian Taste project

E. Monteleone [a,*], S. Spinelli [a], C. Dinnella [a], I. Endrizzi [b], M. Laureati [c], E. Pagliarini [c], F. Sinesio [d], F. Gasperi [b], L. Torri [e], E. Aprea [b], L.I. Bailetti [f], A. Bendini [g], A. Braghieri [h], C. Cattaneo [c], D. Cliceri [a], N. Condelli [h], M.C. Cravero [i], A. Del Caro [j], R. Di Monaco [k], S. Drago [l], S. Favotto [m], R. Fusi [a], L. Galassi [n], T. Gallina Toschi [g], A. Garavaldi [o], P. Gasparini [p], E. Gatti [q], C. Masi [a], A. Mazzaglia [s], E. Moneta [d], E. Piasentier [m], M. Piochi [a,e], N. Pirastu [r], S. Predieri [q], A. Robino [t], F. Russo [u], F. Tesini [g]

[a] *University of Florence, Italy*
[b] *Edmund Mach Foundation, San Michele all'Adige, Italy*
[c] *University of Milan, Italy*
[d] *CREA – Research Centre on Food and Nutrition, Rome, Italy*
[e] *University of Gastronomic Science, Bra, Italy*
[f] *Italian Center of Sensory Analysis & Innovation, Matelica, Italy*
[g] *University of Bologna, Italy*
[h] *University of Basilicata, Potenza, Italy*
[i] *CREA – Research Center for Enology, Asti, Italy*
[j] *University of Sassari, Italy*
[k] *University of Naples, Italy*
[l] *Mérieux NutriSciences, Prato, Italy*
[m] *University of Udine, Italy*
[n] *ERSAF – Regional Agency for Services to Agriculture and Forestry, Italy*
[o] *C.R.P.A. S.p.A., Reggio Emilia, Italy*
[p] *Medical Genetics, UNITS0 – IRCCS Burlo Garofalo, Trieste, Italy*
[q] *IBIMET-CNR, Bologna, Italy*
[r] *Centre for Global Health Research, Usher Institute of Population Health Sciences and Informatics, University of Edinburgh, United Kingdom*
[s] *University of Catania, Italy*
[t] *Institute for Maternal and Child Health – IRCCS "Burlo Garofolo", Trieste, Italy*
[u] *Adacta S.p.A., Naples, Italy*

A B S T R A C T

Food choice is influenced by many interacting factors in humans. Its multidimensional and complex nature is well recognized, particularly within the sensory and consumer food science field. However, the vast majority of the studies aimed at understanding determinants of food choices, preferences, and eating behaviours are affected by important limitations: the limited number of factors that are considered at once and the sample size. Furthermore, sensory and hedonic responses to actual food stimuli are often not included in such studies.

The Italian Taste project is a large-scale study (three thousand respondents in three years) launched by the Italian Sensory Science Society aimed at addressing these limitations by exploring the associations among a variety of measures – biological, genetic, physiological, psychological and personality-related, socio-cultural – describing the dimensions of food liking, preference, behaviour and choice, and their relevance in determining individual differences within a given food culture framework. In addition, the study includes also the collection of sensory and hedonic responses to actual food stimuli commonly consumed in Italy and prepared to elicit a variation in the strength (from weak to strong) of bitterness, sweetness, saltiness, sourness, pungency, umami and astringency.

The aims of the present paper are twofold. Firstly, the paper is aimed to illustrate the variables selected to explore the different dimensions of food choice and to report the experimental procedure adopted for

* Corresponding author.
E-mail address: erminio.monteleone@unifi.it (E. Monteleone).

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data collection. Secondly, the paper is aimed at showing the potential of the Italian Taste dataset on the basis of the data collected in the first year of the project. For the purpose, we selected a small number of variables known to influence food choices from data collected in the first year of the project on 1225 individuals.

1. Introduction

Food choice is influenced by many interacting factors in humans. The selection of a given food depends on the interplay of its intrinsic and extrinsic characteristics with person-related dimensions that are biological, physiological, psychological, and socio-cultural (see Köster, 2009; Mela, 2006; Rozin, 2006; Sobal, Bisogni, Devine, & Jastran, 2006; Sobal, Bisogni, & Jastran, 2014). Food choice is also subject to changes over the lifetime. Its dynamic nature is evident, varying from person to person and from situation to situation (Köster & Mojet, 2007; Sobal et al., 2014). Cultural traditions, social organizations and conditions, shared values and beliefs tend to determine common experiences, while still allowing for individual differences in food choice (see Köster, 2003).

The simplest expression of food choice is relative intake, calculated per capita in a population (Rozin, 2006). In the absence of economic and availability constraints, the major role played by food preferences and liking in determining food choice and intake has been emphasised (Eertmans, Baeyens, & Van den Bergh, 2001; Rozin, 1979, 1990; Tuorila, 2007). The development of food likes and dislikes reflects the operation of multiple influences, from our genetic inheritance, to maternal diet, child-raising practices, learning, cognition and culture, each of which is expressed through hedonic responses to sensory qualities (Prescott, 2012). Preferences are generally defined as choices among available and generally acceptable (i.e. edible) foods in the context in which eating is the issue at hand (Rozin, 2007). However, when faced by a choice, one may prefer one food rather than another for specific reasons such as health, convenience, price, and so on, but actually like better the food not chosen. Thus, preference and liking can be seen as necessary but not sufficient to explain food choice.

The multidimensional and complex nature of food choice is well recognized, particularly within the sensory and consumer food science field. However, the majority of studies examine only a few variables related to specific aspects of one or two dimensions regulating choices, preferences or behaviours. Although these studies have the merit of clarifying specific effects and interactions on a response variable of interest, a lack of research aimed at identifying the associations among the numerous relevant variables in food choice is evident. To address this, more multidisciplinary and multidimensional approaches are needed (Köster, 2009).

In recent years, such multidisciplinary approaches have been increasingly used. Many studies that investigate food behaviours are taking into account health, sociodemographic, psychological and lifestyle factors, thanks also to the support to multidisciplinary networks offered by the European Union (e.g. HabEat project: Caton et al., 2014). Törnwall et al. (2014) reported one of the few recent and most interesting examples of a multidisciplinary approach in exploring the inter-relationships between the different dimensions of food perception and preference. The study was aimed at obtaining a coherent picture of flavour preferences among young adults in relations to different factors, including genotype, gender, age, education, sensory and hedonic responses to varied flavours, taste sensitivity index (PROP), food neophobia, attitudes and food and smoke habits. Food neophobia, pleasantness of pungency, liking of fruits and vegetables and genetic variability were found to be the main factors discriminating two subgroups in a young twin population differing in their liking of sour and pungent foods. However, studies such as this are in the minority.

In addition, many studies tend to generalize findings from small samples to whole populations (Meiselman, 2013). Moreover, academic research is often conducted on convenience samples, e.g., students, that do not necessarily represent larger populations (Golder et al., 2011). The uncertainty about relationships between the responsiveness to PROP and the density of fungiform papillae is an example of this limitation. The association between fungiform papillae density and responsiveness to PROP bitterness found in small size studies (Essick, Chopra, Guest, & McGlone, 2003; Yackinous & Guinard, 2002) has not been confirmed in the more recent, larger studies (Fischer et al., 2013; Garneau et al., 2014).

Understanding the associations among factors involved in food choices requires large-scale studies aimed at making statements about population as a whole, as well as about significant subgroups within the population. A successful model of such an approach can be found in research on the causes of diseases that has benefited from epidemiological studies of genuine population samples (Willett, 2012). In the same way, food choice and behaviour studies can gain predictive power by enlarging the sample size and collecting data on multiple variables in order to identify key explanatory factors and to estimate their actual weight in determining food behaviours.

In line with studies indicating that food hedonics may be better predictors of health outcomes than food intake (Duffy, Hayes, Sullivan, & Faghri, 2009), recent epidemiological studies have included food liking and preference in addition to dietary intake, physical activity, anthropometry, lifestyle, socioeconomic conditions and health status (NutriNet Santé: Hercberg et al., 2010; Lampuré et al., 2014, 2015; Méjean et al., 2014). In addition, large-scale studies (e.g. with three or four thousand respondents) aimed at studying the associations among several factors such as genetics, demographics, taste sensitivity, lifestyles, anthropometrical measures and stated liking for several food categories have been recently published (Pirastu et al., 2012, 2016). Although these studies show the potential of explorative large scale studies on some determinants of food choice and behaviour, they do not include the data collection relative to important dimensions, such as sensory and hedonic responses to actual food stimuli, or psychographics, in particular food-related attitudes. To our knowledge, there are no examples in the literature of genetic studies aimed at understanding food choice and preferences that include hedonic and intensity responses to tastants and odorants presented at different concentration in food product and not in solution, with the exception of Törnwall et al. (2014) on tastes and Jaeger et al. (2013) on odours. Investigating how sensory perception and hedonics vary in relation to an increase of the concentration of a tastant could give us important information for a better understanding of liking.

Food-related motivations and attitudes have been associated with different patterns in food preferences and diet. Hence, general health interest was associated with a lower intake of fat, a lower

consumption of high-fat savoury snacks and high-fat oils and fats, and an increased consumption of vegetables and fruit (Zandstra, de Graaf, & Van Staveren, 2001). Restrained, emotional and external eating behaviours have been linked to food choice. Thus, consumption of sugar-sweetened soft drinks was associated with less restrained and more external eating in adults (Elfhag, Tynelius, & Rasmussen, 2007), and Oliver, Wardle, and Gibson (2000) reported that emotional eaters consume more sweet, high-fat foods in response to emotional stress than did non-emotional eaters. However, the relationship of these eating behaviours with liking and sensitivity is much less explored. In addition, the investigation of food-related lifestyles, including information about attitudes and behaviour relating to purchase, preparation and consumption of food products, has been revealed to be useful in identifying consumer segments and in better understanding the attitudes behind food choice (Brunsø & Grunert, 2007).

In addition to genetic, biological, physiological and sociocultural variables, it has been proposed that personality may play a large role in determining food preferences and food behaviours. This was shown not only for food-related personality traits such as neophobia (Eertmans, Victoir, Vansant, & Van den Bergh, 2005; Knaapila et al., 2011), but also in the case of more general personality traits not explicitly related to food, such as sensitivity to reward (SR) and to punishment (SP). The investigation of the relationships between SR, SP and food preferences and choices is new and still limited but recent studies presented interesting findings. SR was found to be positively associated with the frequency of chilli consumption and weakly, though significantly, correlated with the liking of spicy foods (Byrnes & Hayes, 2013, 2015). Recent studies have also highlighted an association between sensitivity to reward and unhealthier behaviours (higher fat intake, higher alcohol consumption, smoking frequency) (Morris, Treloar, Tsai, McCarty, & McCarthy, 2016; Tapper, Baker, Jiga-Boy, Haddock, & Maio, 2015).

Other relevant associations include those between taste perceptions and preferences and personality dimensions such as private body consciousness, the awareness of bodily sensations (Stevens, 1990; Stevens, Dooley, & Laird, 1998) but the results are controversial (Byrnes & Hayes, 2013; Jaeger, Andani, Wakeling, & MacFie, 1998). Sensitivity to visceral disgust (Herz, 2011, 2014) and alexithymia (inability of individuals to identify and name their emotional states) (Robino et al., 2016) have both been linked to variations in PROP bitter taste responsiveness, with high alexithymia linked in addition to liking of alcohol, sweets and fats/meats, and lower alexithymia related to liking of vegetables, condiments and strong cheeses.

The objectives of the present paper are twofold. Firstly, the paper aims to describe the Italian Taste project, to illustrate the variables selected to explore the different dimensions of food choice and to report the experimental procedure adopted for data collection. The Italian Taste project is a large-scale study (three thousand respondents in three years) aimed at exploring the associations among a variety of measures – biological, genetic, physiological, psychological and personality-related, sociocultural – describing the dimensions of food liking, preference, behaviour and choice, and their relevance in determining individual differences within a given food culture framework. It includes also the collection of sensory and hedonic responses to actual food stimuli commonly consumed in Italy and prepared to elicit a variation in the strength of bitterness, sweetness, saltiness, sourness, pungency, umami and astringency from weak to strong. Secondly, the paper aims to show the potential of the Italian Taste dataset to explain food choice. For these objectives, we selected a small number of variables known to influence food choices from data collected on 1225 individuals in the first year of the project.

2. The Italian Taste project

2.1. Objectives

The aims of Italian Taste (IT) are twofold. Firstly, at a strategic level the targets are:

- to show that large scale and multidisciplinary studies are the necessary condition to increase the understanding of food choice mechanisms.
- to show that large and complex studies can be managed considering several aspects which are economic, cultural and social as we describe here:
  - o Economic: IT is a cost-sharing project among several partners in which the contribution of each partner reflects their available human and financial resources.
  - o Cultural: IT is a multidisciplinary study with a knowledge-sharing approach in which researchers with different scientific backgrounds not only give their own contribution, but learn more about the complex and multidisciplinary factors affecting food preference and choice.
  - o Social: IT is close to the type of epidemiological studies that have been so successful in determining causes of disease and health-related states. The IT dataset has the potential of generating valuable information for human health and wellbeing.

Secondly, the target of the project is to contribute to the uncovering of associations among variables along multiple dimensions that are presumed to be important in determining individual differences in food preference and choice.

2.2. Organization and management of the study

The Italian Taste project was initiated in 2014 by the Italian Sensory Science Society (SISS). It involves, on a voluntary base, 58 SISS members working in 19 sensory laboratories of public and private organizations, across the country (see Appendix 1).

The study is conducted in agreement with the Italian ethical requirements on research activities and personal data protection (D.L. 30.6.03 n. 196). The study protocol was approved by the Ethics Committee of Trieste University where the genetic unit of the project is based. The respondents gave their written informed consent at the beginning of the test according to the principles of the Declaration of Helsinki.

2.3. General project methods

2.3.1. Respondents: Recruitment and inclusion

The recruitment procedure aims to reach a balance between genders, three age classes (18–30; 31–45; 46–60 years) and main geographical areas of the country. Exclusion criteria are pregnancy and not being born in Italy or having lived at least 20 years in Italy. Participants are recruited on a national basis by means of announcements published on the Italian Taste project website (www.it-taste.it), the SISS website (www.scienzesensoriali.it) and social networks (*Facebook*), articles published on national newspapers, and in food and wine magazines. Furthermore, each research unit recruits subjects locally by means of social networks and emails, pamphlet distribution and word of mouth.

2.3.2. Overview of data collection

At the time of recruitment, respondents are given general information about the study aims. They are asked to complete an online questionnaire (OQ; Tables 1 and 2) at home in the days preceding

the data collection and invited to attend two sessions, in two days, in a sensory lab. The data collection scheme is presented in Fig. 1.

On day 1, participants sign the informed consent and are introduced to the general organization of the day which includes a liking and an odour session, followed by the measurement of PROP responsiveness. Designated breaks (10–15 min) between tests are carefully observed. During these breaks, participants are seated together in a comfortable room where water and unsalted crackers are available. Participants are encouraged to comment on, and ask questions about, the procedures with the purpose of giving them the feeling of being part of an important research project, thus increasing their attention and motivation and avoiding fatigue and boredom. During the breaks, participants are given instructions on scaling methods and asked to fill in questionnaires.

Before starting the hedonic evaluation of food samples participants are introduced to the use of the Labeled Affective Magnitude scale (LAM; Schutz & Cardello, 2001). They are seated in individual booths and introduced to the use of the PC for data collection. They are asked to rate their appetite and are presented with four series of products (pear juice, chocolate pudding, bean purée and tomato juice) for liking evaluations. Each series includes four samples with varied intensities of target sensations (Table 3). Food product

Table 1
Socio-demographic and socio-economic, anthropometric and physical health variables: questionnaires and their relative acronym and code.

Questionnaires	Variables	Options
Socio-demographics & socio-economics (SDQ) OQ[1]	Age	Years old at the moment of the test (18-100)
	Gender	M/F
	Place of birth/residence	Province and Council*
	Place of birth of parents	Province and Council*
	Place of birth of grandparents	Province* and Council*
	Educational level	None/Primary/Lower secondary/Upper secondary/Degree/Post-degree
	Marital status	Married or living with a partner/Divorced or separated/widowed/Single
	Employment status	Housemaker/Student/Retired/Unemployed or Never employed/Farmer/ freelance professional/Trader or artisan/Employees
	Number of persons in the house	1–10
	Children <16 years old in the house (n.)	0–5
	Monthly food spending (euro)	Up to 200/From 201 to 400/From 401 to 600/More than 600
	Previous experience in sensory evaluations	Trained panel/Consumer test/Taster or sommelier/Currently working in sensory evaluation/None
Anthropometric (AQ) OQ[1]	Weight (self-reported)	40–180 Kg
	Height (self-reported)	120–220 cm
	Diet	9 items (adapted from De Backer & Hudders, 2015).
Physical health (PHQ) OQ[1]	Practice of restrictive diets (type and reason)	No/Yes, low calorie diet/Yes, for medical reasons (if yes, which one:*)
	Smoking habits	1 Never tried/2 Not smoking (have tried or quit)/3 Yes - If 2: Quit since how many years? Less than 1 year-50 Perceived improvement in smell after quit? No/Yes, for some odours/Yes, in general - If 3: Type: Cigarette/Electronic cigarette/Pipe or cigar Frequency: Occasionally (=not every day)/Regularly If cigarettes, n. per day: 1-more than 40
	Food allergies	Yes/No; if yes, which one*
	Food intolerances	Yes/No; if yes, which one*
	Tendencies to bulimic/anorexic behaviours	Behaviours in the last months such as miss meals, use of medicines, vomit to control weight: No/Yes
	Use of medicines	Regular use for: Flow of blood/Blood pressure/Arthritis pain/To sleep/ Headaches/Digestion/Diabetes/To facilitate the movement/Memory/ Arrhythmias/Antidepressants/Hormonal therapies/None
	Illnesses and chronic diseases	Cardiovascular diseases/Arrhythmia/Hypertension/Type 1 diabetes/Type 2 diabetes (food)/Hypertriglyceridemia/Hypercholesterolemia/Vertigo/ Travel sickness (If yes, details asked)
	Ear infection/otitis	Never/1 time/2 times/From 3 to 5 times/6 or more times
	Problems in taste perception	Yes/No
	Problems in odour perception (except cold)	Yes/No (if yes, details asked)
	Self-rated smell	Above the normal/Below the normal/Normal
	Illnesses and chronic diseases in relatives (first degree)	Type 1 diabetes/Type 2 diabetes/Obesity/Triglycerides/ Cholesterol/ Hypertension (on mother's side)/Hypertension (on father's side/Stroke/ Myocardial infarction/Ischemic heart disease/Sudden death/Neoplasms (on mother's side)/Neoplasms (on father's side)/Glaucoma/Myopia/Thyroid disease/ Ulcer/ Cirrhosis/Kidney disease/Neurological diseases/Other
	Childbirth (natural/caesarean section)	Yes/No/Do not know
	Brest feeding	Yes/No/Do not know (If yes: how many months after birth)
	Pregnancies; Age of first menstr.; Menopausal status	Yes/No (if yes, n.; if no, specify if for medical reasons); age;
	Self-rated health (SRH)	Very good/Good/Fair/Bad/Very bad (Jürges et al., 2008)
	International Physical Activity Questionnaire (IPAQ)	Craig et al. (2003), Mannocci et al. (2012)

The options were presented as check the one/s that apply, if not differently specified. The symbol "-" Indicates that the options include every unit in the range indicated.
[1] OQ = online questionnaire.
* Indicates that the question was open-ended.

Table 2
Food preferences, choice, familiarity and frequency of consumption measurements: Questionnaire, their relative code, items and categories and rating scale.

Questionnaire		Items and domains	Rating scale
Frequency of consumption	OQ*	7 items – 3 categories - Alcoholic beverages (beer; wine; spirits; aperitif/cocktail) - Coffee; Sugar in coffee - Chilli pepper and spicy food	- Alcoholic beverages: (glasses per week; respectively: 330 ml; 125 ml; 40 ml; 100 ml) - Coffee (cups per day) Sugar in coffee (spoon per cup) - Chilli pepper and spicy food (8-point category scale (never, <1/month, 1–3/month, 1–2/week, 3–4/week, 5–6/week, 1/day, 2 +/day).
Familiarity	OQ*	184 items – 7 categories: - Fruit and vegetables (37 items) - Cereal-based products (36 items) - Dairy products (18 items) - Meat, fish and eggs (30 items) - Beverages (28 items) - Seasonings and spices (18 items) - Sweets and desserts (17 items)	5-point labeled scale (1 = I do not recognize it; 2 = I recognize it, but I have never tasted it; 3 = I have tasted it, but I don't eat it; 4=I occasionally eat it; 5 = I regularly eat it); (Tuorila et al., 2001)
Liking	Q1	184 items – 7 categories: - Fruit and vegetables (37 items) - Cereal-based products (36 items) - Dairy products (18 items), - Meat, fish and eggs (30 items) - Beverages (28 items) - Seasonings and spices (18 items) - Sweets and desserts (17 items)	9-point hedonic scale (1 = extremely disliked; 5 = neither liked nor disliked; 9 = extremely liked); (Peryam & Pilgrim, 1957) + option: "I have never tasted it"
Choice	Q7	79 pairs in 4 contexts: - Breakfast (13 pairs) - Snack/light-meal (13 pairs) - Main meal (either lunch or dinner, 43 pairs) - Aperitif (10 pairs)	Forced-choice between two options

* OQ = online questionnaire.

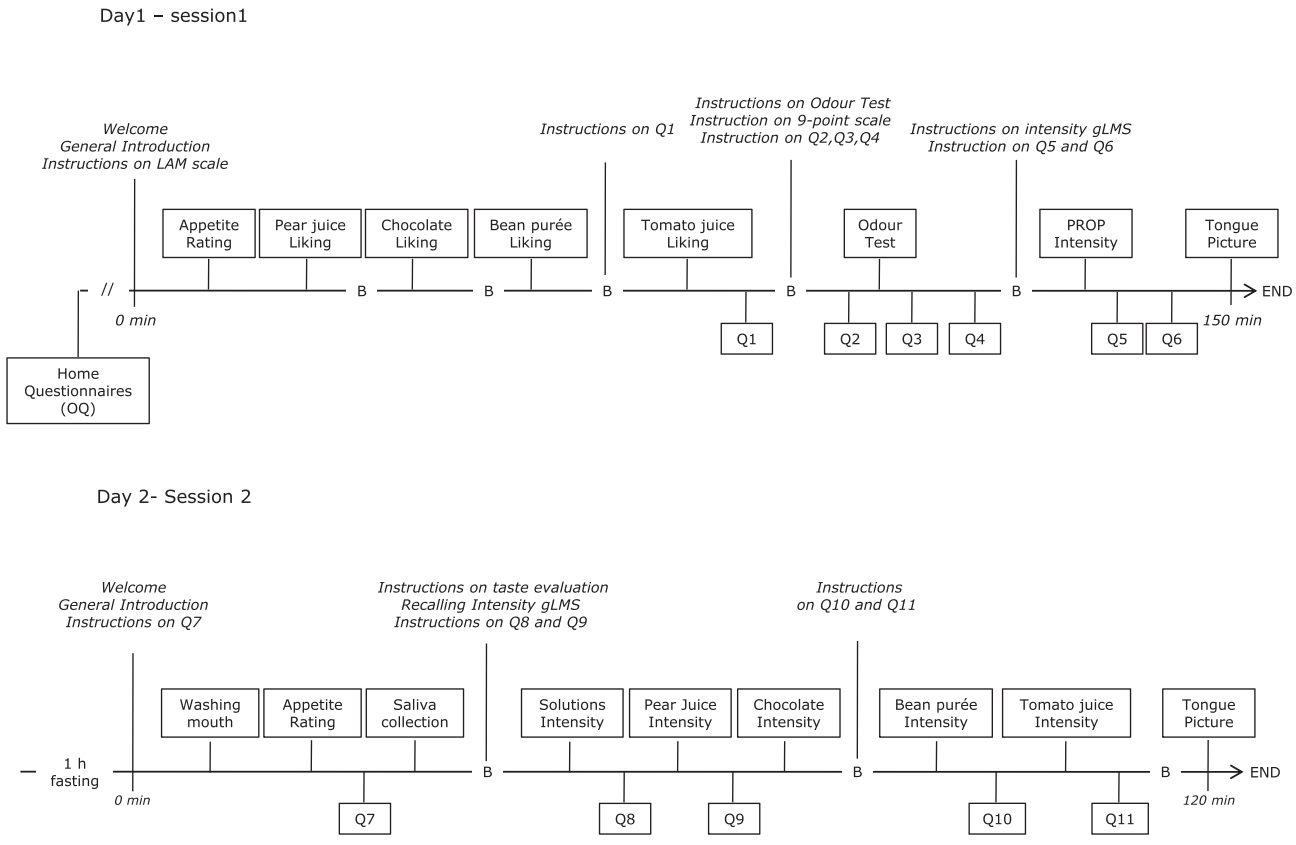

Fig. 1. Overview of data collection.

series are presented in independent sets, each consisting of four samples of the same product. The presentation order of food series is fixed and is designed to avoid perceptive interferences across samples due to the long-lasting sensations of chocolate pudding and tomato juice spiked with capsaicin. Pear juice is presented as first set followed, after a 10 min break, by chocolate pudding.

Table 3
Hedonic and sensory responses to food products, solutions and odours: aims, samples and rating scales.

Stimuli	Response	Aim	Samples	Rating scale
Food products	Liking	To measure variations in liking for real food products due to the variation of the intensity of specific basic tastes or other oral sensations (astringency and pungency)	4 series of 4 samples (spiked with a relevant tastant): - pear juice (citric acid 0.5; 2.0; 4.0; 8.0 g/kg) - chocolate pudding (sucrose 38; 83; 119; 233 g/kg) - bean purée (sodium chloride 2.0; 6.1;10.7; 18.8 g/kg) - tomato juice (capsaicin 0.3; 0.68; 1.01; 1.52 mg/kg)	Labeled Affective Magnitude Scale (0–100) (Schutz & Cardello, 2001)
	Sensory	To measure individual differences in responsiveness to overall flavour, specific basic tastes or other oral sensations (astringency and pungency) in real food products	4 series of 4 samples (spiked with a relevant tastant): - pear juice (citric acid 0.5; 2.0; 4.0; 8.0 g/kg); target sensations: sourness and sweetness - chocolate pudding (sucrose 38; 83; 119; 233 g/kg); target sensations: bitterness, sweetness and astringency - bean purée (sodium chloride 2.0; 6.1;10.7; 18.8 g/kg); target sensations: saltiness and umami - tomato juice (capsaicin 0.3; 0.68; 1.01; 1.52 mg/kg); target sensations: pungency	Generalized Labeled Magnitude Scale (0–100), gLMS (Bartoshuk et al., 2004)
Water solutions	Sensory	To measure individual differences in responsiveness to basic tastes, astringency and pungency in water solutions	7 samples: - citric acid 4 g/kg (sourness) - caffeine 3 g/kg (bitterness) - sucrose 200 g/kg (sweetness) - Sodium Cloride 15 g/kg (saltiness) - Monosodium glutamic acid salt 10 g/kg (umami) - K Aluminum Sulfate 0.8 g/kg (astringency) - capsaicin 1.5 mg/kg (pungency)	Generalized Labeled Magnitude Scale (0–100), gLMS (Bartoshuk et al., 2004)
Odours	Liking	To measure individual differences in liking for odours	4 samples: - mint - anise - pine - banana	9-point hedonic scale (1 = extremely disliked/9 = extremely liked); (Peryam & Pilgrim, 1957)
	Sensory	To measure individual differences in odour responsiveness	4 samples: - mint - anise - pine - banana	Identification: multiple choice Intensity: 9-point scale (extremely week/extremely strong) Irritation: 9-point scale (not at all irritant/extremely irritant)

Subjects have a 15 min break and are then presented with the bean cream set followed, after 10 min break, by tomato juice. The presentation order of food samples within each set is randomized across subjects.

After the liking session, participants are presented with the Food Liking Questionnaire (Q1; Table 2). Then, participants are instructed about the odour test (Table 3) and receive general information about Food Related Life Style (Q2), Food Neophobia Scale (Q3) and Private Body Consciousness (Q4) questionnaires (Tables 4 and 5). They complete Q2 and the odour test, followed by a break during which they complete Q3 and Q4. Participants are then trained to the use of gLMS (0: no sensation-100: the strongest imaginable sensation of any kind) following published standard procedure (Bartoshuk, 2000; Green, Shaffer, & Gilmore, 1993; Green et al., 1996). Subjects are instructed to treat the "strongest imaginable sensation" as the most intense sensation they can

Table 4
Eating behaviours, food-related lifestyles and attitude measurements: questionnaires and their relative acronym, code, items and domains, rating scale and references.

Questionnaire		Items/Domains	Scale/question format	References
Food Related Life Style (FRL)	Q2	69 items – 23 lifestyle dimensions in 5 domains: - Ways of shopping (6 subscales) - Importance of quality aspects (6 subscales) - Cooking methods (6 subscales) - Consumption situations (2 subscales) - Purchasing motives (3 subscales)	7-point Likert scale (1 = disagree strongly; 7 = agree strongly)	Brunsø and Grunert (1998)
Health and Taste Attitudes Scale (HTAS)	Q8	38 items – 6 domains: 3 health-related domains: - General Health Interest (GHI) - Light Products Interest (LPI) - Natural Products Interest (NPI) 3 taste-related domains: - Craving for Sweet Foods (CSF) - Food as a Reward (FR) - Pleasure (P)	7-point Likert scale (1 = disagree strongly; 7 = agree strongly)	Roininen et al. (1999)
Dutch Eating Behaviour Questionnaire (DEBQ)	Q9	33 tems – 3 domains: - Restrained eating - Emotional eating - External eating	5-point scale: - never (1) - seldom (2) - sometimes (3) - often (4) - very often (5)	Strien, Frijters, Bergers, and Defares (1986)

Table 5
Psychological and personality trait measurements: questionnaires with their relative acronym, code, items and domains, rating scale, and references.

Questionnaire	Code	Items and domains	Scale/question format	References
Food Neophobia Scale (FNS)	Q3	10 items	7-point Likert scale (1=disagree strongly; 7=agree strongly)	Pliner and Hobden (1992)
Private Body Consciousness (PBC)	Q4	5 items	5-point scale (1 = extremely uncharacteristic; 5 = extremely characteristic)	Miller, Murphy, and Buss (1981)
Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ)	Q5	48 items – 2 subscales: - Sensitivity to punishment (SP) - Sensitivity to reward (SR)	Yes/No	Torrubia et al. (2001)
Toronto Alexithymia Scale (TAS-20)	Q6	20 items – 3 factors: - Difficulty identifying feelings - Difficulty describing feelings - Externally oriented thinking	5-point Likert scale (1 = disagree strongly;7 = agree strongly)	Bagby et al. (1994)
Portrait Values Questionnaire (PVQ)	Q10	21 items – 10 factors: - Self-Direction - Stimulation - Hedonism - Achievement Power - Universalism - Benevolence - Tradition Conformity - Security	6-point scale (1 = not like me/6 = very much like me)	Schwartz et al. (2001), Davidov, Schmidt, and Schwartz (2008)
Sensitivity to Disgust (DS-SF)	Q11	8-item Short form of the Disgust Scale (DS-SF) – 2 subscales	5-point category scale subscale 1: 1 = Strongly disagree (very untrue about me), 5 = Strongly agree (very true about me) subscale 2: 1 = not at all disgusting 5 = extremely disgusting	DS-SF: Inbar, Pizarro, and Bloom (2009), Haidt (2004) DS-R: Haidt, McCauley, and Rozin (1994); modified by Olatunji et al. (2007)

imagine that involves remembered/imagined sensations in any sensory modality. They are informed about Sensitivity to Punishment and Reward (Q5) and Alexithymia (Q6) questionnaires (Table 5). Then they rate the intensity of PROP solutions and fill in Q5 and Q6. At the end of day 1, respondents are instructed on fasting conditions preceding the collection of a saliva sample in the day 2. Session 1 lasts around 150 min.

Day 2 starts with a general introduction to tests, instructions on saliva collection and introduction to the Choice Questionnaire (Q7). Then, participants are seated in individual booths where they rate their appetite and, before completing the saliva collection procedure, complete questionnaire Q7. After that, the gLMS is briefly introduced again and the Health and Taste (Q8) and the Dutch Eating Behaviour (Q9) questionnaires are illustrated. Then, the first part of intensity data collection starts. Participants are first asked to rate the intensity of basic tastes, astringency and burn in a series of seven samples (Table 3). The presentation order of stimuli is randomised for the basic tastes and astringency while the burning solution is always evaluated as the last sample to avoid perceptive interferences across samples due to the long lasting sensation of capsaicin. They have a break and are asked to fill in Q8. Finally, taste and oral sensation intensities are collected from four series of the same food products presented in day 1. During breaks between sample series, participants are asked to fill in Qs 9, 10 and 11. The picture of the tongue for papillae counting is taken at the end of day 1 or 2, according to individual availability. Session 2 lasts around 120 min. At the end of the session participants receive a certificate of attendance to the project and are compensated for their time with a gift. From 1 to 7 days were left between the two sessions, according to subject availability.

2.3.3. Questionnaires

Using questionnaires, information is collected concerning socio-demographic and socio-economic, anthropometric and physical health (Table 1); food preferences, choice, familiarity and frequency of consumption (Table 2); eating behaviours, food-related lifestyles and attitudes (Table 4); psychological and personality traits (Table 5).

For those questionnaires not originally developed in Italian, or when an Italian validated version was not available, the questionnaires were translated to Italian by two different bilingual Italian native-speakers and then back translated into the source language. Back translations were reviewed by an expert in semantics and adjustments were made when necessary to select the most appropriate translation.

2.3.3.1. Socio-demographic, socio-economic, anthropometric and physical health questionnaires. Information is collected on socio-demographic and socio-economic indices, and anthropometric and physical health measures through an online questionnaire (Table 1). The questionnaire includes multiple choice questions (select one or select multiple) and open-ended questions to collect further details. Information is collected concerning marital status, number of children, number of family members, current job, education level, tobacco smoking habit, past medical history, current use of medication, dietary supplements, familial medical history, causes of death of first-degree relatives (when appropriate) and, for women, obstetric history, pregnancies, and menopausal status. Self-rated health is measured using the European World Health Organization (WHO) version (Jürges, Avendano, & Mackenbach, 2008). Anthropometric includes questions on height and weight and dietary restraint. To determine eating habits, respondents are asked to indicate which diet they follow out of list of nine eating diets descriptions adapted from De Backer and Hudders (2015). Information about physical and sedentary activity is collected using the Italian version of the International Physical Activity Questionnaire (IPAQ) (Craig et al., 2003; Mannocci et al., 2012). Physical activity is described according to 3 levels of exercise intensity (walking, moderate or vigorous), frequency of exercising (days/week) and daily duration of each performed activity.

2.3.3.2. Food Familiarity, liking and choice questionnaires. Information about frequency of consumption is collected for alcoholic beverages (beer; wine; spirits; aperitif/cocktail), coffee, sugar addition in coffee and chilli pepper and spicy food (Table 2).

The Food Familiarity and Food Liking questionnaires were developed to measure, respectively, familiarity with, and liking for, a selection of 184 foods appropriate in different eating situations (Table 2). Eating situations were identified considering either the traditional Italian meal pattern (breakfast, lunch and dinner), as well as new habits, such as snack/light meals and aperitif, that tend to substitute lunch or dinner, thus breaking the traditional meal timing. The item selection reflected variations in familiarity (more/less familiar foods), flavour (strong/mild) and energy content (high-energy/low-energy dense) as well. Items are grouped in product categories based on their chemical composition. The presentation order of the items within each product category as well as the product category order are randomized across participants.

The Food Choice Questionnaire was developed in order to evaluate preferences within a pair of items. For each pair, respondents are asked to indicate which food they would choose in that specific eating situation. In this questionnaire, food items (selected among the 184 items of the Food Familiarity and Liking questionnaires) were grouped in 79 pairs and distributed in specific eating situations as follows: breakfast (13 pairs), snack/light-meal (13 pairs), main meal (either lunch or dinner, 43 pairs) and aperitif (10 pairs). Items in each pair represent variations in terms of familiarity, taste (e.g. bitter vs sweet) and energy content (e.g. low-fat vs full-fat). In some cases, pairs consist of different foods or food categories (e.g. fruit vs cake) both suitable for a specific eating situation (e.g. breakfast). The presentation order of the food items within each pair, and of the pairs within each eating context, is randomized across participants, while the presentation order of the eating situations is the same for all participants (breakfast, snack/light-meal, main meal, aperitif).

2.3.3.3. Eating behaviours, food-related lifestyles and attitudes. Questionnaires are completed during the course of the testing days to assess eating behaviours and attitudes towards foods. Food-related lifestyles are determined using the Food Related Lifestyle (FRL) questionnaire, while consumers' orientations towards health and hedonic characteristics of foods is determined through the Health and Taste Attitudes Scale (HTAS). The Dutch Eating Behaviour Questionnaire (DEBQ) is used to assess restrained, emotional and external eating behaviours (Table 4).

2.3.3.4. Psychological and personality traits. Questionnaires are completed during the course of the testing days to assess seven psychological or personality related traits: food neophobia (FNS); private body consciousness (PBC), that it, awareness of internal sensations; sensitivity to punishment and reward (SPSRQ); sensitivity to core disgust (DS-SF); alexithymia (TAS-20); and orientation to value (PVQ); (Table 5).

2.3.4. Sensory stimuli

2.3.4.1. Water solutions. Seven water solutions, corresponding to five basic tastes, astringent and burning sensations are rated for intensity (Table 3). The concentration of the tastants were decided based on published psychophysical data (Feeney & Hayes, 2014; Hayes, Sullivan, & Duffy, 2010; Masi, Dinnella, Monteleone, & Prescott, 2015) and previous preliminary trials conducted with one hundred untrained subjects recruited in five Italian sensory laboratories (unpublished data) in order to select solutions equivalent to moderate/strong on a gLMS. The results of the preliminary trials were confirmed in a pilot study performed in 10 sensory laboratories with an average number of 5 subjects per lab.

2.3.4.2. Food products. The criteria followed for the selection of foods for the study were: i) being food or drink products widely consumed and distributed in Italy; ii) being simple and reproducible to prepare (e.g. preferable ready-made products), to handle (e.g. to be consumed at room temperature) and homogeneous in composition and aspect to be easily portioned (e.g. liquids or semi solid). A pear juice (PJ), a chocolate pudding (CP), a bean purée (BP) and a tomato juice (TJ) were selected as the most appropriate food matrices for testing the responses to target tastes. For each food product, four levels of tastant concentration were selected to elicit a variation in the strength of target sensations (the five basic tastes and two chemestetic sensations- astringency and pungency – from weak to strong, Table 3). As with the water solutions, the choice of concentration of tastants for each product was based on published psychophysical data, preliminary tests (unpublished data) and the pilot study.

2.3.4.3. Odours. The odours were selected from the ones included in the European Test of Olfactory Capabilities (Joussain et al., 2016) and presented using cardstocks designed for the project "La Prévalence des troubles Olfactifs en France" (Projet DEFISENS – PREVAL – OLF) coordinated by Moustafa Bensafi (CRNL, Lyon, France) who kindly provided the material. Odorant molecules were trapped in tight microcapsules (aminoplast type, diameter: 4–8 micro). The microcapsule-based ink was printed on a cardstock (SILK-250 g; Dimension: 11 cm x 21 cm). Each odorant was printed on a delimited area (2cm^2 disc). The release of the odour is done simply by rubbing the printed microcapsule reserve.

Liking, intensity, identification and irritation are measured for each odour: mint, anise, pine, banana. First, the odorant is presented and the respondent is asked to identify the name of the odour among four possibilities. Then, the respondent is asked to evaluate the odour's intensity, its degree of irritation, and how much they like it. The odorants are presented in a randomized order and a break of one minute is observed between each evaluation.

2.3.5. Taste function indices

2.3.5.1. Fungiform papillae number. The anterior portion of the dorsal surface of the tongue is swabbed with household blue food coloring, using a cotton-tipped applicator. This made the FP easily visible as red structures against the blue background of the stained tongue. Digital pictures of the tongue are recorded (Shahbake, Hutchinson, Laing, & Jinks, 2005) using a digital microscope (MicroCapture, version 2.0 for 20×-400×) (Masi et al., 2015). For each participant, the clearest image is selected, and the number of FP is counted in two 0.6 cm diameter circles, one on right side and one on left side of tongue, 0.5 cm from the tip and 0.5 cm from the tongue midline. The number of FP is manually counted by two researchers independently according to Denver Papillae Protocol (Nuessle, Garneau, Sloan, & Santorico, 2015). The average of these values is used for each subject.

2.3.5.2. PROP taster status. A 3.2 mM PROP solution is 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, Soo, Campbell, & Roberts, 2004). Subjects are presented with 2 identical samples (10 ml) coded with a three-digit code. Subjects are 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 gLMS (Bartoshuk et al., 2004). Subjects have a 90 s break in order to control for carry-over effect after the first sample evaluation. During the break, subjects rinse their mouths with distilled water for 30 s, have some plain crackers for 30 s, and finally rinse their mouths

with water for a further 30 s. The average bitterness score is used for each subject.

2.3.6. Genotyping

Saliva samples are collected from all participants using the Norgen Saliva DNA collection and preservation devices. DNA extraction is then performed using the Saliva DNA Isolation kit, according to the manufacturer's instructions (Norgen Biotek Corp; Ontario, Canada). Genotyping of these samples is carried out using Illumina MEGAEX high-density SNP chip array (Illumina, Inc., San Diego, CA, USA), which contains > 2 millions of selected markers. After quality control, samples will be imputed using the 1000G Project phase 3 reference (Auton et al., 2015) plus an INGI (Italian Network of Genetic Isolates) reference panel, for a total of about 88.000.000 markers.

3. Preliminary project dataset and analysis of selected variables

One of the aims of the present paper is to show the potential of the IT dataset on the basis of the results from the first year of the study, based on data from 1225 individuals. For this purpose, we selected a limited number of variables from the complete set in the project. The aim of reporting this particular set of data is to show how measurement of multiple variables provides an advantage in understanding food preferences.

The variables reported here are: demographics (age and gender), biological (PROP status), psychological (food neophobia, sensitivity to reward and punishment), socio-cultural (health and taste attitudes) and behavioural (familiarity for specific vegetables). For these variables, we described the distribution of the data and studied both gender and age effects. In addition, we investigated the role of these variables in determining preferences (stated liking) for specific vegetables: rocket and radish salads. We selected these items for the following reasons: 1) understanding consumer liking for vegetables is relevant in itself because of the general interest in promoting health eating in many countries (Appleton et al., 2016); 2) the sensory properties of radish and rocket (bitterness and pungency) may represent a potential barrier to consumption (Dinnella et al., 2016).

Liking for Brassica vegetables has been reported to be affected by PROP status (Shen, Kennedy, & Methven, 2016) and psychological traits (i.e. the level of neophobia in adult subjects has been found to be a barrier to the development of preference for vegetables in relation to their sensory properties; Törnwall et al., 2014). Thus, they are appropriate to set up a multidimensional model to show the potential of the Italian Taste dataset in studying the association among several different variables affecting food choice.

3.1. Materials and methods

3.1.1. Participants

The data from 1225 participants were collected during 2015. Their demographic and social characteristics are reported in Table 6. The sample was 61% female with a mean age of 36.9 years (SD 12.8; 18–60 years old range). The age distributions of the male and female groups were not significantly different. Regarding the region of residence of the respondents, the Northern of Italy was the most represented (46%), followed by the Southern and Islands (34%) and by the central area of Italy (20%) in line with ISTAT data (ISTAT, 2011). As expected, more females were in the normal range and underweight than males, whereas more males were overweight or obese ($\chi^2 = 15.8$; $p < 0.01$). 14% percent of the respondents smoked regularly and 11% occasionally. The vast majority of respondents (more than 90%) reported no history of food allergy and/or intolerance. Vegetarians were the 2.2% of the total.

Table 6
Socio-demographic characteristics of respondents recruited in the first year of the Italian Taste study.

	Males (n = 474) %	Females (n = 751) %	Total (n = 1225) %
Sex	38.7	61.3	100
Age (years)			
18–30	41.6	40.9	41.1
31–45	25.3	28.5	27.3
46–60	33.1	30.6	31.6
Region of residence[a]			
North West	17.1	18.5	18.0
North East	28.7	26.9	27.6
Centre	18.1	19.4	18.9
South	16.0	17.0	16.7
Islands	8.4	7.9	8.1
Education level			
Primary school	0.2	0.4	0.3
Lower secondary school	7.6	6.0	6.6
Upper secondary school	46.4	42.1	43.8
Degree	32.1	36.4	34.7
Post-degree (MSc; PhD)	13.5	15.2	14.5
Occupation			
Employees	59.5	51.8	54.8
Unemployed	5.1	10.8	8.6
Retired	2.5	1.7	2.0
Students	32.5	35.3	34.2
Body mass index (kg/m^2)[b]			
Underweight (<18.50)	1.1	5.6	3.8
Normal range (18.50–24.99)	53.6	72.0	64.9
Overweight (25.00–29.99)	35.4	15.8	23.4
Obese (≥30.00)	9.5	6.5	7.7
Smoking			
Never tried	53.2	61.3	58.1
Not smoking (have tried or quit)	17.1	15.3	16.0
Occasionally	12.2	10.5	11.2
Regularly	17.1	12.4	14.2
Monthly expense for food (euro)			
Up to 200	16.9	20.6	19.2
From 201 to 400	46.2	45.0	45.5
From 401 to 600	29.3	26.4	27.5
More than 600	7.4	8.0	7.8

[a] Classification according to Nomenclature of Territorial Units for Statistics (NUTS).
[b] Classification according to World Health Organization (WHO).

Almost all enrolled subjects attended the first laboratory session (more than 99%). Around 3% of subjects dropped out after the first session, generally due to time constraints.

3.1.2. Measuring sensitivity to PROP

PROP status was assessed according to the procedure described in § 2.3.5.2.

3.1.3. Personality and attitude measures

3.1.3.1. Food neophobia scale (FNS). The trait of food neophobia, defined as the reluctance to try and eat unfamiliar foods, was quantified using the 10-item instrument developed by Pliner and Hobden (1992). The individual FNS scores were computed as the sum of ratings given to the ten statements, after the neophilic items had been reversed; the scores thus ranged from 10 to 70, with higher scores reflecting higher food neophobia levels.

3.1.3.2. Sensitivity to punishment and sensitivity to reward questionnaire (SPSRQ). According to Gray's neuropsychological theory of personality, two basic brain systems control behaviour and emotions: the Behavioural Inhibition System (BIS) and the Behavioural Activation System (BAS). The responsiveness to these systems was measured using the SPSRQ (Torrubia, Ávila, Moltó, & Caseras,

2001). The SP scale is formed by a set of items reflecting situations which describe individual differences in reactivity and responsivity to BIS. The SR scale was conceived as a single measure of the functioning of the BAS dealing with specific rewards (i.e. money, sex, social power and approval, and praising). The SP and SR scales were scored with a yes/no format. For each subject, scores for each scale were obtained by adding all the "yes" answers.

3.1.3.3. Health and taste attitude scale (HTAS). The HTAS questionnaire was developed to assess orientations toward the health and hedonic characteristics of foods (Roininen, Lähteenmäki, & Tuorila, 1999). The HTAS items were scored on a seven-point category scale with the scales labeled from "disagree strongly" to "agree strongly". For each participant and each subscale, after recodification of negatively worded items, a mean score was computed from the individual scores.

3.1.4. Measuring food liking and familiarity

We selected from the Food Liking and Familiarity questionnaires stated liking for and familiarity with rocket and radish salads (for details on the rating scales see Table 2: Q1; OQ).

3.1.5. Data analysis

For the variables PROP, FNS, SR, SP and HTAS we analysed the distributions of data (by means of descriptive statistical tools) and both gender and age effects (by means of a Two-Way ANOVA model with interactions). A Partial Least Square (PLS) regression model was computed assuming the sum of liking data for rocket and radish for each subject as response variable (Y) and 23 explanatory variables (X). The selection of the regression model was made considering the multi-block nature of the X matrix (several food choice dimensions) and the expected co-variation between the different X variables (interplay among factors affecting food choice). In fact, as reported by Martens, Tenenhaus, and Esposito Vinzi (2007), PLS can model many types of data simultaneously and treats natural co-variation between variables as a stabilizing advantage. In particular, we considered the following X variable blocks: two demographic variables (gender and age); three psychological traits (FNS, SR and SP); five domains of the Health and Taste Attitude Scale (GHI, LPI, NPI, CSF, FR); PROP status and familiarity.

PROP ratings were first categorized using the characteristic values of the percentile distribution (first and third quartiles); then, three dichotomic variables were considered: Non Taster (NT), Medium Taster (MT) and Super Taster (ST). Familiarity scores with rocket and radish were included in the model as ten dichotomic variables (from category 1 to category 5 of the familiarity scale for each of the vegetables). PROP status and familiarity with rocket salad and radish were introduced in the model as dummy variables (Martens & Martens, 2001). The PLS model was computed on standardized variables in order to have unit variance. Cross-validation was used to estimate the number of statistically reliable principal components while jack-knifing was used for stability assessment (significance) of estimated regression coefficients (Martens & Martens, 2000).

3.2. Results

3.2.1. PROP status

Distributions of PROP ratings were compared among research units. Distributions of two units differed from the others showing higher frequency of ratings close to the maximum of the scale, due the lack of compliance with the procedure for training subjects to the gLMS use. Thus, data from these units were excluded (79 subjects) and analysis were performed on 1149 participants.

Distribution of PROP bitterness ratings of the whole sample is described in Fig. 2. Based on the theoretical distribution of haplotypes, the percentile distribution of ratings was computed. The upper limit of the first quartile and lower limit of the third quartile were 17 and 58 on gLMS, respectively. These values are in good agreement with the arbitrary cut-offs used in previous studies to categorize subjects in Non Taster (arbitrary cut-off gLMS < moderate, 17) and Super Taster (arbitrary cut-off gLMS > very strong, 53) (Fischer et al., 2013; Hayes et al., 2010).

The distribution of PROP bitterness ratings in males and females is reported in Fig. 3. Based on an *a priori* cut-off, 27.7% of males and

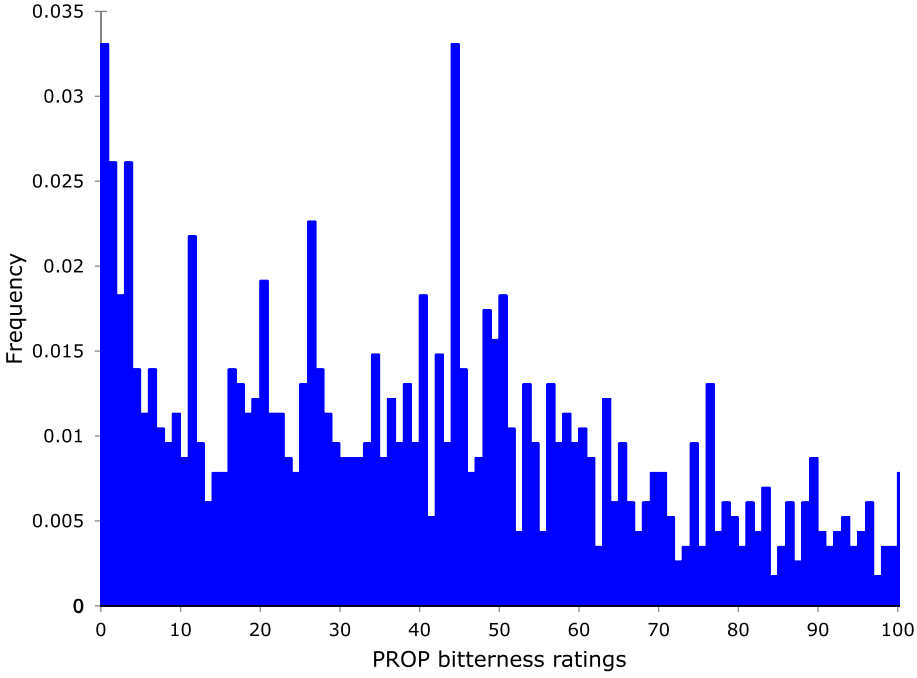

Fig. 2. Distribution of PROP bitterness ratings (n = 1149).

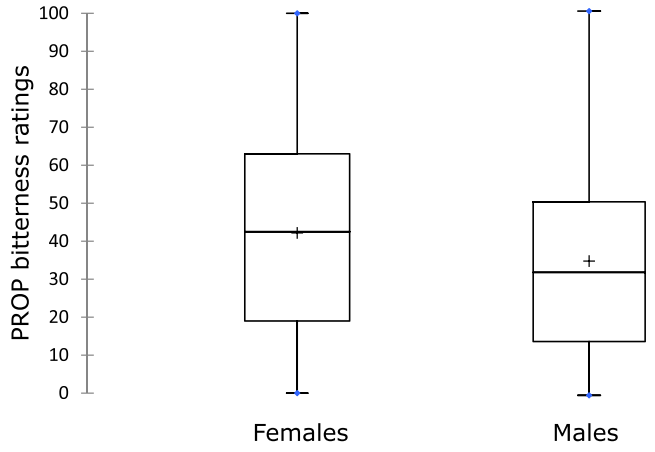

Fig. 3. Gender differences in PROP bitterness ratings. Median (line) and mean (cross) values.

23.6% of females were classified as NT; 21.1% of males and 34.6% of females were classified as ST. Females and males significantly differed in PROP group distribution ($\chi^2 = 5.99$; $p < 0.0001$). MT males and ST females were significantly larger groups than expected. The male distribution in PROP taster groups roughly reflected the haplotype frequencies of 25, 50 and 25% for NT, MT and ST, respectively, while the female distribution did not. The Two-Way ANOVA model (gender and age) shows that the PROP bitterness mean value was significantly higher in females (mean = 40.74) than in males (mean = 34.94) ($F = 16.77$; $p < 0.001$) (Table 7). Age effects on PROP ratings are also significant ($F = 4.19$; $p = 0.015$), while the gender * age effect is not significant ($p = 0.501$). In order to better analyse the age effect on PROP bitterness ratings, data from males and females were independently submitted to a Two-Way ANOVA model with interactions, considering age (three levels: 18–30; 31–45; ≥46 years) and PROP group (three levels: NT, MT, ST) as effects. Age significantly affects PROP bitterness ratings of the three PROP taster groups in females (age effect: $F = 5.46$; $p = 0.004$; age * PROP group: $F = 2.82$, $p = 0.04$). PROP intensity ratings decrease significantly in MT and ST groups over 45 years old. No significant effect of age was observed in males.

3.2.2. Food neophobia scale (FNS)

The internal consistency of the FNS score, as measured by Cronbach's α, was satisfactory (α = 0.87). Overall, the mean was 27.4 (n = 1225, SD = 11.7, range = 10–69). Correlation among items was always highly significant ($p < 0.0001$) with Pearson correlation coefficients ranging from $r = 0.19$ and $r = 0.72$. The score distribution (Fig. 4) had a skewness of 0.60 and a kurtosis of −0.20. Gender- and age-related differences in FNS scores were tested through Two-way ANOVA with interaction (Table 7), which showed a significant main effect of gender ($F = 4.24$, $p < 0.043$) and age ($F = 7.26$, $p < 0.001$). Males (mean = 28.3) were significantly more neophobic than females (mean = 26.9) and the youngest participants (18–30 years: mean = 25.9) were significantly less neophobic than the older group (>46 years: mean = 28.9). FNS scores of the middle-aged group (31–45 years: M = 27.9) lay in between. The age * gender interaction was not significant.

3.2.3. Sensitivity to punishment (SP) and sensitivity to reward (SR)

The Cronbach's α for each of the scales was good, this being slightly higher for the SP (0.84) than for SR (0.75) scale. The two scales were poorly correlated with each other ($r = 0.061$, $p = 0.035$). We also observed sufficient variation in scores: out of a possible range of 0–24, SP scores ranged from 0 to 24 (mean = 10.01; SD = 5.26) while SR ranged from 0 to 22 (mean = 8.92; SD = 3.96). The Two-Way ANOVA model with interaction (Table 7) computed on the SP and SR scores showed a significant effect of both gender and age, while the interaction effect was not significant. Females obtained higher scores than males on the SP scale, while males clearly score higher than females on the SR scales ($p < 0.001$). Both SP and SR scores in participants aged 18–30 were higher than in participants > 31 years old. In addition, on the SR scale, participants 31–45 obtained higher scores than subjects 46–60 ($p < 0.001$).

3.2.4. Health and taste attitudes scale (HTAS)

Concerning the internal consistency of each Health and Taste domain, only *Pleasure* revealed a low internal validity (Cronbach's α = 0.42). The differences in α-values across countries seem to indicate that the internal consistency of this domain changes in relation to cultural aspects (Table 8).

The effect of gender and age and their interaction was tested by a Two-Way ANOVA model (Table 7). Significant gender differences were found for *General Health Interest* ($F = 24.64$; $p < 0.001$), *Natural Product Interest* ($F = 16.16$; $p < 0.001$), *Craving for Sweet Food* ($F = 66.16$; $p < 0.001$), *Pleasure* ($F = 12.19$; $p < 0.001$), with females having more positive attitudes towards both the Health and Taste domains. The gender effect is stronger for the domain *Craving for Sweet Foods* than for *General Health Interest*, *Natural Product Interest*, and *Pleasure*. We did not find a gender effect for *Light Product Interest* ($F = 1.026$; $p = 0.311$), that had also the lowest mean score among the HTAS domains. No gender effect was found for the domain *Food as a Reward*.

A significant association with age was found for *General Health Interest* ($F = 34.89$; $p < 0.001$) and *Natural Product Interest*, ($F = 37.72$; $p < 0.001$), which were rated gradually higher with

Table 7
Two-Way ANOVA. Gender, age and their interaction effect on selected variables: mean scores and p-values.

Variable*	Gender (G)			Age (A)				G*A
	P-value	Male	Female	P-value	18–30	31–45	46–65	P-value
PROP rating	**<0.001**	**34.9**	**41.7**	**0.015**	**40.7^{a}**	**39.11^{ab}**	**35.21^{b}**	0.501
Food neophobia scale	**0.043**	**28.3**	**26.9**	**<0.001**	**25.9^{a}**	**27.9^{ab}**	**28.9^{b}**	0.822
Sensitivity to punishment	**<0.001**	**9.1**	**10.6**	**<0.001**	**11.4^{b}**	**8.9^{a}**	**9.1^{a}**	0.915
Sensitivity to reward	**<0.001**	**10.1**	**8.2**	**<0.001**	**10.6^{c}**	**8.2^{b}**	**7.3^{a}**	0.232
General Health Interest**	**<0.001**	**36.5**	**38.9**	**<0.001**	**36.1^{a}**	**37.9^{b}**	**40.4^{c}**	0.405
Light Product interest**	0.311	20.8	20.4	0.081	21.2	20.1	20.2	0.149
Natural Product interest**	**<0.001**	**25.8**	**27.3**	**<0.001**	**25.1^{a}**	**26.7^{b}**	**28.9^{c}**	0.906
Cravings for Sweet Foods**	**<0.001**	**26.2**	**30.5**	0.064	29.8	28.5	27.9	**0.001**
Using Food as Reward**	0.084	26.1	27.1	**<0.001**	**28.0^{b}**	**27.2^{b}**	**24.7^{a}**	0.090
Pleasure**	**<0.001**	**30.2**	**31.2**	0.171	30.8	31.2	30.5	**0.034**

In **bold** significant values. Letters indicate significantly different mean scores (Tukey's Honest Significant Difference, HSD).
* The total degree of freedom (d.f.) for each of the computed ANOVA models was 1219 with exception of the variable PROP (d.f. = 1143).
** HTAS domains.

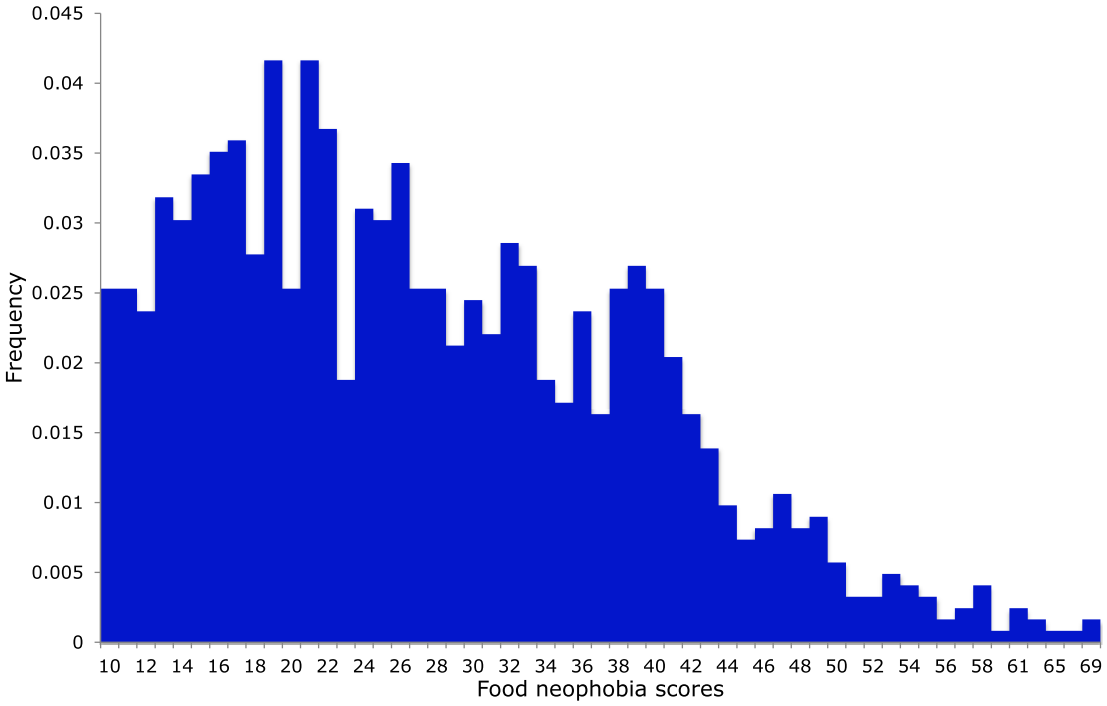

Fig. 4. Distribution of Food Neophobia Scores (n = 1225).

Table 8
Descriptive statistics, and Cronbach's alpha (α) for each domain of the Health and Taste subscales and comparison with other studies.

HTAS Domain	Theoretical range	Min	Max	Mean	SD*	α	α [a]	α [b]	α [c,1]	α [c,2]	α [c,3]	α [d]
General Health Interest	8–56	11	56	37.94	8.08	0.79	0.80	0.89	0.87	0.84	0.80	0.77
Light Product Interest	6–42	6	42	20.56	6.98	0.81	0.78	0.82	0.78	0.66	0.70	0.71
Natural Product Interest	6–42	6	42	26.73	6.84	0.74	0.70	0.76	0.76	0.65	0.69	0.66
Craving for Sweet Foods	6–42	6	42	28.84	8.75	0.87	0.86	0.87	0.84	0.77	0.74	0.74
Using Food as a Reward	6–42	6	42	26.75	7.57	0.81	0.79	0.79	0.74	0.67	0.67	0.65
Pleasure	6–42	9	42	30.82	4.60	0.42	0.33	0.67	0.63	0.39	0.54	0.53

* SD = Standard Deviation.
[a] Values from Endrizzi et al. (2015) (Italian data).
[b] Values from Roininen et al. (1999) (Finnish data).
[c] Values from Roininen et al. (2001) ([1]Finnish data, [2]English data, [3]Dutch data).
[d] Values from Zandstra et al. (2001) (Dutch data).

the increasing age of the groups. In addition, older respondents (>45 years old) rated lower *Using Food as a Reward* compared to the other two age groups ($F = 19.31$; $p < 0.001$).

A Gender * age interaction was found in the case of *Craving for Sweet Foods* ($F = 6.87$; $p = 0.001$) and *Pleasure* ($F = 3.39$; $p = 0.034$). Females aged 18–30 years old and 31–45 years old rated higher than males on *Craving for Sweet Foods*, and females aged 18–30 years rated higher than males on *Pleasure*.

3.2.5. Stated liking for rocket and radish

Four PLS components were estimated and retained as significant with a total explained variance of 45%. The PLS loading plot for the first two components (Fig. 5) allows the observer to explore the associations among variables. Liking increases with age, when the familiarity with the products is high and when GHI and NPI scores increase. In contrast, liking decreases when food neophobic scores, sensitivity to reward and sensitivity to punishment increase. Gender does not seem to influence liking. The PLS regression coefficients and their significance are shown in Fig. 6. It is interesting to note that being a PROP ST is, as expected, negatively associated with liking and positively associated with a low familiarity with the two vegetables.

3.3. Discussion

We applied a PLS model to study the associations among a selected number of variables in affecting stated liking for two vegetables. The purpose of the analysis was to give an example of how to explore and understand the complex picture determined by the interplay of biological, physiological, psychological and socio-cultural factors determining individual differences in food preferences and choice, very well depicted by several authors already cited in the introduction of this paper. Our relatively simple example clearly showed that individual differences in stated liking for two specific vegetables characterized by sensory properties such as bitterness and pungency are driven by experience and exposure.

However, some psychological traits, such as being neophobic or sensible to reward and to punishment may act as barriers to this process.

The importance of food neophobia among a variety of variables in modulating flavour preferences in young adult subjects (21–25 y.o.) has been highlighted by Törnwall et al. (2014). In addition, our findings indicate that psychological traits potentially involved in explaining individual food choices are not limited to food neophobia. Our results suggest that sensitivity to reward and punish-

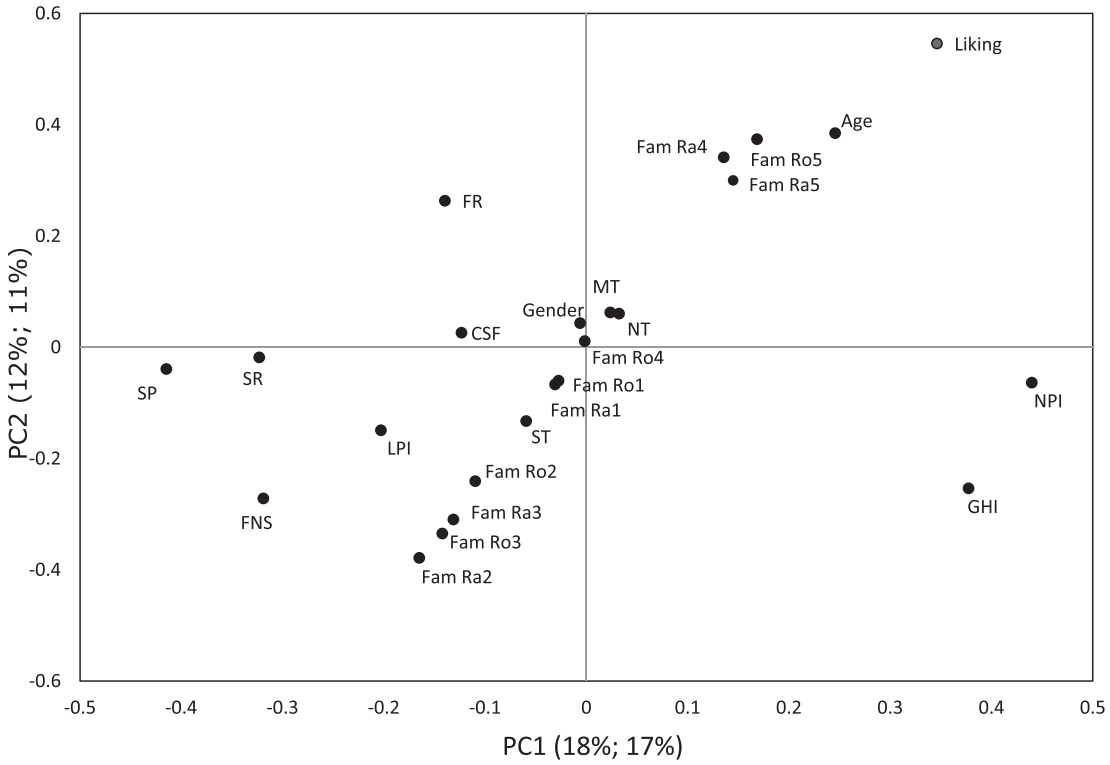

Fig. 5. PLS regression loading plot (n = 1149).Variance accounted for X and Y for PC 1 and PC2 are reported in brackets. Health and Taste Attitudes Scale variables: *Natural Products Interest* (NPI), *General Health Interest* (GHI), *Light Products Interest* (LPI), *Food as a Reward* (FR). PROP Status: Non Taster (NT), Medium Taster (MT), Super Taster (ST). Psychological traits: Food Neophobia Scale (FNS), Sensitivity to Reward (SR), Sensitivity to Punishment (SP). Demographics: Age, Gender. Familiarity with rocket: Fam Ro 1–5. Familiarity with radish: Fam Ra 1–5.

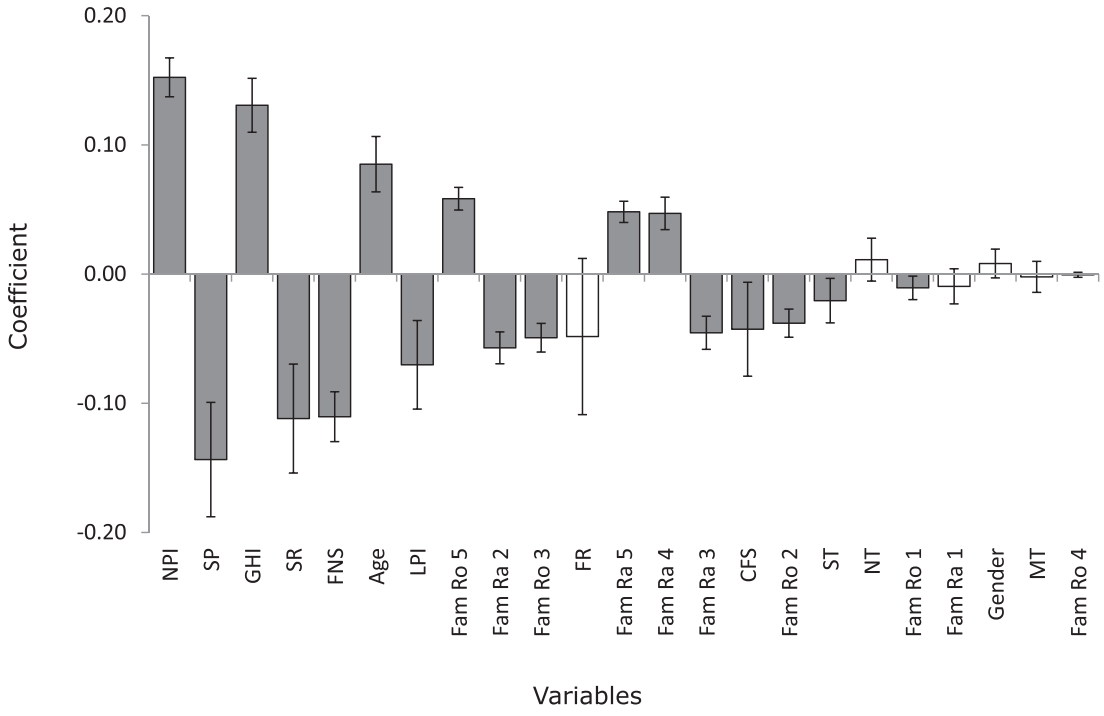

Fig. 6. PLS regression coefficients displayed with 95% Jack-knife confidence interval (n = 1149). Variables with interval overlapping 0 (white bars) are not significant. Health and Taste Attitudes Scale variables: *Natural Products Interest* (NPI), *General Health Interest* (GHI), *Light Products Interest* (LPI), *Food as a Reward* (FR). PROP Status: Non Taster (NT), Medium Taster (MT), Super Taster (ST). Psychological traits: Food Neophobia Scale (FNS), Sensitivity to Reward (SR), Sensitivity to Punishment (SP). Demographics: Age, Gender. Familiarity with rocket: Fam Ro 1–5. Familiarity with radish: Fam Ra 1–5.

ment could also play a relevant role as barriers to exposure and familiarization with specific foods. In fact, both higher SP and SR were associated with a lower liking for radish and rocket salad, thus representing a possible barrier to vegetable consumption. Recent studies have highlighted an association between these traits and unhealthier behaviours; higher sensitivity to reward predicted higher fat intake, higher alcohol consumption, greater likelihood of binge drinking, greater likelihood of being a smoker and, amongst smokers, smoking frequency. Higher sensitivity to punishment predicted lower alcohol consumption but higher sugar intake (Tapper et al., 2015). Higher SR scores were significantly related with a more frequent drinking and heavier consumption per occasion of alcohol. In addition, drinkers more sensitive to reward reported feeling more stimulated shortly after drinking and exhibited an attenuated rate of decline in stimulation over the blood alcohol curve, relative to drinkers with less strong reward sensitivity (Morris et al., 2016). The Italian Taste dataset represents an opportunity to study more in depth the contribution of these traits to unhealthy food behaviours investigating their association to preferences for specific food categories such as vegetables. This may be particularly worth of investigation in the case of younger adults, that we found more sensitive both to reward and punishment: for this age group these traits can play a role in creating a barrier to consumption of healthier products or encouraging unhealthier food behaviours.

Finally, the model suggests that being a ST phenotype may also mediate familiarity with and thus liking for specific food, as reported by Prescott and co-workers (Lee, Prescott, & Kim, 2008; Yeomans, Prescott, & Gould, 2009).

In this example, there is good evidence for the interplay between factors affecting liking: some psychological traits like food neophobia, sensitivity to reward and punishment and phenotype characteristics (PROP taste group) represent possible barriers to consumption of the considered vegetables because of their negative effect on liking. In contrast, age and experience, interpreted as familiarity with the products and acquired attitudes (GHI, NPI), facilitated liking and thus consumption.

Considering the PLS model as an example and interpreting its results in a broader view, we suggest that coupling the measurement of many variables related to food preferences with appropriate multidimensional statistical analysis allows the researcher to obtain relevant information to answer to either applied or more fundamental research questions. In fact, it is possible to identify variables that are relevant for consumer segmentation in relation to the acceptance of specific products. At same time, the obtained information is relevant even when the research question is how to overcome barriers to the consumption of specific healthy foods in respect to segments clearly characterized for their physiological, psychological, and socio-cultural traits.

Overall, the project sample to date has been quite well balanced in terms of gender, age (within the range 18–60 years) and geographic areas. The proportion between the two sexes among respondents is in line with other large scale studies (e.g. Pirastu et al., 2016) and can be judged acceptable, considering that males tend to be less inclined to volunteer for research than females, as clearly shown also in the NutriNet Santé study (Hercberg et al., 2010; Méjean et al., 2014).

The analysis of the structure and distribution of the data for each of the selected variables allowed us to draw several conclusions regarding the variables presented here.

3.3.1. PROP status

The distribution of PROP ratings and the relative values of the first and third quartile supported the validity of previously proposed arbitrary cut-offs to classify subjects as NTs, MTs and STs (Fischer et al., 2013; Hayes et al., 2010). In line with the present results, studies on large population samples identified gender as significant predictor of PROP bitterness intensity, with male mean ratings lower than those of females and a higher frequency of ST among females (Fischer et al., 2013; Garneau et al., 2014).

Our data revealed an age effect on PROP ratings in females. In supra-threshold studies, age has been reported as a negative predictor of PROP bitterness (Garneau et al., 2014). A decrease in PROP bitterness sensitivity over the life span has been reported only in PROP taster subjects in a large size threshold study (Mennella, Pepino, Duke, & Reed, 2010). The general decoupling of threshold and supra-threshold PROP sensitivity has been often reported (Bartoshuk, 2000; Hayes & Keast, 2011; Webb, Bolhuis, Cicerale, Hayes, & Keast, 2015); thus, the age effect on PROP bitterness sensitivity deserves further investigation. PROP status classification based on phenotype might also reflect the oral responsiveness due to other factors, such as fungiform papillae density, which in turn are affected by age. The interplay between responsiveness to PROP bitterness and fungiform papillae density has been reported in taster subjects depending on their genotype (Hayes, Bartoshuk, Kidd, & Duffy, 2008). The relationships between genotype and phenotype, as well as responsiveness to PROP and fungiform papillae density, deserve further investigation and will be explored as part of the Italian Taste project as soon as population genotyping is completed.

3.3.2. Food neophobia

Since research on food neophobia suffers from a lack of standardization in the age groups being compared, and in the number of participants involved (Meiselman, King, & Gillette, 2010), the present results will be discussed only considering previous nationally representative samples of consumers with a similar age range as the one considered in our study.

The analysis conducted on Food Neophobia scores showed that the internal validity (α) of data was similar to that reported in other large studies, confirming that FNS is a robust and efficient tool even when translated in other languages (Ritchey, Frank, Hursti, & Tuorila, 2003). In fact, internal consistency of the FNS scores in the present study ($\alpha = 0.87$, n = 1225, age range = 18–66 years) was similar to those reported in previous research involving large population samples of Finns ($\alpha = 0.88$, n = 2191, age range = 18–57 years, Knaapila et al., 2015; $\alpha = 0.85$, n = 1083, age range = 16–80 years, Tuorila, Lähteenmäki, Pohjalainen, & Lotti, 2001) and Swiss ($\alpha = 0.80$, n = 4436, age range: 21–99 years, Siegrist, Hartmann, & Keller, 2013). The mean FNS score observed here (27.4, SD = 11.7) was considerably lower than the one reported in a study performed in a sample of Italian subjects of similar age (mean = 34.0, SD = 15.5, n = 167, age range = 20–59 years, Dematte et al., 2013) and moderately lower than the mean FNS score found for Finns (mean = 28.5, SD = 11.0, N = 2191, age range = 18–57 years, Knaapila et al., 2015). Cultural origins may explain the difference between our results and those by Knaapila et al. (2015) but not the difference with the outcome of Dematte et al. (2013). In this latter case, it might be hypothesized that the sample was small, local and not representative of the general Italian population. However, considering that in Italy strong regional differences in food culture exist, the Italian Taste dataset has the potential to explore the differences among geographic macro-areas of the country (North, Central and South) that also reflect socio-economical differences.

Significant effects of age and gender on FNS were found. We found a significant, though somewhat modest, effect of gender on FNS score, with males being more neophobic than females. Analysis of nationally representative studies involving consumers of comparable age to the one considered in the present study

showed no gender effect in one study (Knaapila et al., 2015) or a slight effect in three other studies (Hursti & Sjödén, 1997; Siegrist et al., 2013; Tuorila et al., 2001). When gender-related differences were found, all studies agreed that males were more neophobic than females. This has been explained by the greater involvement of women rather than men in food purchase and preparation (Hursti & Sjödén, 1997). However, it should be pointed out that the effect of gender on FNS scores was always very small (from 1.5 to 2.9 points on a scale ranged from 10 to 70), leading to the conclusion that such effects are likely to be less important than many other variables related to food rejection (Nordin, Broman, Garvill, & Nyroos, 2004). Similarly, the effect of age, although significant, was somewhat weak. However, FNS scores tend to increase with age. Age-related differences in the level of food neophobia are often reported in large population studies, with FNS scores increasing with age (Meiselman et al., 2010; Siegrist et al., 2013; Tuorila et al., 2001). Further analysis of the current dataset may reveal age and gender effects on specific FNS items. At same time, the Italian Taste dataset will facilitate the study of the associations between this trait and other psychological and biological measurements, as well as with attitudes relevant to food choice.

3.3.3. Sensitivity to reward and sensitivity to punishment

In line with previous results (O'Connor, Colder, & Hawk, 2004; Torrubia et al., 2001), the internal validity (α) of both scales was good, being slightly higher for the SP than for SR scale. Our results confirm that the two personality traits seem to be uncorrelated. The gender effect was in line with previous results (Caseras, Ávila, & Torrubia, 2003; Torrubia et al., 2001), with females more sensitive to punishment than males, and males more sensitive to reward than females. To our knowledge, the age effect on sensitivity to reward and sensitivity to punishment scores in adult populations (e.g. from 18 to 60 years old) has not been studied in depth yet. In a study that used the BIS/BAS scale developed by Carver and White (1994), Pagliaccio et al. (2016) observed that both sensitivity to reward and punishment scores tended to be higher in young adulthood (18–22 years old) than in later adulthood (30–45 years old) and in childhood. Our data clearly show that both sensitivity to reward and sensitivity to punishment are higher in the younger adults aged 18–30, and that individuals aged 31–45 tend to be more sensitive to reward than older individuals.

3.3.4. Health and Taste attitudes

It has been shown that the HTAS predicts choices between products varying in health and hedonic aspects and it has been consequently used to segment consumers (Tuorila, 2015). In the present study, the internal validity (α) of the sub-scales is generally in line with other studies for five out of six domains. The Cronbach's α value is not satisfactory for the *Pleasure* domain only. It seems that when this domain is used in countries different from the one in which the questionnaire was developed, the scores for each of the statements tend to be not strongly related each other. The interpretation of the meaning of the statements describing the link of food with pleasure could vary from culture to culture (Rozin, Fischler, Imada, Sarubin, & Wrzesniewski, 1999), thus a translation-back translation could not always be sufficient to guarantee the adherence with the original meaning. Further studies on the adaptation of this domain taking into account the relevant socio-cultural aspects of the country in which the study is conducted are needed.

Roininen et al. (1999, 2001) registered comparable mean scores in the three domains of the Health subscale, although with some differences between countries (2001). We noticed a low interest of the Italian sample for light products which reflects a general tendency in the country to consider the Mediterranean diet healthy and tasty at same time (Monteleone & Dinnella, 2009), with a consequent low interest in light foods.

Early studies from the HTAS questionnaire creators pointed out a noticeable variability in values among gender, age and countries and their interactions (Roininen et al., 1999, 2001). Our results partially confirm previous findings, with females having more positive attitudes towards both the Health and Taste domains (Endrizzi et al., 2015; Roininen et al., 1999, 2001). However, we found a stronger gender effect for the domain *Craving for Sweet Foods* than for *General Health Interest*, *Natural Product Interest*, and *Pleasure*, while in the previous studies reported above, a strongest effect of gender for the *General Health Interest* domain was reported. The variability induced by the gender by age interaction on HTAS scores deserves further investigations as well as the effectiveness of this set of scales of predicting choices, even in association with other variables.

4. Conclusion

Studies on influences on food choice are subjected to two main limitations: the sample size and an approach based on a limited perspective that does not take into account at the same time genetics, taste sensitivity, psychographics and sensory and hedonic responses to foods based on evaluations of samples and not only of names or tastant in solution. The Italian Taste project plans to overcome the above-mentioned limitations and may be seen as a model to explore the complex interplay of factors contributing to food choices. The design of the study we presented here may in fact easily be reproduced in other countries, with the precaution of adapting the Food Liking and Choice questionnaires taking into account the specificities of the food culture considered and selecting appropriately the products used for the sensory and hedonic tests among commonly consumed products.

The exploration of cross-cultural differences will contribute to a further deeper insight into the understanding of food choices.

In recent years, multicenter research has become increasingly common in situations in which single research centres have the tools and skills to investigate a question, but the power of data would suffer due to slow data collection or too few available respondents. The present report describes a project in which Italian researchers have rallied their resources to investigate human food choice behaviour and preferences using current knowledge of possible predictors from genetic, physiological and psycho-social domains. When planning a multicenter research, it is particularly important to ensure the alignment in the procedure of data collection of the different labs involved in the study. Specific attention should be paid to the procedure of sample preparation, papilla count and to the instructions on the use of the gLMS. Training periods of all the researchers involved in data collection are recommended to guarantee the reduction of differences due to the operators. Great attention is also required to align the instructions to give to the respondents before and during the test, in order to avoid an effect of different type of information given.

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Appendix 1 – Organization and management of the project

A scientific committee of thirteen members of the Italian Sensory Science Society (SISS), all experienced and internationally recognized researchers, designed the study. Each member of the scientific committee coordinated one of the following activities: ethics, bibliography, recruitment; liking/choice/familiarity questionnaires; attitudes and psychological traits; liking and sensory tests; genetic tests; data analysis; database implementation and management; communication; fund raising. The corresponding author of the present paper served as project coordinator.

Working groups open to all SISS members were organized to define a procedure for each activity under the responsibility of a coordinator.

All the procedures related to data collection and data analysis were reviewed by the members of an international advisory board composed by experienced sensory and consumer researchers. Procedures were revised according to their advice and tested in pilot studies before the approval of the scientific committee. Similarly, a general procedure for data acquisition was designed, reviewed, and tested in a pilot study run in April-June 2015 with 95 respondents (5 in each of the 19 laboratories involved in the project, (Table 9).

During the pilot study a checklist was provided to each unit to report deviations from the procedures. The checklist included the control of the following critical points: sample preparation (time between preparation of food sample and testing; time between the two sessions; temperature of conservation of samples); papilla count (two-way ANOVA to investigate the effect of the operators, if any), critical points for each step of the test; missing data; data control.

After a final revision, the data acquisition procedure was approved by the scientific committee and data collection started in July 2015 with the objective of recruiting three thousand respondents in three years across the laboratories and the country. Sixteen labs out of nineteen utilized the same computerised system for data collection in the lab (Fizz, Biosystèmes, France). Methods were centrally designed at Florence University. Four units collected data on paper forms prepared on the basis of the Fizz sessions.

Table 9
SISS Sensory Laboratory Network: Institutions and their geographic distribution.

Geographic area	Institution	Town
North	CREA-ENO, Enology Research Center	Asti
	Edmund Mach Foundation	Trento
	ERSAF – Regione Lombardia	Mantova
	University of Gastronomic Sciences	Bra
	University of Milan	Milan
	University of Udine	Udine
Central	Centro Ricerche Produzioni Animali S.p.A	Reggio Emilia
	CIAS Innovation S.R.L.	Matelica
	CNR – Institute of Biometeorology	Bologna
	CREA-NUT, Research Centre on Food and Nutrition	Rome
	Mérieux NutriSciences Italia	Prato
	University of Bologna	Cesena
	University of Florence	Florence
South and Islands	Adacta International S.p.A	Naples
	Agris Sardegna	Sassari
	University of Basilicata	Potenza
	University of Catania	Catania
	University of Naples	Naples
	University of Sassari	Sassari

Before the pilot studies, two days of training were organised at the Sensory Lab of Florence University in order to uniform the PROP and papillae procedures. Special attention was paid to training researchers from all the labs in the use of the gLMS. Similarly, researchers were trained in the preparation of food samples participating in the preparation of a session.

To assist all the units involved in the project during data collection five help-desks were activated on: sample preparation (Trento Unit); PROP and Papillae (Florence unit) and Data acquisition (Florence, Bra, Bologna).

In each research unit, after the collection of the data the researcher responsible for the data entry uploaded the collected data on a default spreadsheet in order to obtain the unit dataset. Then, the researcher responsible for the whole database of the study merged the 19 unit datasets to obtain a complete dataset.

In order to check the reliability of the data entry process, a data control procedure was applied to the both unit datasets and complete dataset. At the unit level, each responsible completing the data entry, firstly applied a filter function to each variable of the unit dataset to verify the absence of anomalous data. Secondly, the correspondence between the data reported in the unit dataset and the original data reported on the result files of the software used for data acquisition (or on the paper forms filled in by the participants) was checked. In particular, all the responses provided by at least the 20% of the subjects who took part in the study in the sensory laboratory of each research unit were controlled. Similarly, at a global level, the responsible controlled the merged datasets, firstly, applying a filter function to each variable of the complete dataset to verify the absence of anomalous data, and secondly, checking the correspondence between the data reported in the complete dataset and the original data reported on the unit dataset for the 20% of the subjects who performed the testing in each sensory laboratory. Additionally, a second researcher controlled the correspondence between the data reported in the complete dataset and the original data reported on the unit dataset for an additional 10% of the subjects who performed the testing in each sensory laboratory.

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