Exploring influences on food choice in a large population sample: the Italian Taste Project

Authors (almost 36)

Abstract

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 two important limitations: the mono-disciplinary approach and the sample size. 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.

The aims of the present paper are twofold: At a first level, the paper is aimed to describe the structure of the 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 paper is aimed also at showing the potential of the Italian Taste data set on the basis of the data collected in the first year of the project.

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 Rozin 2006; Mela 2006; Sobal et al. 2006; Köster 2009; Sobal et al. 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 and 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 et al., 2001; Rozin, 1979, 1990; Tuorila, 2007). 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 choose one food rather than another for specific reasons such as health, convenience, price, and so on, but actually prefer the food not chosen. Thus, preference or liking can be seen as necessary but not sufficient to explain food choice. 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).

The multidimensional and complex nature of food choice 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 two important limitations: a mono-disciplinary approach and the size of the population sample under study. Thus, 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. More multidisciplinary and multidimensional approaches are needed. This aspect was clearly pointed out by Köster (2009), who identified this lack as one of the major problems of sensory and consumer food science, and pointed out that in food choice studies there is too little interdisciplinary research (Köster 2009).

Not all food choice studies are limited in this way. Törnwall et al. (2014) reported one of the few recent 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 a 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 et al., 2003; Yackinous and 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 populations 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 disease that has benefited from epidemiological studies of genuine population samples (Willett, 2012). In the same way, food choice and behavior studies can gain a definite advantage in enlarging the sample size and in collecting a variety of responses in order to identify the factors and to estimate their actual weight in determining food behaviors.

In line with studies indicating that food hedonics may be better predictors of health outcomes than food intake (Duffy et al., 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; Méjean et al. 2014). In addition, large-scale studies (e.g. with three or four thousand respondents) in "genetics of food preference" 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 behavior, they still remain linked to a mono-disciplinary perspective (in this case, genetics), and as such fail to collect data relative to important dimensions, such as sensory and hedonic responses to actual food stimuli, as well as psychographics and attitudes.

In addition to genetic, biological, physiological and socio-cultural variables, it has been proposed that personality may play a large role in determining food preferences and food behaviors. This was shown not only for food-related personality traits such as neophobia (Eertmans et al., 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 and to punishment. The investigation of the relationships between Sensitivity to Reward (SR) and Punishment (SP) and food preferences and choices is

new and still limited but recent studies presented interesting findings. SR was found to be positively associated to frequency of chili consumption, and weakly though significantly correlated with the liking of spicy foods (Byrnes and 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) (Tapper et al. 2015; Morris et al. 2016).

1.1 Aims of the present paper

The objectives of the present paper are twofold:

At a first level, the paper is aimed to describe the structure of 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 addressing some of 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.

The paper is aimed also at showing the potential of the Italian Taste data set. Here, we report on data collected in the first year of the project on 1225 individuals. For the purpose, we selected a small number of variables known to influence food choices.

2. The Italian Taste project

2.1 Objectives of the Italian Taste project

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

- to show that large scale and multidisciplinary studies are the necessary condition to fully understand food choice mechanisms.
- to show that large and complex studies can be managed in a "sustainable" way in relation to several aspects which are economic, cultural and social as we describe here:
    - Economical: IT is a cost sharing project among several partners in which the contribution of each partner is adequate to the available human and financial resources.
    - 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.

- 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 nineteen sensory laboratories of public and private organizations, across the country (see Table 1). A scientific committee of thirteen experienced and internationally recognized researchers designed the study. Each member of the scientific committee coordinated one of the following activities: ethics, bibliography, recruitment; preference/choice/familiarity questionnaires; attitudes and psychological traits; liking and sensory tests; genetic tests; data analysis; data base implementation and management; communication; fund raising. Working groups open to all SISS members were organized to define a procedure for each activity under the responsibility of a coordinator. The corresponding author of the present paper served as project 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 ninety respondents in each of the involved laboratories. 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.

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. The respondents gave their written informed consent at the beginning of the test according to the principles of the Declaration of Helsinki.

2.3 Recruitment and inclusion

2.3.1 Respondents

168 The recruitment procedure aims to reach a balance between genders, four age classes (18-30;
169 31-40; 41-50; 51-60 years) and main geographical areas of the country. Participants are
170 recruited on a national basis by means of announcements published on the Italian Taste project
171 website, the SISS website and social network websites (*Facebook*), articles published on national
172 newspapers, and in food and wine magazines. Furthermore, each research unit recruits subjects
173 locally by means of *Facebook* pages and emails, pamphlet distribution and word of mouth.

174

175 **2.4 Overview of data collection**

176

177 *2.4.1 Variables included in the study*

178 Data are collected from each respondent according to a multi-disciplinary approach. Using
179 questionnaires, information is collected concerning socio-demographic and socio-economic,
180 anthropometric and physical health (Table 2); psychological and personality traits (Table 3);
181 eating behaviours, food-related lifestyles and attitudes (Table 4); food preferences, choice,
182 familiarity and frequency of consumption (Table 5). Furthermore, the design includes the
183 collection of hedonic and sensory responses to food products, solutions and odours (Table 6),
184 taste function measurement (Fungiform Papillae Number and PROP status) and the collection of
185 saliva samples for DNA determination and genotyping.

186

187 *2.4.2 Data collection scheme*

188 At the time of recruitment, respondents are given general information about the study aims.
189 They are asked to complete an online questionnaire (OQ) in the days preceding the data
190 collection and invited to attend two sessions, in two days, in a sensory lab. The data collection
191 scheme is presented in Figure 1.

192

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

Before starting the hedonic evaluation of food samples participants are introduced to the use of the Labelled Affective Magnitude scale (LAM) (Schutz and 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 6). After the liking session, participants are presented with the Food Preference Questionnaire (Q1). Then, participants are instructed about the odor test (Table 6) and receive general information about Food Related Life Style (Q2), Food Neophobia Scale (Q3) and Private Body Consciousness (Q4) questionnaires (Table 2 and 3). They complete Q2 and the odor test, followed by a break during which they complete Q3 and Q4. Participants are then introduced to the use of the generalized Labelled Magnitude Scale (gLMS) (Bartoshuk et al., 2004) with particular emphasis on the meaning of the descriptor "the strongest imaginable sensation of any kind". They are informed about Sensitivity to Punishment and Reward (Q4) and Alexithymia (Q5) questionnaires (Table 3). Then they rate the intensity of PROP solutions and fill in Q4 and Q5 before the picture of the tongue is taken. At the end of day 1, respondents are instructed on fasting conditions preceding the collection of a saliva sample in the day 2.

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 6). 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 the Q9, Q10 and Q11. The picture of the tongue for papillae counting was taken at the end of day 1 or day 2, according to individual availability.

2.5 General project methods

2.5.1 Sensory stimuli

Water solutions

Seven water solutions corresponding to five basic tastes, astringent and burning sensations are used (Table 6). The concentration of the tastants were decided based on published psychophysical data and previous preliminary trials conducted with one hundred untrained subjects recruited in five sensory laboratories (unpublished data) in order to select solutions equivalent to moderate/strong on a gLMS. The results of the preliminary trials were confirmed

239 in a pilot study performed in 10 sensory laboratories with an average number of 5 subjects per
240 lab.

241

242 Food Products

243 The criteria followed for the selection of foods for the study were: i) being food or drink products
244 widely consumed and distributed in Italy; ii) being simple and reproducible to prepare (e.g.
245 preferable ready-made products) and to handle (e.g. liquids or semi solid, to be consumed at
246 room temperature). A pear juice (PJ), a chocolate pudding (CP), a bean purée (BP) and a tomato
247 juice (TJ) were selected as the most appropriate food matrices for testing the responses to target
248 tastes. For each food product, four levels of tastant concentration were selected to elicit a
249 variation in the strength of target sensations going from weak to strong (Table 6). As for water
250 solutions, the choice of concentrations of tastants for each product was based on published
251 psychophysical data, preliminary tests (unpublished data) and the pilot study.

252 *2.5.2 Taste function indices*

253 Fungiform Papillae Number

254 The anterior portion of the dorsal surface of the tongue is swabbed with household blue food
255 coloring (F.lli Rebecchi), using a cotton-tipped applicator. This made the FP easily visible as red
256 structures against the blue background of the stained tongue. Digital pictures of the tongue are
257 recorded (Shahbake et al., 2005) using a digital microscope (MicroCapture, version 2.0 for 20x-
258 400x) (Masi et al., 2015). For each participant, the clearest image is selected, and the number
259 of FP is counted in two 0.6 cm diameter circles, one on right side and one on left side of tongue,
260 0.5 cm from the tip and 0.5 cm from the tongue midline. The number of FP is manually counted
261 by two researchers independently according to Denver Papillae Protocol (Nuessle et al. 2015).
262 The average of these values is used for each subject.

263

264 PROP taster status

265 According to the "one solution test" (Prescott et al., 2004) a 3.2 mM PROP water solution is
266 prepared by dissolving 0.5447 g/L of 6-n-propyl-2-thiouracil (European Pharmacopoeia
267 Reference Standard, Sigma Aldrich, Milano, IT) into deionized water. Subjects are presented
268 with 2 samples (10 ml) coded with a three-digit code. Subjects are instructed to hold each
269 sample (10 ml) in their mouth for 10 s, then expectorate, wait 20 s and evaluate the intensity
270 of bitterness using the gLMS. The average bitterness intensity score is used for each subject.

271

272 *2.5.3 Familiarity, Food Preference and Choice questionnaires*

273 A total of 184 food items were selected and grouped in seven categories as described in Table
274 5. The items were selected considering the typical Italian meal patterns (light breakfast, lunch
275 and dinner) and the most appropriate foods for these contexts. Further criteria for item selection

reflected variations in familiarity (more/less familiar foods), taste (strong/mild) and energy content (high-energy dense/low energy dense). In both Familiarity and Preference Questionnaires, the presentation order of the items within each food category as well as the seven food categories are randomized across participants.

A Food Choice Questionnaire was developed in order to evaluate preferences within a pair of food items. For each pair, respondents are asked to indicate which food they would choose in a specific eating situation. The choice is contextualized to 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) for a total of 79 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).

2.5.4 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

One of the aims of the present paper is to show the potential of the IT dataset based on the results after one-year of the study, based on data from 1225 individuals. For this purpose, we selected a limited number of variables belonging to the different dimensions of food choice 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

312 investigated the role of these variables in determining preferences (stated liking) for specific
313 vegetables: rocket and radish salads.
314 We selected these items for the following reasons: 1) understanding consumer liking for
315 vegetables is relevant in itself because of the general interest in promoting health eating in many
316 countries (Appleton et al., 2016); 2) the sensory properties of radish and rocket (bitterness and
317 pungency) may represent a potential barrier to consumption (Dinnella et al., 2016). Liking for
318 Brassica vegetables has been reported to be affected by PROP status (Shen et al., 2016) and
319 psychological traits (i.e. the level of neophobia in adult subjects has been found to be a barrier
320 to the development of preference for vegetables in relation to their sensory properties; Törnwall
321 et al. 2014). Thus, they are appropriate to set up a multidimensional model to show the potential
322 of the Italian Taste data set in studying the association among several and different variables
323 affecting food choice.
324

325 **3.1 Materials and methods**

326 *3.1.1 Participants*

327 The data from 1225 participants were collected during 2015. Their demographic and social
328 characteristics are reported in Table 7. The sample was 61% female with a mean age of 36.9
329 years (SD 12.8; 18-60 years old range). The age distributions of the male and female groups
330 were not significantly different. Regarding the region of residence of the respondents, the
331 Northern of Italy was the most represented (46%), followed by the Southern and Islands (34%)
332 and by the central area of Italy (20%) in line with ISTAT data (ISTAT, 2011). As expected, more
333 females were in the normal range and underweight than males, whereas more males were
334 overweight or obese (χ^2=15.8; $p<0.01$). Fourteen percent of the respondents smoked regularly
335 or 11% occasionally. The vast majority of respondents (more than 90%) reported no history of
336 food allergy and/or intolerance. Vegetarians were the 2.2% of the total.
337

338 *3.1.2 Measuring sensitivity to PROP*

339 PROP status was assessed on 1149 participants according to the procedure described in 2.5.2.
340

341 *3.1.3 Personality and attitude measures*

342 All the questionnaires considered were translated to Italian by two different bilingual Italian
343 native-speakers and then back translated into the source language. Back translation were
344 reviewed by an expert in semantics and adjustments were made when necessary to select the
345 most appropriate translation.
346

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 & 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.

Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ). According to Gray's neuropsychological theory of personality two basic brain systems that control behavior and emotions: the Behavioural Inhibition System (BIS) and the Behavioural Activation System (BAS). The responsiveness to these systems was measured using the SPSRQ (Torrubia et al., 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.

Health and Taste Attitude Scale (HTAS). The HTAS questionnaire was developed to assess orientations toward the health and hedonic characteristics of foods (Roininen et al., 1999). The HTAS items were scored on a seven-point category scale with the scales labelled from "disagree strongly" to "agree strongly". For each participant and each subscale, after recodification of negatively worded items, a sum score was computed by summing the individual scores.

3.1.4 Measuring food preference and familiarity

We selected from the Food Preference and Familiarity questionnaires stated liking for and familiarity with rocket and radish salads (for details on the rating scales see Table 5: Q1; OQ).

3.1.5 Data Analysis

For the variables PROP, FSN, 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 (n=1204) 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 et al. (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 and 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 and Martens, 2000).

3.2 Results

3.2.1 PROP Status

Distribution of PROP bitterness ratings of the whole sample is described in Figure 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 Figure 3. Based on an *a priori* cut-off, 27.7% of male population and 23.6% of female population were classified as NT; 21.1% of male and 34.6% of female were classified as ST. Females and males significantly differed in PROP group distribution (χ^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 value=41.74) than in males (mean value=34.94) (F=16.77; p<0.001) (Table 8). 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; 31-46; >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 alpha, 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 (Figure 4) had a skewness of 0.60 and a kurtosis of -0.20. The distribution of FNS scores by gender and age is depicted in Figure 5 a-b. Gender- and age-related differences in FNS scores were tested through Two-way ANOVA with interaction (Table 8), which showed a significant main effect of gender ($F=4.24$, $p<0.05$) and age ($F=7.26$, $p<0.001$). Males (M=28.3) were significantly more neophobic than females (M=26.9) and the youngest participants (18-30 years: M=25.9) were significantly less neophobic than the older group (>46 years: M=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 alpha (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 8) 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)

The data from this scale are summarized in Table 9. Concerning the internal consistency of each Health and Taste domain, only Pleasure revealed a low internal validity (Cronbach's alpha=0.42), which was indeed found in other comparable studies in terms of scale. Furthermore, the differences in α-values across countries seem to indicate that the internal consistency of this domain changes in relation to cultural aspects. The effect of gender and age and their interaction was tested by a Two-Way ANOVA model (Table 8). 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 box plot of Figure 6 clearly shows that 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 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 by 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 18-30 years and 31-45 years rated higher than males on *Craving for Sweet Foods*, and females 18-30 years rated higher than males on *Pleasure*.

3.2.5 Stated liking for specific vegetables

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 (Figure 7) 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 is shown in Figure 8. It is interesting to note that being a PROP ST is, as expected, negatively associated to liking and positively associated to a low familiarity with the two vegetables.

4. Discussion

Overall, the project sample to date has been quite well balanced in terms of gender, age (within the range 18-60) 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.

PROP status

The distribution of PROP ratings distribution 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 et al., 2010). The general decoupling of threshold and supra-threshold PROP sensitivity has been often reported (Bartoshuk, 2000; Hayes and Keast, 2011; Webb et al., 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 et al., 2008). The relationships between genotype and phenotype, as well as responsiveness to PROP and fungiform papillae density, deserves further investigation and will be explored as part of the Italian Taste project as soon as population genotyping is completed.

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 et al., 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 et al., 2003). In fact, internal consistency of the FNS scores in the present study (α=0.87, n=1225, age range= 18-66 years) was similar to those reported in previous research involving large population samples of Finns (α=0.88, n=2191, age range= 18-57 years, Knaapila et al. 2015; α=0.85, n=1083, age range= 16-80 years, Tuorila et al. 2001) and Swiss (α=0.80, n= 4436, age range: 21-99 years, Siegrist et al. 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 Dematté 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 data set 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 and 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 and 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 10-70), leading to the conclusion that such effects are likely to be less important than many other variables related to food rejection (Nordin et al., 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 data set may reveal age and gender effects on specific FN scale items. At same time, the Italian Taste data set 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.

Sensitivity to Reward and Sensitivity to Punishment

In line with previous results (O'Connor et al., 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 et al., 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 & 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

18-31, and that individuals aged 31-45 tend to be more sensitive to reward than older individuals.

Health and Taste

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 sub-scale 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 et al., 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 subscale including 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 and 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; Roininen et al. 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.

Associations among variables.

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 punishment 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 behaviors 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 behaviors.

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 et al., 2008; Yeomans et al., 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.

Conclusion

Studies on influences in food choice are subjected to two main limitations: the mono-disciplinary approach and the sample size. 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.

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881 characteristics of odours: influence of sweet liker and propylthiouracil taster status. Quarterly
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885 Table 1. SISS Sensory Laboratory Network: Institutions, their geographic distribution and
886 number of subjects recruited per geographic area.
887

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

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Table 2. Socio-demographic and socio-economic, anthropometric and physical health variables: questionnaires and their relative acronym and code.

Questionnaires	Variables
Socio-demographics & socio-economics (SDQ) OQ*	- Age - Gender - Place of birth/residence - Place of birth of parents - Place of birth of grandparents - Educational level - Marital status - Employment status - Number of persons in the house - Children <16 years old in the house (n.) - Monthly food spending
Anthropometric (AQ) OQ*	- Weight (self-reported) - Height (self-reported) - Practice of restrictive diets (type and reason)
Physical health (PHQ) OQ*	- Smoking habits - Food allergies and intolerances - Tendencies to bulimic/anorexic behaviours - Use of medicines - Illnesses and chronic diseases - Ear infection/otitis - Problems in taste perception - Problems in odour perception - Illnesses and chronic diseases in relatives - Childbirth (natural/caesarean section) - Brest feeding - Pregnancies/Age of first menstr./Menopausal status - Self-rated health (SRH) - International Physical Activity Questionnaire (IPAQ)

*OQ = online questionnaire

Table 3. Psychological and personality trait measurement: 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 (disagree strongly/agree strongly)	Pliner & Hobden 1992
Private Body Consciousness (PBC)	Q4	5 items	5-point scale (extremely uncharacteristic/extremely characteristic)	Miller et al. 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 (disagree strongly/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 et al. 2008
Sensitivity to Disgust (DS-SF)	Q11	8-item Short form of the Disgust Sensitivity Scale (DSS) – 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 et al. 2009; Haidt 2004 DS-R: Haidt et al. 1994; modified by Olatunji et al. 2007

902 Table 4. Eating behaviours, food-related lifestyles and attitude measurements: questionnaires
903 and their relative acronym, code, items and domains, rating scale and references.
904

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 (disagree strongly /agree strongly)	Brunsø & 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 (disagree strongly /agree strongly)	Roininen et al. 1999
Dutch Eating Behaviour Questionnaire (DEBQ)	Q9	33 items – 3 domains: - Restrained eating - Emotional eating - External eating	5-point scale: - never (1) - seldom (2) - sometimes (3) - often (4) - very often (5)	Strien et al. 1986

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907 Table 5. Food preferences, choice, familiarity and frequency of consumption measurement:
908 Questionnaire, their relative code, items and categories and rating scale.
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Questionnaire		Items and domains	Rating scale
Frequency of consumption	OQ*	7 items – 3 categories - Alcoholic beverages (beer; wine; spirits; aperitivo/cocktail) - Coffee and 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 labelled 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)
Preference	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/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) - Aperitivo (10 pairs)	Forced-choice between two options

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911 *OC=online questionnaire.
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915 Table 6. Hedonic and sensory responses to food products, solutions and odours: aims, samples
916 and rating scales.
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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 burn)	4 series of 4 samples (spiked with a relevant tastant): - pear juice (citric acid) - chocolate pudding (sucrose) - bean purée (sodium chloride) - tomato juice (capsaicin)	Labeled Affective Magnitude Scale (Schutz & Cardello 2001)
	Sensory	To measure individual differences in responsiveness to overall flavour, specific tastes or other oral sensations (astringency and burn) 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: burning	Generalized Labeled Magnitude Scale, gLMS (Bartoshuk et al. 2004)
Water solutions	Sensory	To measure individual differences in responsiveness to basic tastes, astringency and burn in water solutions	7 samples: - citric acid 4 g/kg (sourness) - caffeine 3 g/kg (bitterness) - sucrose 200 g/kg (sweetness) - Monosodium glutamic acid 10 g/kg (umami) - K Aluminum Sulfate 0,8 g/kg (astringency) - capsaicin 1,5 mg/kg (burn)	Generalized Labeled Magnitude Scale, 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)

(*) 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-250g; Dimension: 11cm x 21cm). Each odorant was printed on a delimited area (2cm2 disc). The release of the odor is done simply by rubbing the printed microcapsule reserve.

Table 7. 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**			
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	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)			
Underweight	1.1	5.6	3.8
Normal range	53.6	72.0	64.9
Overweight	35.4	15.8	23.4
Obese	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

* Classification according to Nomenclature of Territorial Units for Statistics (NUTS).

Table 8. Two-Way ANOVA. Gender, age and their interaction effect on selected variables: mean scores and p-values.

	Gender (G)			Age (A)				G*A
Variable	P-value	Male	Female	P-value	18-30	31-45	46-66	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)

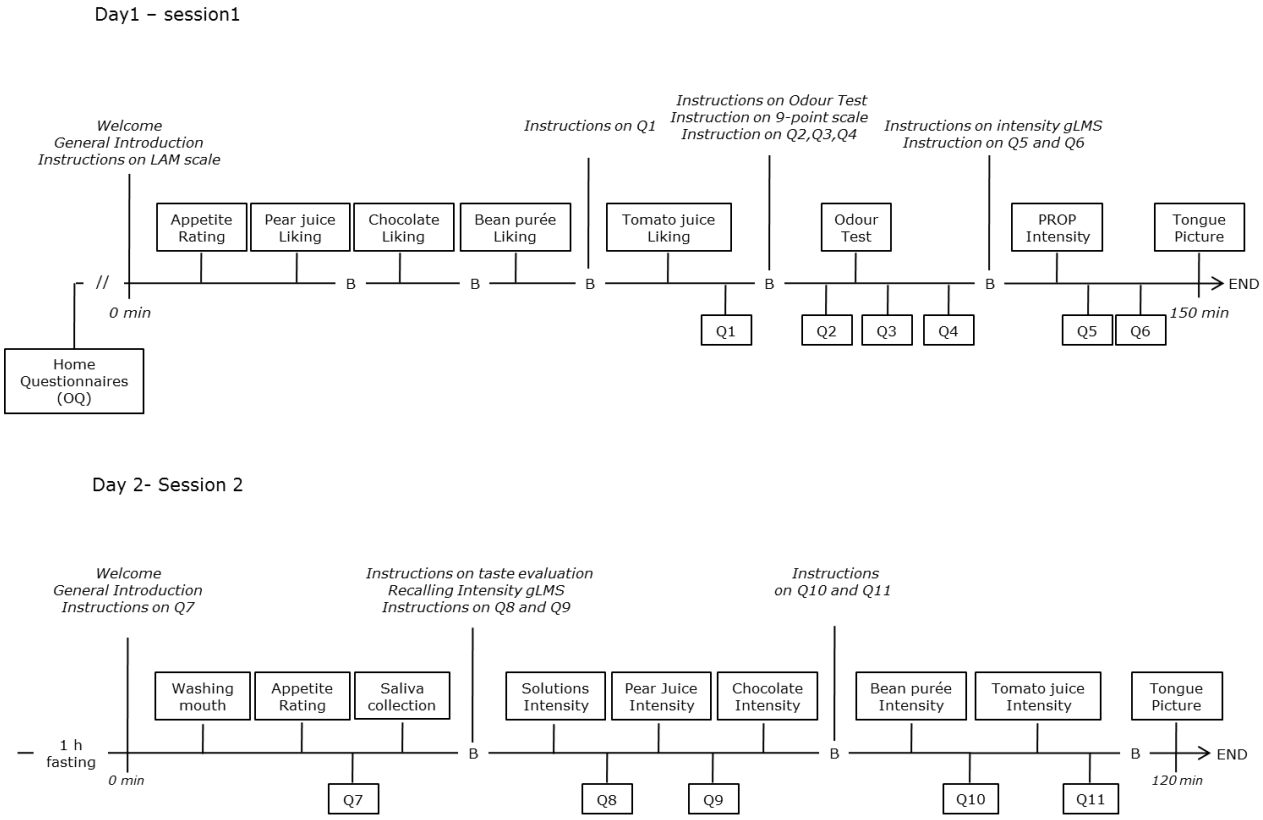
* The total degree of freedom (d.f.) for each of the computed ANOVA models was 1219 with exception of the variable PROP (d.f.=114)

Table 9. Descriptive statistics, and Cronbach's alpha (α) for each domain of the Health and Taste subscales and comparison with other studies (n=1224 per each domain).

HTAS Domain	Theoretical range	Min	Max	Mean	SD*	α	α^{a}	α^{b}	$\alpha^{c,1}$	$\alpha^{c,2}$	$\alpha^{c,3}$	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).

990 FIGURE 1. Overview of data collection.



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

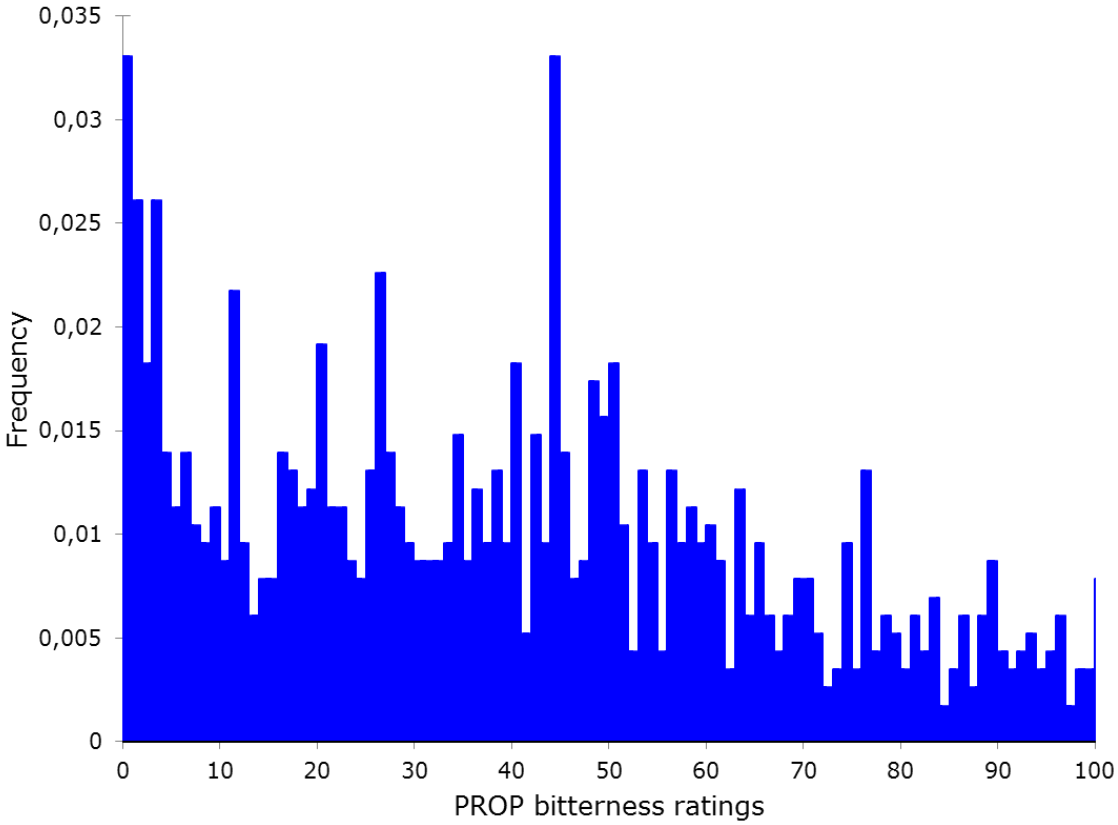

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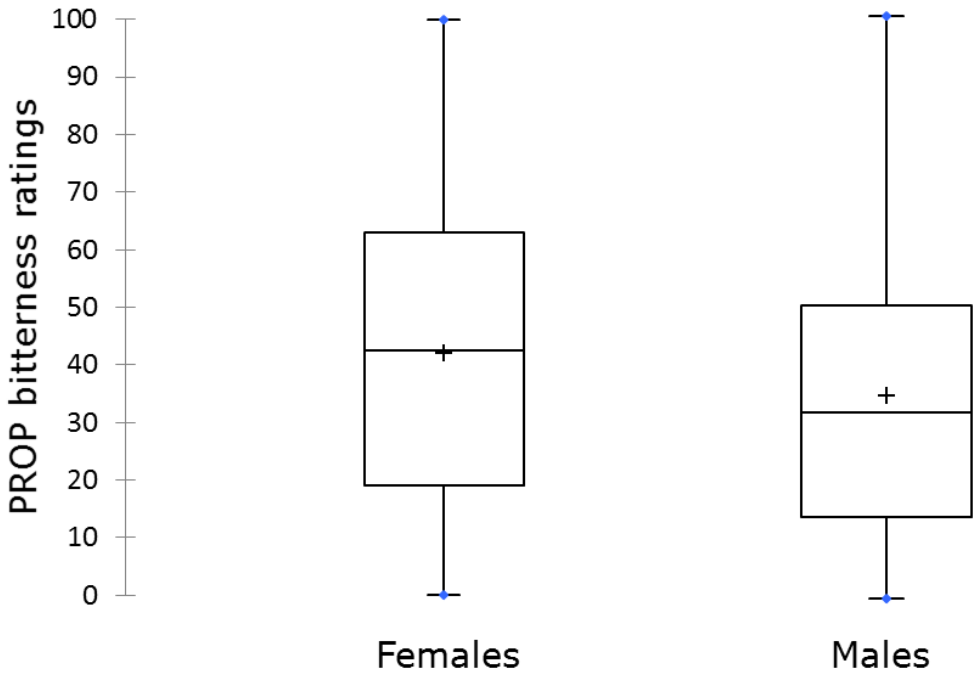
Fig. 3. Gender differences in PROP bitterness ratings. Median (line) and mean (cross) values.



1007 Fig. 4. Distribution of Food Neophobia Scores (n = 1225).

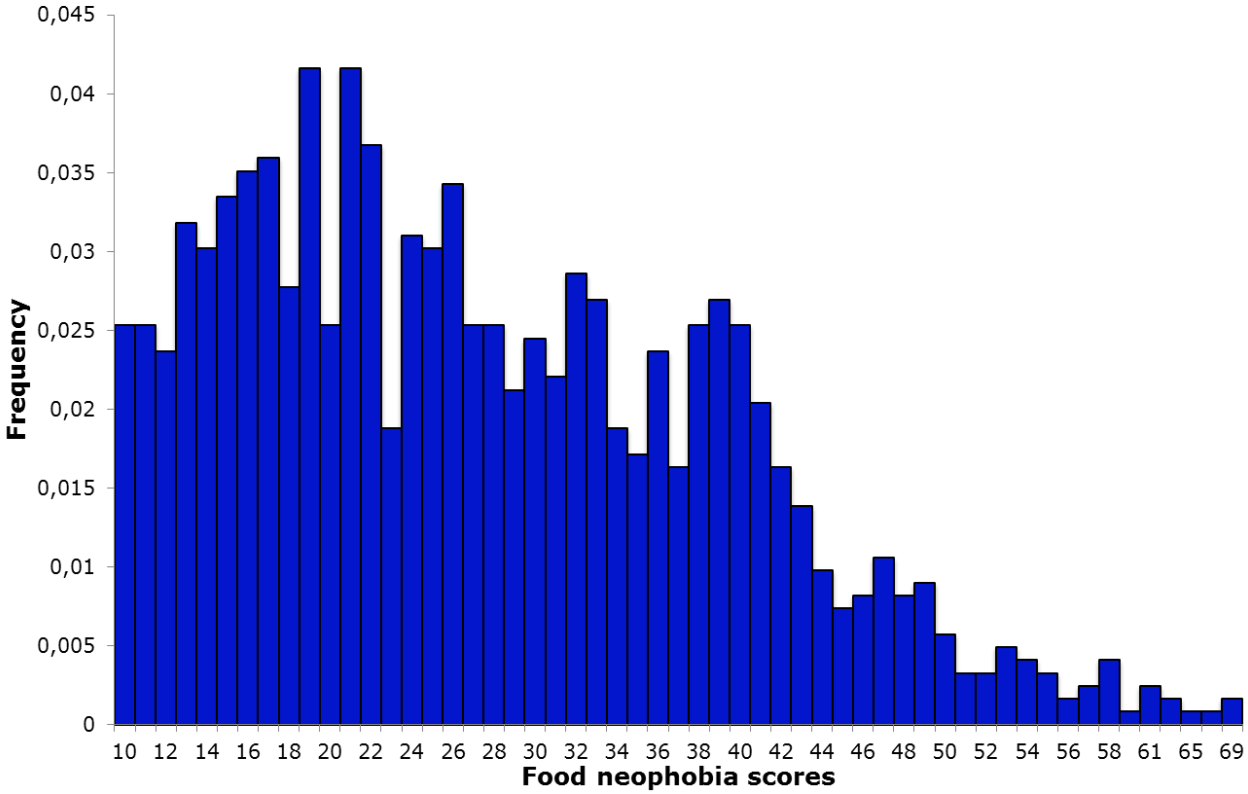


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Figure 5(A-B). Box-and-Whisker plot of food neophobia scores distribution by gender (A) and age (B). Different letters indicate significant differences ($p<0.05$) according to HSD post-hoc analysis.

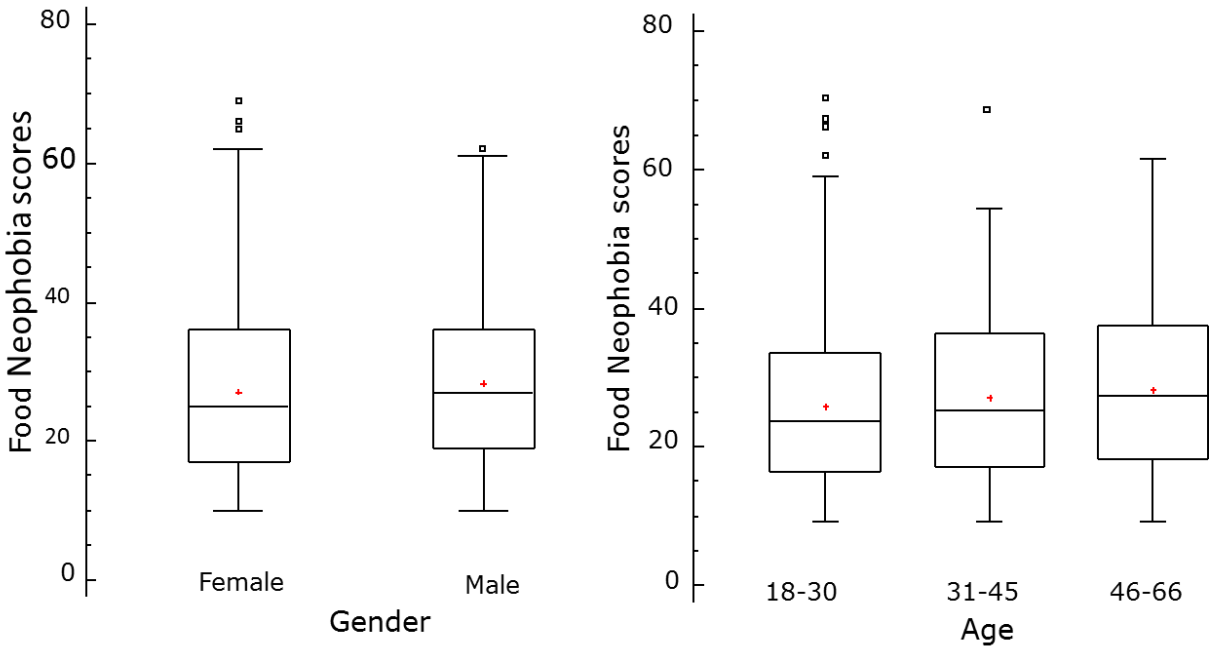


Figure 6. Box-plot of General Health Interest (GHI), Natural Products Interest (NPI), Craving for Sweet Foods (CSF) and Pleasure (P) scores distribution by gender (F= female; M=male). Median (line) and mean (cross) values.

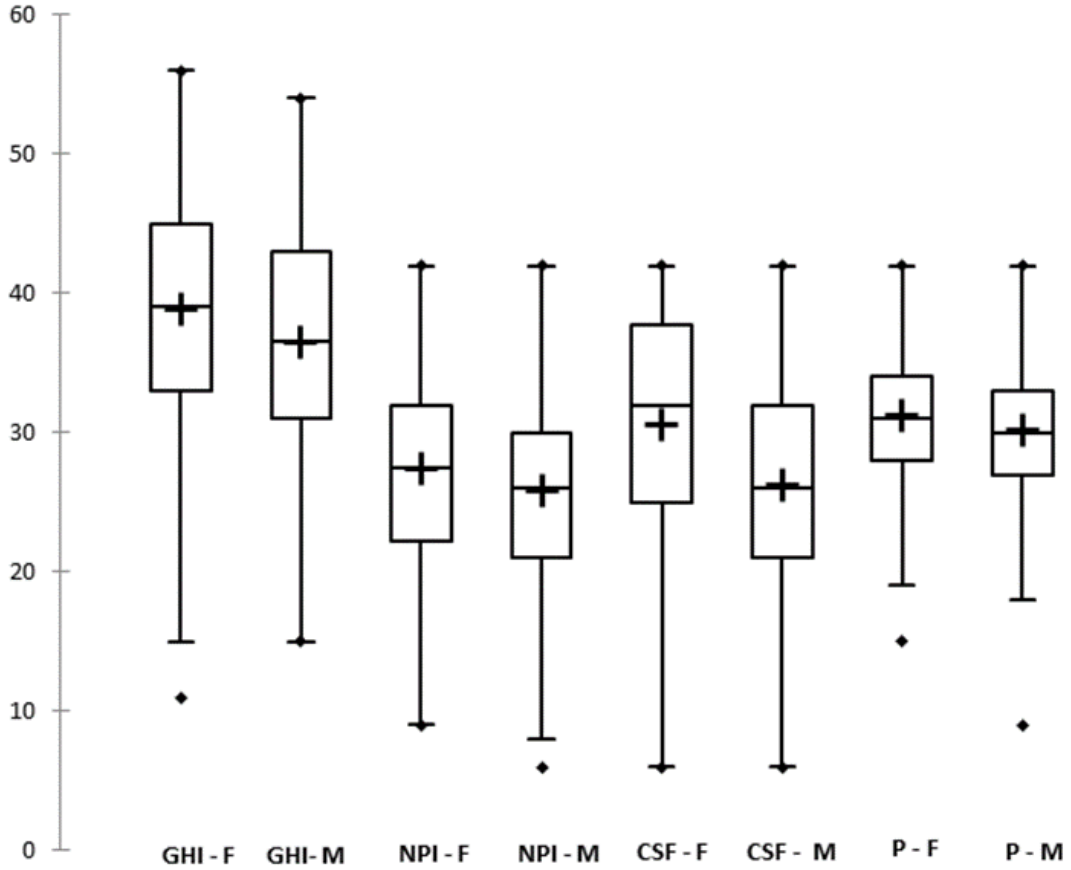
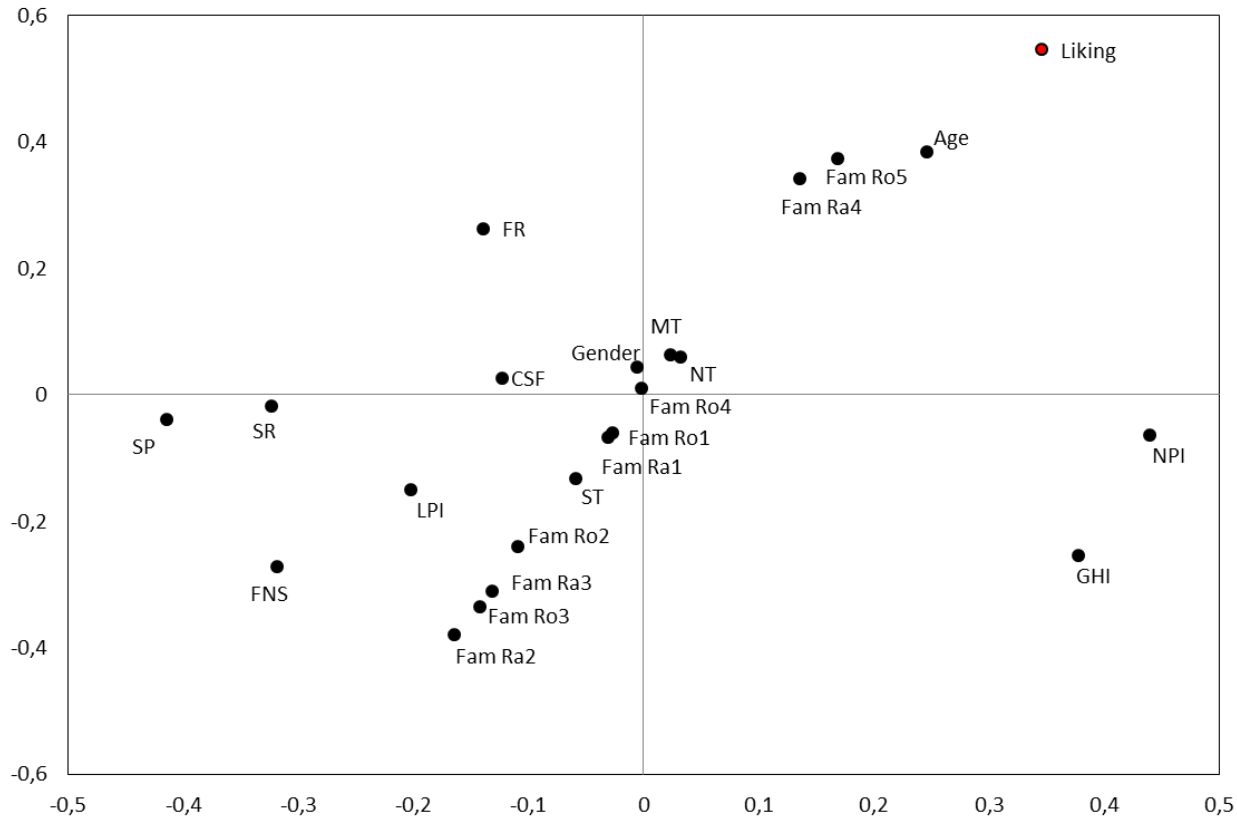
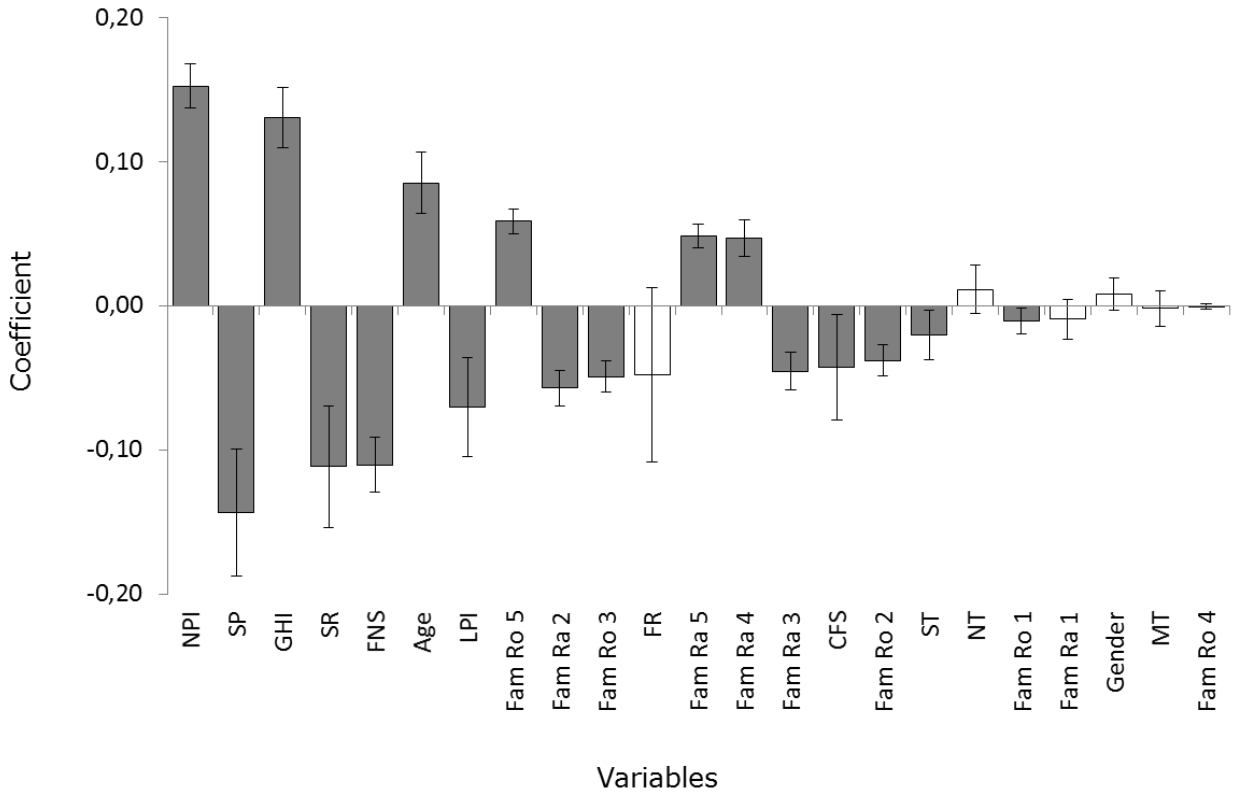


Figure 7. PLS regression loading plot. PC1 vs PC2. Variance accounted for X and Y for each PC are reported in brackets.



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.

Figure 8. PLS regression coefficients displayed with 95% Jack-knife confidence interval: variables (white bars) with interval overlapping 0 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.