# Food neophobia and liking for fruits and vegetables are not related to Italian children's overweight

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**Abstract**

Food acceptance and food choice are largely driven by taste preferences and liking, particularly among children. It is often assumed that overweight individuals differ from their normal-weight counterparts in that they prefer foods that are thought implicated in the development of obesity. Despite this, previous findings concerning the relationship between adults' adiposity and food liking are inconclusive, and there is limited research in children. We investigated the relationship among the body mass index (BMI), food neophobia and liking of fruits and vegetables (F&V) in a large cohort of Italian children (n=528, aged 6-9 years) in an ecological environment. According to principal component analysis (PCA), the BMI was unrelated to either the food neophobia or the liking values. Food neophobia was negatively correlated with liking of both F&V, but liking of vegetables contributed more in discriminating children according to their neophobia level than fruits liking. This suggests that liking of vegetables is a better indicator of children's food neophobia than liking of fruits. This outcome was further confirmed as low, medium and highly neophobic children differed significantly for their vegetables liking but not for fruits liking. Food neophobia was higher in boys than in girls and decreased systematically with increasing age.

**Keywords:** Childhood; Willingness to taste; Obesity; Acceptability; Fruits and vegetables

**Abbreviations:** Fruits and vegetables, F&V Body mass index, BMI; Principal component analysis, PCA

## 1. INTRODUCTION

In the past few decades there has been a steep rise in childhood obesity worldwide, with one third of children becoming overweight or obese by the time they are 2 years old (Horne, Greenhalgh, Erjavec, Lowe, Viktor, & Whitaker, 2011). Childhood obesity can cause social, psychological and health problems and it is linked to obesity later in life (Dietz, 1998; Sandhu, Ben-Shlomo, Cole, Holly, & Smith, 2006). Given that childhood obesity and its health impacts track into adulthood (Van Duyn, & Pivonka, 2000), preventing obesity from an early age has become a major public health priority in the developed world (WHO, 2012). To deal effectively with this widespread obesity epidemic, it is important to identify its determinants. The origins and causes of obesity are manifold and complex: although there are some genetic causes, most of them are related to lifestyle and the dietary habits of the children and their families (Gortmaker et al., 2011). Food preferences are believed to play a central role in the prediction of human food choices (Drewnowski, 1997; Pilgrim and Kamen, 1963), particularly children's food choices (Birch, 1992). Although adult food and taste preferences have been relatively well documented, there have been few studies on children's preferences in daily life. Understanding the child population's food preferences and their determinants is important for progress in preventing overweight and obesity and improving children's poor food intake.

Food neophobia is one of the main factors influencing the quality of children's diets and the development of food preferences (Russell & Worsley, 2008). Food neophobia literally means "fear of new food". It is manifested in children as a reluctance to eat and/or the avoidance of novel food (Pliner & Hobden, 1992; Birch & Fisher, 1998). Although food neophobia has been evolutionarily useful, in a modern society where food safety is guaranteed, it can have a negative effect on food choices as food neophobic individuals avoid new food experiences and thus lack dietary variety (Cooke, Wardle, & Gibson, 2003). Evidence for a negative relationship between food neophobia and dietary variety in children has been reported (Koivisto-Hursti & Sjöden, 1996; Falciglia et al., 2000; Skinner, Carruth, Bounds, & Ziegler, 2002), being neophobic children less inclined to eat certain types of foods (*e.g.*, fruit, vegetables and foods of animal origin) than their more neophilic peers (Galloway, Lee, & Birch, 2003; Nicklaus, Boggio, Chabanet, & Issanchou, 2005; Cooke, Carnell, & Wardle, 2006). Although the negative effects of food neophobia on children's everyday food intake are increasingly well documented, the role of food neophobia in children nutritional status remains unclear. Falciglia et al. (2000) showed a tendency toward a higher caloric intake in the neophilic children, while Zalilah, Khor, Mirnalini, & Sarina (2005) suggested that neophobic children had a greater prevalence of both overweight and underweight.

To the best of our knowledge, very few studies have investigated the relationships among food neophobia, food preferences and nutritional status in an ecological environment, particularly in children. In this context, Knaapila et al. (2011) conducted a multidisciplinary investigation of the origins of food neophobia and its relationship with a series of variables, among which were personality traits, the pleasantness of the food and the body mass index. However, this study did not involve children and was conducted in a laboratory context. In everyday life, the perceived danger of food may be greater than that in the safety of a laboratory, so that the effects of food neophobia may be underestimated. In addition, a limitation of the research on children that has been conducted to date is that both food neophobia and liking have often been assessed using parent reports. Information about their children's food behavior that is obtained from questionnaires provided to the parents may be misleading because it underestimates the role of the children in the process. In addition, parents may sometimes project their own behaviors onto those of their children (Mata, Scheibehenne, & Todd, 2007).

The aim of this study was to obtain a self-reported measurement of food neophobia and liking of F&V involving a representative sample of primary school children in an ecological environment (*i.e.,* at school) and to evaluate how food neophobia and liking are related to the children's nutritional status. We hypothesized that food neophobia is associated with a reduced liking of F&V, and that both food neophobia and liking are related to the children's body mass index (BMI). More specifically, we expect that high acceptance of healthy food, such as F&V, may be associated with a lower prevalence of excess weight among children. Finally, since in previous studies, age (Dovey, Staples, Gibson, & Halford, 2008; Pagliarini, Gabbiadini & Ratti, 2005) and gender (Dovey et al., 2008; Koivisto-Hursti and Sjöden, 1997) have been reported to play a role in children's food neophobia and liking, age- and gender-related differences were also investigated.

## 2. MATERIALS AND METHODS

### 2.1 Participants

Five hundred and twenty-eight (267 boys and 261 girls) children aged between 6 and 9 years (mean age: 7.8 ± 1.1 years) who attended three urban public primary schools participated in this cross-sectional study. The schools were selected in the center and the larger metropolitan area of Milan (Italy). Food neophobia, the liking of F&V and the BMI of all of the participants were assessed at school between October 2011 and February 2012.

The children were selected based on a consent form that was completed by the parents. The parents were asked to read a short explanation of the study and to complete a questionnaire in which they were asked to indicate whether their child had any food allergy or followed a specific diet. All of the children involved in the study met the following criteria: healthy, not on a specific diet, and not suffering from food allergies. The study was performed in adherence with the principles established by the Declaration of Helsinki. The protocol was approved by the Institutional Ethics Committee at the study site.

## 2.2 Nutritional status evaluation

Anthropometric measurements were taken at the schools by trained technicians according to standardized procedures (Lohman, Roche, & Martorel, 1988). Height was recorded to the nearest 0.1 cm using a stadiometer and weight was measured to the nearest 0.1 kg using a high-precision mechanical scale. The BMI was calculated as the weight (kg) per height$^2$ ($m^2$). The gender-specific BMI-for-age percentiles and Z scores were calculated using the 2000 CDC Growth Charts (Center for Disease Control and Prevention, 2000). In accordance with CDC guidelines, a Z-score below the 5$^{th}$ percentile represented underweight, a score between the 5$^{th}$ and 85$^{th}$ percentile represented a normal weight, a score at or above the 85$^{th}$ percentile and below the 95$^{th}$ percentile represented overweight, and a score at or above the 95th percentile represented obesity (Center for Disease Control and Prevention, 2000).

## 2.3 Evaluation of food neophobia

The scale used was an Italian adaptation of the original food neophobia scale that was developed by Pliner and Hobden (1992). The original scale was reduced to 8 items, 4 related to neophilic attitudes and 4 related to neophobic attitudes. Specifically, the items “Ethnic food looks too weird to eat”, “I like trying new ethnic restaurants” and “I like foods from different countries”, which were present in the original food neophobia scale, were removed and replaced by the item “I like trying new food and tastes that are from other countries”. The modification was necessary because a preliminary test showed that children (n=30, 16 girls and 14 boys, age range of 6-10 years) did not understand the term “ethnic” properly. Internal consistency was evaluated using Cronbach’s alpha test ($\alpha$=0.77, n=8). The design and validation of the food neophobia scale used in the present study is the subject of another publication (Laureati et al., submitted).

The adapted food neophobia scale was presented to the children in the classroom by the teacher and an experimenter who explained to them how to complete the questionnaire. For each item, the children were asked to indicate the degree to which they considered the statement to be true for them, using a 5-point facial scale (from left to right: “Very false for me”, “False for me”, “So and so”, “True for me”, and “Very true for me”). The administration method was the same across all age groups of children, except for 6-years-old children for whom the administration was simplified (e.g., questionnaires administered in small groups of 5-6 children and questions read aloud by the experimenter). A neophobia score ranging from 8 to 40 was calculated for each child (neophilic items scores were reversed).

**2.4 Evaluation of liking**

The liking test was performed one week after the food neophobia evaluation. The children received small portions of F&V (fruit: apple, pear, grapes and miyagawa-citrus fruit); vegetables: fennel, radish, broccoli and carrot). A portion of approximately 40 g of each fruit and vegetable was served raw to the children immediately prior to their mid-morning snack. To increase ecological validity, children were tested in a familiar environment, namely their classroom because at midmorning snack Italian children usually eat there. FV were selected based on availability in season, ease of handle and storage. In addition, stimuli were chosen in order to have FV that were familiar for Italian children.

The F&V were fresh and were cut into standardized, uniform-sized pieces; they were presented to the children at room temperature in plastic cups encoded with the word “fruit” or “vegetable”. For each stimulus, the children were asked to rate their degree of liking using a 7-point hedonic-facial scale (Pagliarini, Ratti, Balzaretti & Dragoni, 2003; Pagliarini et al., 2005). Children were also asked whether they consider each stimulus to be familiar or not and whether they had already tasted it. All items were familiar for more than 93% of children, except for radish, which was known only by 60% of them. In addition, children reported having tasted frequently all items, except broccoli (11%) and radish (8%).

### 2.5 Data analysis

The food neophobia and liking data were first analyzed using an analysis of variance (ANOVA) test that considered the school (school 1-3), the age (6-9 years), the gender, and the stimulus (the F&V provided) as factors.

The relationship among the BMI, food neophobia and liking data was evaluated using principal component analysis (PCA). Autoscaling was performed on the data prior to any modeling. Cross validation was chosen as the validation method. To further interpret the relationship between liking of F&V and food neophobia, the children were divided according to their level of neophobia into 3 groups: 'low' (children with scores in the lower $25^{th}$ percentile of food neophobia scores, score $\leq 17$, n=141), 'medium' (children with scores between the $25^{th}$ and $75^{th}$ percentiles, score $\geq 18$ and $\leq 24$, n=234) and 'high' (children with scores in the upper $25^{th}$ percentile, score $\geq 25$, n=154). The data were subjected to a GLM ANOVA that considered the *Neophobia level* ('low', 'medium' and 'high'), *Stimulus category* (fruits and vegetables) and their interaction as factors and liking as a dependent variable.

All ANOVAs were conducted using SAS/STAT statistical software package version 9.3.1. (SAS Institute Inc., Cary, USA). PCA modeling was performed using The Unscrambler X software (CAMO Software AS, Oslo Norway).

## 3. RESULTS

### 3.1 Nutritional status evaluation

The distribution of the socio-anagraphic (gender and ethnicity) and nutritional status (BMI classification) variables according to age is reported in Table 1. Age was not related to gender ($p=0.81$) or to the BMI classes ($p=0.76$). Of the total sample, 8 children (1.5%) were underweight, 369 (69.9%) were of normal weight, 132 (25.0%) were overweight and 19 (3.6%) were obese. Only 5.3% of the entire sample was non-Caucasian.

### 3.2 Evaluation of food neophobia

Internal consistency was satisfactory (Cronbach's alpha: $\alpha=0.73$). The mean food neophobia scores by school, age and gender are reported in Table 2. A significant difference in the food neophobia scores was found for gender ($F=4.82$, $p=0.03$) and age ($F=8.67$, $p<0.001$). According to the LSD post-hoc test, boys were more neophobic than girls and the four age classes differed significantly, with a reduction of the neophobic attitude with increasing age. The interaction of gender by age was not significant ($F=0.77$, $p=0.51$), with boys being more neophobic than girls regardless of the age class. However, the differences between the boys and girls were more pronounced at 6 and 7 years and vanished with increasing age. No differences ($F=0.19$, $p=0.83$) were detected in the food neophobia scores among the three schools. The food neophobia results did not change when the analysis was performed only on the Caucasian children.

### 3.3 Evaluation of liking

The mean hedonic scores by school, age, gender and stimulus are reported in Table 3. Age was found to have a significant effect on liking ($F=6.66$, $p<0.001$). According to the LSD post-hoc test, nine-year-old children showed significantly lower liking scores than the younger children, which in turn were similar. Additionally, a significant effect for the type of stimulus ($F=154.22$, $p<0.0001$) and stimulus category ($F=814.28$, $p<0.0001$) was found. Overall, fruits were more liked than vegetables. According to the LSD post-hoc test, apple and grapes were the most favored stimuli, followed by carrot and pear. Carrot was the only type of vegetables that received a comparable or even higher liking score than the fruits. Miyagawa was the least liked type of fruits probably due to its sourness. Fennel received significantly lower liking scores than the fruits, whereas radish and broccoli received comparable and very low ratings. No significant differences in the liking scores were found for the school ($F=1.60$, $p<0.20$) or the gender ($F=0.01$, $p<0.94$). The same results were obtained when the analysis was performed only on Caucasian children.

### 3.4 Relation among nutritional status, food neophobia and food liking

The BMI, food neophobia and liking data were subjected to PCA to examine the results from a multidimensional point of view (Figures 1 a-b). The first two PCs explained 39% of the variance (Figure 2a). The BMI was unrelated to either the food neophobia or the liking values. Food neophobia was positioned in the positive part of PC1 (23% of the explained variance) and was negatively correlated with all of the liking values, which were in turn positioned in the negative part of PC1. The negative correlation between food neophobia and the liking for F&V was confirmed by the data shown in Table 4. The correlation coefficients were somewhat low (range: -0.11 to -0.28) but were significant ($p<0.05$), considering the large number of individuals ($n > 200$). Food neophobia also showed positive coordinates in PC2. The relation between food neophobia and the liking values could be further interpreted from examining Figure 1b. For this figure, PC2 was plotted against PC3, which explained a further 11% of the variance. The BMI variable showed high loading on PC3 and low loading on PC2 thus confirming that this variable is unrelated to the food neophobia and liking scores. In addition, the liking values were distributed along PC2, with the vegetables liking values in the negative part of PC2 and the fruits liking values in the positive part. The distribution of the liking values along PC2 perfectly reflected the direction of the children's preference evidenced by the ANOVA results, with broccoli and radish being the least liked items, followed by fennel and carrots and then by all of the fruits. Food neophobia was positioned near to the fruits' liking values, but it was still opposite to vegetables' liking scores. To further interpret the relationship between liking of F&V and food neophobia, the children were divided according to their level of neophobia into 3 groups: 'low', 'medium' and 'highly' neophobic children. ANOVA results revealed that the interaction of *Neophobia level by Stimulus category* was significant ($F=3.81$, $p<0.05$). As shown in Figure 2, vegetables' liking scores significantly ($p<0.0001$) decreased with increasing neophobia level, whereas fruits' liking scores remained stable whatever the level of the children's neophobia. In other words, vegetables liking contributed more in discriminating children according to their neophobia level than fruits liking. This result confirms PCA results and suggests that vegetables' liking is a better indicator of children's food neophobia than is fruits' liking.

## 4. DISCUSSION

Food neophobia and food liking have been studied extensively in children, but the implication for the children's nutritional status is not well understood. It is widely agreed that food acceptance and food choice are largely driven by taste preferences and liking, particularly among the children in contemporary western environments (Bere & Klepp, 2005; Birch, 1999). For this reason, it is often assumed that overweight individuals differ from their normal-weight counterparts in that they prefer foods that are thought implicated in the development of obesity. Despite this opinion, earlier findings on the relationship between adiposity and food liking for common foods are inconclusive in adults and relevant research in children is limited (Hill, Wardle & Cooke, 2009).

The children involved in this study showed a prevalence of excess weight consistent with the last Italian survey of primary-school children (Ministero della Salute, 2012).The percentage of obese children was low (4%) compared with the mean Italian percentage (10.6% obese children) but coherent with the reduced prevalence of obese children generally observed in the north of Italy (6% in the Lombardia region).

One of the hypotheses proposed in the present paper was that neophobic behaviors may be associated with a higher risk of becoming overweight and attaining an obesity status in children. This assumption is based on the fact that neophobia is generally high for F&V among children. This attitude could lead to a higher consumption of energy dense foods that are high in sugar and fat at the expense of the consumption of healthier food. However, the results of the present study did not find any association between the BMI and food neophobia or food liking in children. This result is consistent with the findings of Hill et al. (2009), who did not find any relationship between adiposity and the reported liking for a series of foods, among which were F&V. Conversely, Knaapila et al. (2011) found a moderate but significant positive correlation between the BMI and food neophobia in women aged 20-25 years. In their study, Knaapila and colleagues speculated that the link between food neophobia and nutritional status might be bidirectional. Therefore, neophobia might manifest in a diet with a limited variety of foodstuffs, thus reducing the frequency of using foods overall, and in turn, the energy intake; in contrast, food neophobics could prefer to consume traditional foods with a higher energy density compared with healthier food, resulting in a higher BMI.

Our results confirm previous findings that high food neophobia is associated with low food liking (Russell & Worsley, 2008) and low consumption of F&V (Galloway et al., 2003; Cooke et al., 2003, 2004, 2006; Wardle, Carnell & Cooke, 2005). However, we found that liking of vegetables was the best indicator of children's' food neophobia. Similar findings are reported by Knaapila et al. (2011), who found that in young adults, high levels of food neophobia are associated with low pleasantness of food in general and the reduced use of vegetables. It remains unclear why food neophobia is particularly high for certain categories of food. For instance, children food neophobia is highly related to F&V as well as to fish and meat but not to starchy, sweet or fatty snack foods (Cooke et al., 2003). Some authors suggested that this behavior may be due to personality traits (Dovey, Staples, Gibson, & Halford, 2008), whereas others reported perceptive (Coulthard & Blissett, 2009) and even genetic reasons (Knaapila et al., 2011). The fact that vegetables are less liked than fruits is well known and has been confirmed by previous reports indicating that vegetables are among the least favored food of children (Skinner et al., 2002; Perez-Rodrigo et al., 2003; Cooke & Wardle, 2005). This pattern of preferences is consistent with the evidence for innate tendencies to prefer sweet tastes and to dislike bitter tastes (Birch, 1999). Indeed, most fruits are sweet, whereas vegetables are often perceived as bitter due to compounds that are specifically found in cruciferous vegetables (*e.g.,* broccoli, cauliflower and kale) (Forestell & Mennella, 2007). Recent evidence has shown that this behavior, which is particularly prevalent among children, may be explained in part by genetic factors. Polymorphism in the TAS2R38 gene may lead to a variation in the perception of the bitterness of 6-n-propylthiouracil (PROP), which can in turn influence dietary patterns. In this context, it has been reported that PROP supertaster children are less likely than the nontasters to have tried/tasted cruciferous vegetables (Feeney et al., 2014).

Consistent with the literature, we observed a decrease in the food neophobia score with increasing age (Dovey et al. 2008; Koivisto-Hursti & Sjöden, 1996; Pliner & Loewen, 1997; Nicklaus et al., 2005; Rigal, Frelut, Monneuse, Hladik, Simmen, & Pasquet, 2006). It has been suggested that food neophobia occurs in all age groups and that its intensity depends on inter-individual variability (Pliner & Salvy, 2006). In particular, it has been shown that after reaching a peak between 2 and 6 years (Pliner, 1994; Pelchat & Pliner, 1995; Pliner & Loewen, 1997), food neophobia generally decreases progressively throughout childhood and adolescence (Cashdan, 1994; Addessi, Galloway, Visalberghi, & Birch, 2005), becoming relatively stable during adulthood as a result of increased experiences with foods (Cooke & Wardle 2005). In particular, we found that the 9-year-aged children differed in terms of both food neophobia and liking from the younger children, indicating that this age is a critical period in a child’s life with respect to food behavior development. Indeed, it has been reported that children around this age develop a different neophobic reaction due to different optimal levels of arousal (Loewen & Pliner, 1999) and a more critical attitude toward food as a consequence of exposure to a more varied diet (Pagliarini et al., 2005). Furthermore, the finding of a progressive decline in the food neophobia score according to age seems to support previous reports indicating that food neophobia may not be considered entirely as a personality trait but rather a state prone to changes, particularly in children (Mustonen & Tuorila, 2010).

In terms of gender differences in food neophobia scores, our data showed a significantly higher neophobic attitude for younger males than for females. The data in the literature on gender-related differences in food neophobia scores are scanty and contradictory, particularly for children. Some studies conducted with adults have found differences, with women being more neophobic than men (Frank & van der Klaauw, 1994) or men being more neophobic than women (Koivisto-Hursti & Sjöden, 1997; Tuorila, Lähteenmäki, Pohjalainen, & Lotti, 2001). The few data available on gender-related differences in food neophobia considering children are in accordance with the findings of the present study and indicate more a neophobic behavior in boys than in girls (Koivisto-Hursti & Sjöden, 1996; Koivisto-Hursti &

Sjöden, 1997). The confusing results of these studies suggest that there is a complex interplay between gender and food neophobia that has yet to be revealed.

## 5. CONCLUSION

The present study investigated two important determinants of children's nutritional status, food neophobia and their liking of F&V. Most of the hypotheses we formulated were confirmed, as we found a negative relationship between food liking and food neophobia, with vegetables being the best predictor of children's food neophobia. Additionally, our data confirmed previously reported findings that food neophobia is more pronounced in boys than in girls and decreases with the children's age. Finally, we did not find any relationship between the BMI and either food neophobia or food liking. To our knowledge, no information exists about the associations among food neophobia, food liking and nutritional status in Italian children. Our results could expand the knowledge in an open research field, allowing better understanding of crucial behaviors in the pathogenesis of overweight and obesity in childhood.

One of the strengths of the present study is that it was conducted involving a relatively high number of children in an ecological setting during an actual mealtime situation. The naturalistic environment is an important point to consider when studying factors linked to food behavior. Food neophobia and food liking may indeed be underestimated when assessed in a laboratory setting, particularly for children. A limitation of the study is that only four items were considered within each food category. However, when conducting sensory testing with children providing a too wide range of stimuli is an option that should be considered with caution since other problems such as sensory and psychological fatiguing may arise. We believe that providing 8 food stimuli is a good compromise between children's fatigue and representativeness of stimuli. Finally, this study was cross-sectional. Therefore, we cannot explore the onset and causality of these associations. Longitudinal studies are needed to examine the course of food neophobia and liking and its possible effect on nutritional status.

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**Table 1**: Children's characteristic and association with age (Statistical differences between groups were determined by using the $\chi^2$ test).

| **Variable** | | **Age (Years)** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **TOTAL** | | **6** | | **7** | | **8** | | **9** | | |
| | | **N** | **%** | **N** | **%** | **N** | **%** | **N** | **%** | **N** | **%** | **p Value** |
| **Gender** | Boys | 267 | 50.6% | 70 | 50.7% | 91 | 52.0% | 70 | 51.5% | 36 | 45.6% | 0.806 |
| | Girls | 261 | 49.4% | 68 | 49.3% | 84 | 48.0% | 66 | 48.5% | 43 | 54.4% | |
| **BMI Classes** | Underweight | 8 | 1.5% | 2 | 1.4% | 4 | 2.3% | 1 | 0.7% | 1 | 1.3% | 0.763 |
| | Normal weight | 369 | 69.9% | 95 | 68.8% | 127 | 72.6% | 97 | 71.3% | 50 | 63.3% | |
| | Overweight | 132 | 25.0% | 37 | 26.8% | 36 | 20.6% | 34 | 25.0% | 25 | 31.6% | |
| | Obese | 19 | 3.6% | 4 | 2.9% | 8 | 4.6% | 4 | 2.9% | 3 | 3.8% | |
| **Ethnicity** | Caucasian | 500 | 94.7% | 130 | 94.2% | 167 | 95.4% | 133 | 97,8% | 70 | 88.6% | 0.22 |
| | Other | 28 | 5.3% | 8 | 5.8% | 8 | 4.6% | 3 | 2.2% | 9 | 11.4% | |

**Table 2.** Mean food neophobia scores and standard error of the mean (SEM) by school, age and gender with relevant significance for each factor. Mean values with different superscripts by column and variable are significantly different (p<0.05) according to LSD post-hoc test.

| **Variable** | **Food neophobia** | | |
|---|---|---|---|
| | Mean | SEM | F-value (p-value) |
| **School** | | | F=0.19 (p=0.83) |
| School 1 | 21.2 | 0.4 | |
| School 2 | 20.8 | 0.4 | |
| School 3 | 21.2 | 0.4 | |
| **Age (years)** | | | F=8.67 (p<0.0001) |
| 6 | $23.2^{a}$ | 0.6 | |
| 7 | $21.5^{b}$ | 0.4 | |
| 8 | $20.7^{b}$ | 0.5 | |
| 9 | $18.8^{c}$ | 0.6 | |
| **Gender** | | | F=4.82 (p<0.03) |
| Boys | $21.6^{a}$ | 0.4 | |
| Girls | $20.5^{b}$ | 0.4 | |
| **Gender by Age** | | | F=0.77 (p<0.51) |
| Boys 6 y | 24.1 | 0.8 | |
| Boys 7 y | 22.5 | 0.6 | |
| Boys 8 y | 20.9 | 0.6 | |
| Boys 9 y | 19.0 | 0.9 | |
| Girls 6 y | 22.4 | 0.8 | |
| Girls 7 y | 20.5 | 0.6 | |
| Girls 8 y | 20.5 | 0.7 | |
| Girls 9 y | 18.6 | 0.8 | |

**Table 3.** Mean liking scores and standard error of the mean (SEM) by school, age, gender and type of stimulus with relevant significance for each factor. Mean values with different superscripts by column and variable are significantly different (p<0.05) according to LSD post-hoc test.

| **Variable** | **Liking scores** | | |
|---|---|---|---|
| | Mean | SEM | F-value (p-value) |
| **School** | | | F=1.60 (p=0.20) |
| School 1 | 4.7 | 0.1 | |
| School 2 | 4.7 | 0.1 | |
| School 3 | 4.6 | 0.1 | |
| **Age (years)** | | | F=6.66 (p<0.001) |
| 6 | 4.8 $^{a}$ | 0.1 | |
| 7 | 4.8 $^{a}$ | 0.1 | |
| 8 | 4.6 $^{a}$ | 0.1 | |
| 9 | 4.3 $^{b}$ | 0.1 | |
| **Gender** | | | F=0.01 (p=0.94) |
| Boys | 4.6 | 0.1 | |
| Girls | 4.6 | 0.1 | |
| **Stimulus** | | | F=154.22 (p<0.0001) |
| Apple | 6.0 $^{a}$ | 0.1 | |
| Grapes | 5.9 $^{a}$ | 0.1 | |
| Carrot | 5.5 $^{b}$ | 0.1 | |
| Pear | 5.4 $^{b}$ | 0.1 | |
| Miyagawa | 5.0 $^{c}$ | 0.1 | |
| Fennel | 4.3 $^{d}$ | 0.1 | |
| Radish | 2.6 $^{e}$ | 0.1 | |
| Broccoli | 2.4 $^{e}$ | 0.1 | |
| **Stimulus category** | | | |
| Fruits (overall, n=4) | 5.6 $^{a}$ | 0.1 | F=814.28 (p<0.0001) |
| Vegetables (overall, n=4) | 3.7 $^{b}$ | 0.1 | |

**Table 4.** Pearson's correlation coefficients for BMI, food neophobia and liking of fruits and vegetables (* significant for $p<0.05$, ** significant for $p<0.01$).

| Variables | BMI | FN | Pear liking | Apple liking | Miyagawa liking | Grapes liking | Broccoli liking | Carrot liking | Fennel liking | Radish liking |
|---|---|---|---|---|---|---|---|---|---|---|
| BMI | 1 | -0.05 | 0.05 | 0.03 | -0.01 | 0.00 | 0.00 | 0.05 | -0.02 | -0.01 |
| Food neophobia | -0.05 | 1 | -0.15 * | -0.16 * | -0.11 | -0.11 | -0.21 ** | -0.28 ** | -0.20 ** | -0.12 |
| Pear liking | 0.05 | -0.15 * | 1 | 0.22 ** | 0.23 ** | 0.25 ** | 0.18 ** | 0.17 * | 0.25 ** | 0.17 * |
| Apple liking | 0.03 | -0.16 * | 0.22 ** | 1 | 0.28 ** | 0.25 ** | 0.24 ** | 0.23 ** | 0.21 ** | 0.11 |
| Miyagawa liking | -0.01 | -0.11 | 0.23 ** | 0.28 ** | 1 | 0.30 ** | 0.13 | 0.16 * | 0.19 ** | 0.13 |
| Grapes liking | 0.00 | -0.11 | 0.25 ** | 0.25 ** | 0.30 ** | 1 | 0.11 | 0.27 ** | 0.19 ** | 0.14 * |
| Broccoli liking | 0.00 | -0.21 ** | 0.18 ** | 0.24 ** | 0.13 | 0.11 | 1 | 0.18 ** | 0.22 ** | 0.40 ** |
| Carrot liking | 0.05 | -0.28 ** | 0.17 * | 0.23 ** | 0.16 * | 0.27 ** | 0.18 ** | 1 | 0.41 ** | 0.15 * |
| Fennel liking | -0.02 | -0.20 ** | 0.25 ** | 0.21 ** | 0.19 ** | 0.19 ** | 0.22 ** | 0.41 ** | 1 | 0.34 ** |
| Radish liking | -0.01 | -0.12 | 0.17 * | 0.11 | 0.13 | 0.14 * | 0.40 ** | 0.15 * | 0.34 ** | 1 |

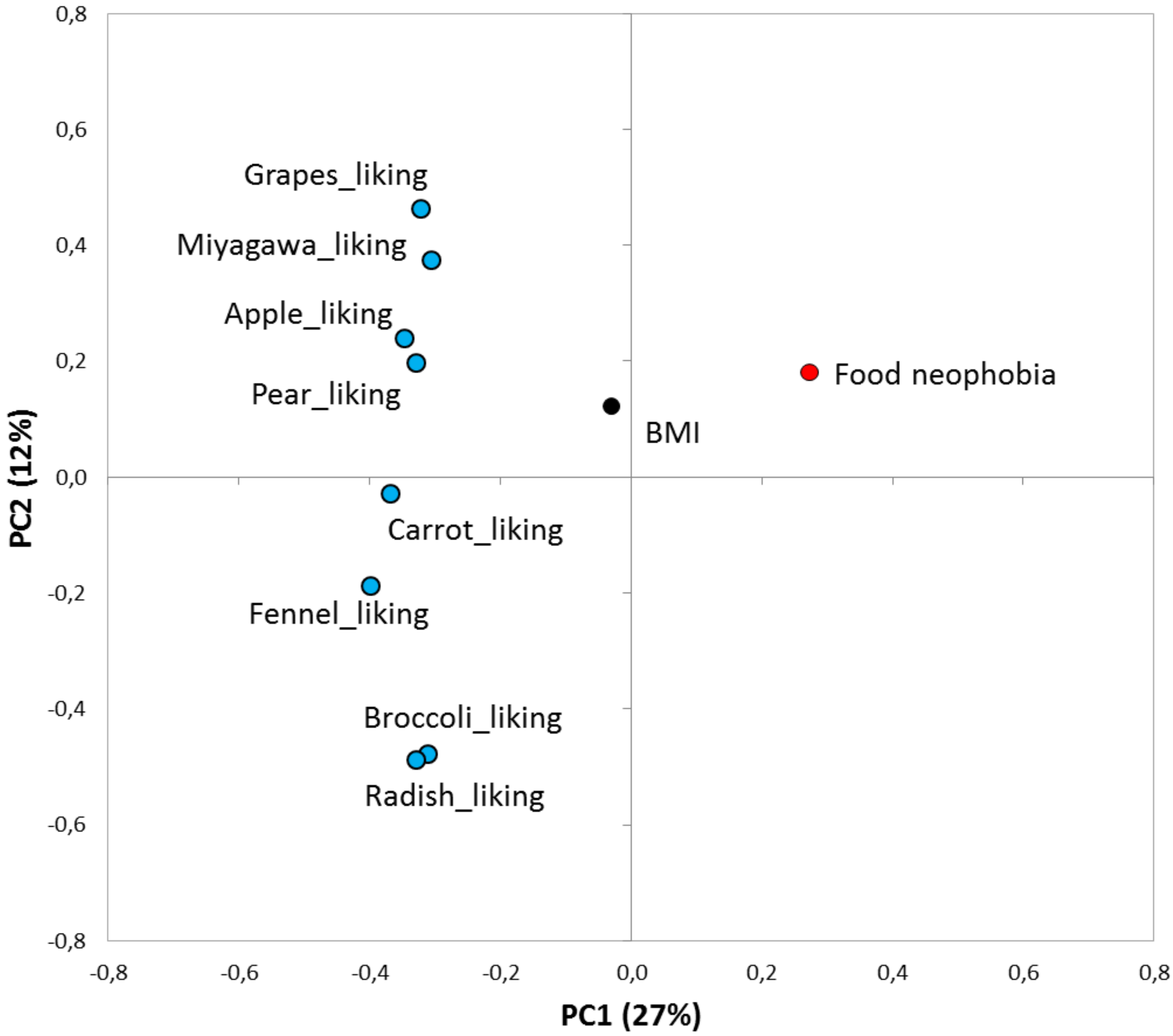
**Figures caption**

**Figure 1 (a-b).** PCA loadings plots (PC1 vs PC2, fig. 1a; PC2 vs PC3, fig. 1b) showing the relationship between food liking, food neophobia and BMI measurements.

**Figure 2.** Liking measurements of fruits and vegetables according to children's food neophobia level (*** significant for $p<0.001$, n.s. not significant).

**Figure 1 (a-b).**

a)


0,8
0,6
0,4
0,2
0,0
-0,2
-0,4
-0,6
-0,8
PC2 (12%)
Grapes_liking
Miyagawa_liking
Apple_liking
Pear_liking
BMI
Food neophobia
Carrot_liking
Fennel_liking
Broccoli_liking
Radish_liking
-0,8
-0,6
-0,4
-0,2
0,0
0,2
0,4
0,6
0,8
PC1 (27%)

b)

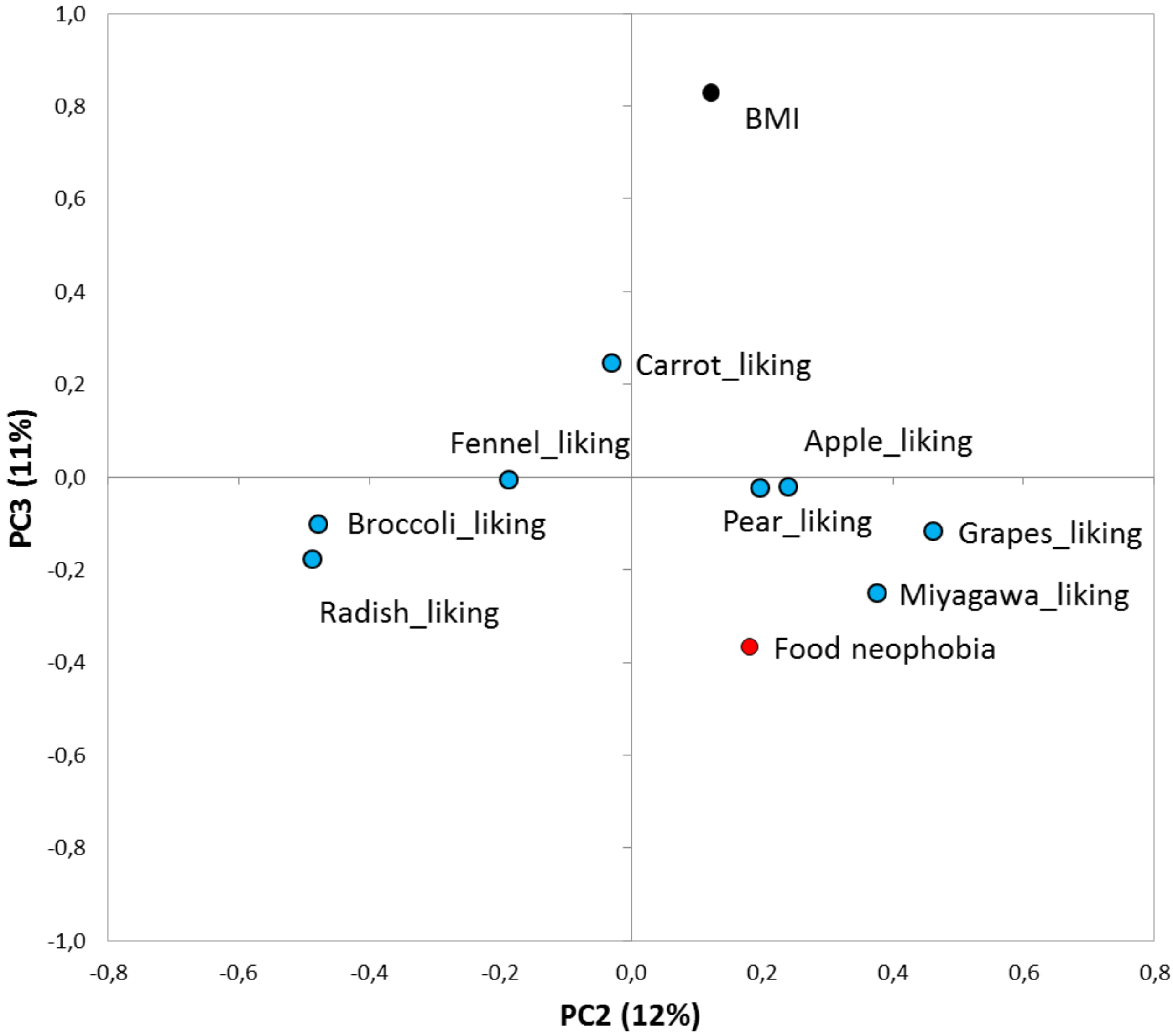
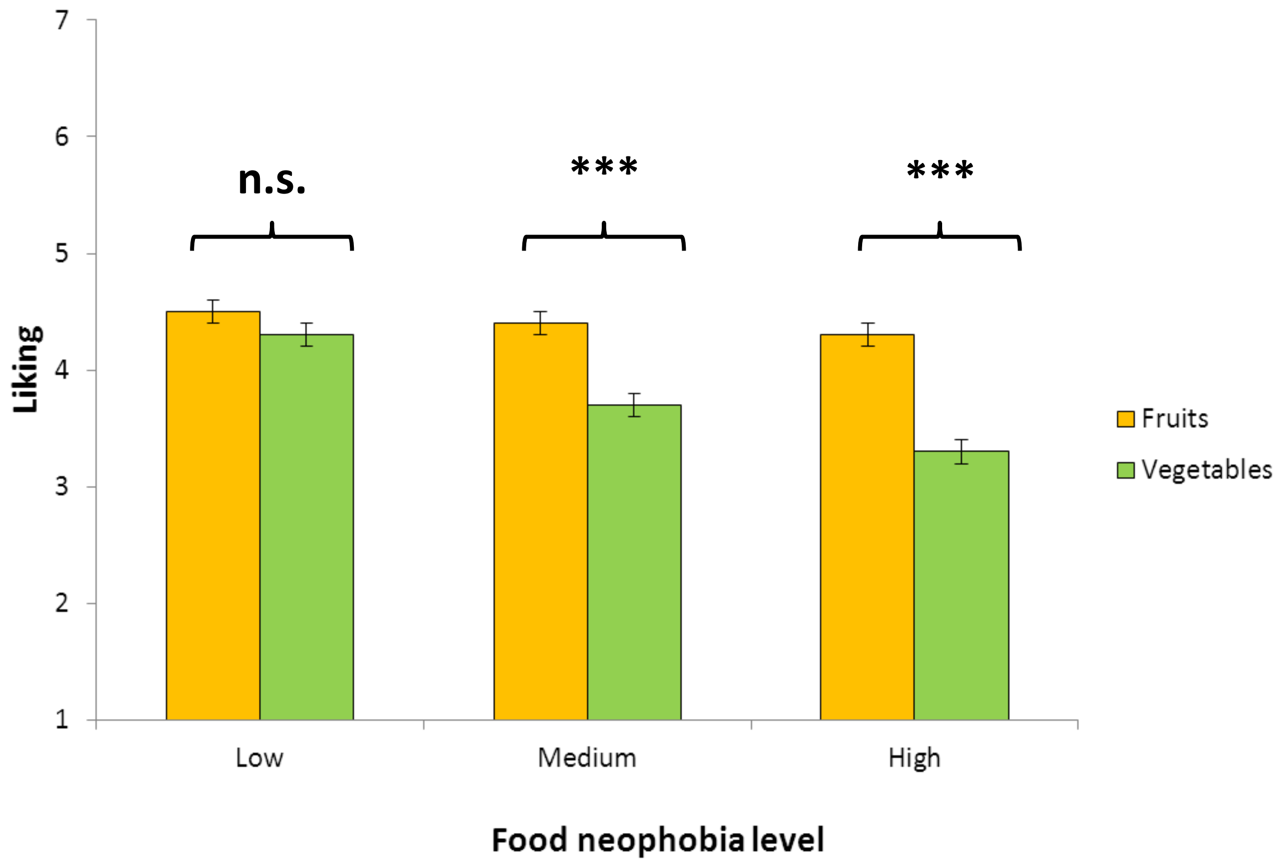

BMI
Carrot_liking
Fennel_liking
Apple_liking
Pear_liking
Broccoli_liking
Grapes_liking
Radish_liking
Miyagawa_liking
Food neophobia
PC3 (11%)
PC2 (12%)
1,0
0,8
0,6
0,4
0,2
0,0
-0,2
-0,4
-0,6
-0,8
-1,0
-0,8
-0,6
-0,4
-0,2
0,0
0,2
0,4
0,6
0,8

**Figure 2.**



7
6
5
4
3
2
1
Liking
n.s.
***
***
Low
Medium
High
Food neophobia level
Fruits
Vegetables