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Individual differences in texture preferences among European children: Development and validation of the Child Food Texture Preference Questionnaire (CFTPQ)

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ABSTRACT

Texture has an important role in children's acceptance and rejection of food. However, little is known about individual differences in texture preference. The aim of this study was to develop and validate a child-friendly tool to explore individual differences in texture preferences in school-aged children from six European countries (Austria, Finland, Italy, Spain, Sweden and United Kingdom). Six hundred and ten children aged 9–12 years and their parents participated in a cross-sectional study. Children completed the Child Food Texture Preference Questionnaire (CFTPQ) and a Food Neophobia Scale (FNS). The CFTPQ consisted in asking children to choose the preferred item within 17 pairs of pictures of food varying in texture (hard *vs.* soft or smooth *vs.* lumpy). Children also evaluated all food items for familiarity. Parents completed the CFTPQ regarding their preferred items, a food frequency questionnaire for their child, and provided background information. For a subset of children, a re-test was done for the CFTPQ and FNS to assess reliability. The results showed that the tool was child-friendly, had high test-retest reliability, and identified country-related differences as well as segments of children with different texture preferences (hard- *vs.* soft-likers). These segments differed in consumption frequency of healthy foods, and in food neophobia.

1. Introduction

The importance of individual differences in food perception, liking and choice and the consequences on human health are well recognized. One of the most studied source of individual differences in sensory perception is the ability to perceive bitter compounds (i.e. PROP taster status), which has been associated with alcohol misuse and abuse (Duffy et al., 2004), increased Body Mass Index (Proserpio, Laureati, Invitti, & Pagliarini, 2018) and reduced intake of vegetables (Hayes, Feeney, & Allen, 2013, Sandell et al., 2014). Phenotypic variation in the sense of smell is also well documented and associated with detection and disliking of a range of plant foods (Hayes et al., 2013).

Individual differences in texture perception and the implication on food appreciation are less explored. It is evident that individuals vary in the way they process food in their mouth, which results in differences in texture preferences (Jeltema, Beckley, & Vahalik, 2015, 2016). Variation in oral viscosity perception has been associated with levels of salivary alpha amylase. The greater the enzyme concentration in saliva, the faster the glucose monomers bonds in starch are broken, with consequences on the perception of oral viscosity of starchy food (Mandel, Peyrot des Gachons, Plank, Alarcon, & Breslin, 2010). Variation in salivary protein content has also been shown to affect the

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perceived astringency and liking of apple, grape and carrot juices containing added tannic acid (Dinnella, Recchia, Tuorila, & Monteleone, 2011).

Texture is a complex sensory property, which encompasses many sensory dimensions ranging from tactile to visual and auditory sensations. Texture has been referred to as the 'forgotten attribute', because for many years it received little attention, especially compared with flavor (Guinard & Mazzucchelli, 1996). Nowadays, it is well known that texture is a driver of likes and dislikes for many foods (Szczesniak, 2002). Food preference and acceptance, in turn, have a great impact on consumers' nutritional status and on food manufacturers incomes (Guinard & Mazzucchelli, 1996).

Texture is especially important for children, because its perception and preference change with age, in line with developments of the mouth muscles, jaw and teeth as well as innervation of taste buds (Lukasewycz & Mennella, 2012; Rose, Laing, & Hutchinson, 2004; Szczesniak, 1972; Zeinstra, Koelen, Kok, & de Graaf, 2010). Moreover, children usually reject textures that are difficult to process in the mouth (Szczesniak, 2002) and prefer soft and uniform food compared to lumpy or granular food (Laureati et al., 2017; Werthmann et al., 2015; Zeinstra et al., 2010). The importance of texture in children's rejection of certain foods is also underlined by the fact that tactile sensitivity is associated with food neophobia and pickiness, which are both high during childhood (Coulthard & Blissett, 2009).

Recently, in an attempt to explore differences in texture perception and preferences, Jeltema et al. (2015, 2016) developed and validated a tool to segment adult individuals in Crunchers, Chewers, Suckers and Smooshers, according to their mouth behavior. Crunchers and Chewers, are those who like to use their teeth to break down foods, with Crunchers preferring foods that break upon biting and Chewers preferring foods that can be chewed longer and do not fracture on biting. Suckers and Smooshers prefer to manipulate food between the tongue and palate with the main difference between the two groups being the hardness of preferred foods. Suckers like hard foods that can be sucked on for a long time, while Smooshers prefer soft foods. These different mouth behaviors have been shown to be predictive of food preferences and choices (Jeltema et al., 2015). However, currently there are no child-friendly tools available to categorize young consumers based on their texture preference. The need of developing new methods to segment children according to their texture-liker status is even more striking as texture perception has been reported to be highly influential in modulating food consumption. Interestingly, recent literature reported a relationship between texture perception, eating rate and energy intake. Children who eat faster have a higher energy intake, and this was associated with increased BMI z-score and adiposity (Fogel et al., 2017). Moreover, it has been shown that modulating food texture from thinner to thicker can significantly reduce eating rate and energy intake (McCrickerd, Lim, Leong, Chia, & Forde, 2017), indicating that texture properties of food and how they are perceived can greatly influence our eating behavior and consequently our health.

Therefore, the aim of the present study was to develop and validate a child-friendly tool to investigate texture preferences in school-aged children from different European countries and to explore, with this new tool, the association between children texture-liker status, background variables (i.e., children's dental status, food neophobia, parental texture preferences) and food frequency consumption of healthy foods.

This study is part of a larger project carried out by the European Sensory Science Society, which aims to deepen the knowledge about the mechanisms underlying texture perception and preference in children.

2. Material and methods

2.1. Participants

Six hundred and ten children aged 9–12 years and their parents participated in a cross-sectional study. They were recruited via primary schools in six European countries (Austria, Finland, Italy, Spain, Sweden and United Kingdom). This age range was chosen to have a relatively homogeneous group as these children have sufficient cognitive skills to understand most sensory tests and have sufficient reading skills to complete simple questionnaires on their own (Guinard, 2001; Laureati, Pagliarini, Gallina Toschi, & Monteleone, 2015). Parents were informed about the procedures and were asked to sign an informed consent when they agreed on participation. Invited children were informed about the test in writing as well as orally and gave verbal consent. Children without a signed informed consent or declining participation verbally were excluded from the study. The study protocol was approved by the Ethical Committees of each country.

2.2. Experimental procedures

Questionnaires and procedures for both children and parents were originally developed in English and reviewed by a native English speaker, and then translated in every language by two independent native speakers. The two translated versions were compared to identify differences and reach consensus for an updated version. In order to maximize consistency across countries, experimenters were instructed not to deviate from the protocol instructions.

2.2.1. Development of the Child Food Texture Preference Questionnaire (CFTPQ)

In order to assess children's texture preferences, a Child-friendly Food Texture Preference Questionnaire (CFTPQ) was developed. Attention was put in identifying questionnaire and item formats suitable for primary school children. Moreover, according to the work of Lukasewycz and Mennella (2012), pictures of pairs of foods were chosen that would fit the European context (i.e. would be familiar to most children in the participating European countries). Foods within a pair were as similar as possible regarding taste, and differed mainly in texture. Texture differences were represented primarily by hard *versus* soft foods (e.g. hard candy *vs*. gummy candy) but also by particulate *versus* smooth foods (e.g. yoghurt with fruit pieces *vs*. yoghurt without fruit pieces). For simplicity, in the rest of the text, texture differences will be referred to as Hard *vs*. Soft. The questionnaire was thus developed as a series of paired comparison tests, which have been reported to be a cognitively appropriate methodology for children aged 9–12 years (Kimmel, Sigman-Grant, & Guinard, 1994).

A preliminary version of the CFTPQ consisted of 21 food pairs. Clear and recognizable pictures were selected for each food product to make it specific for the children (Schaffer, 2003). Besides the picture, the product designation was also written in words (e.g. "yoghurt with fruit pieces"). This preliminary questionnaire was pre-tested among 66 children (36 girls, 55%) aged 8–11 years in four countries (Austria, n = 11; Italy, n = 24; Sweden, n = 14; UK, n = 17) to check familiarity of the products and representativeness of the pictures with the question "Have you ever tasted this food?". Products that were familiar to < 70% of the children in more than one country, were excluded from the questionnaire (four pairs in total: 1. Hard cheese *vs*. Spreadable cheese; 2. Cheese cubes *vs*. Spreadable cheese; 3. Raw red pepper *vs*. Cooked red pepper; 4. Peanut *vs*. Peanut butter). Attention was also paid to items that were familiar to less than 80% of the pretest children. In this case, the images and/or descriptions of the items were replaced or modified to achieve higher recognition and familiarity (e.g. in English, the term "sorbet" was modified to "slushy"). The pretest was carried out in four out of six countries for practical reasons, but in the countries that were not included in the pretest, the images were thoroughly discussed by the investigators to control their suitability. The final questionnaire consisted of 17 pairs of foods (see Appendix A1 and A2).

To improve comparability of the data collected in different cultures (Ares, 2018), procedures, experimental design and instructions to children and parents were the same in all countries and all tests and

retests were carried out within a three-month period in the spring of 2018.

2.2.2. Questionnaires completed by children

Children completed the questionnaires at school or a nearby facility using tablets or computers. This choice was made in an attempt to create a game-like situation, thus keeping pupils' attention high. Since consumer testing with children requires a specifically designed introduction to the methodologies and more extensive training (Kimmel et al., 1994), the research teams visited the schools and carefully explained the procedures to the children. Children were tested by class or in smaller groups depending on the availability of tablets/computers. First, the children indicated their age and gender, and then completed the CFTPQ. The order of presentation of pictures of food pairs and of the two foods within a pair, were both randomized across subjects. When the first pair of food pictures was shown, the children were asked to indicate the item they preferred: *"Which product do you prefer?"* (forced choice answer). When this question was answered for all 17 pairs, the 34 food pictures were shown again individually, but now the children had to indicate whether they were familiar with the food products: *"Have you ever tasted this product?",* with answer categories yes or no. Subsequently, the children completed a child-friendly Food Neophobia Scale (Laureati, Bergamaschi, & Pagliarini, 2015); they scored 8 items on a 5-point facial scale ranging from 'very false' to 'very true'.

A subsample of children (N = 65; 54% boys; Italy: n = 22, Sweden: n = 21 and UK: n = 22) was re-tested within a time frame of approximately two months. They were asked to complete the ICFNS following the same procedures as with the first test.

2.2.3. Parental questionnaire

The parents of the participating children were invited to complete an online questionnaire to obtain socio-demographic, eating habits of children and complementary information about their child and themselves. One adult per child (mother, father or other responsible caregiver) could answer at the discretion of the family. The child's date of birth, gender, weight and height (self-reported), whether the child completed the teeth changing phase (yes/no), whether the child was wearing a brace (yes/no), and - if yes - whether the brace was worn during meal times (yes/no), the age of introducing semi-solid and solid foods (before the age of 4 months, between 4 and 6 months, between 7 and 9 months, later than 9 months, I don't know/I don't remember at all), and the child's country of birth were included. Parents reported on their own age, gender, their perceived socio-economic situation on a 7-point scale ("1 = difficult", "4 = moderate" and "7 = well-off", Almli, Verbeke, Vanhonacker, Næs, & Hersleth, 2011), and the area they live in (large city/medium town/small town or rural area).

Parents also completed the CFTPQ but they only indicated for each of the 17 pairs of food pictures which of the two products they preferred without answering the question on familiarity as it was supposed that all the food items would have been well known by adults.

Finally, parents completed a food consumption frequency questionnaire, focused on the intake of refined *vs.* whole grain products and fruit and vegetables (see Appendix A3), which was based on the work of Hedrick, Comber, Estabrooks, Savla, and Davy (2010). For 17 food categories, parents indicated how often their child had eaten the food products in that category during the last month. Answering options were: less than once a month or never, 1–3 times a month, 1–3 times a week, 4–6 times a week, once a day, multiple times a day along with the option 'I don't know for my child'. For each category, example pictures were given to make it more attractive and specific for the parents. For every category, product examples were also given in words; these were adapted to the habits of a country (i.e. if a particular product was very uncommon in one country, this example product would be left out in the questionnaire for that country).

2.3. Data analysis

The SAS/STAT statistical software package version 9.3.1 (SAS Institute Inc., Cary, USA) was used for the data analysis. Effects showing a *p*-value of 0.05 or lower were considered significant.

2.3.1. Calculation of the CFTPQ index

For each child, an individual CFTPQ index was calculated. When the hard/particulate version of a food pair was preferred, a score of 2 was given. When children preferred the soft/smooth version of a food pair, they received a score of 1 for that pair. Only food pairs wherein both of the items were familiar to the child (i.e. had been tasted before) were used for the CFTQP index calculation for that child. Children with < 8 valid pairs (which is approximately 50% of the total pairs) were removed from the calculation. Thereby, 40 children were excluded (6.6% of the total sample). On the remaining 570 children, the scores (either 1 or 2) for the valid pairs were summed and divided by the total number of valid pairs. Thus, each participant could theoretically get a score ranged from 8 to 34. To make the score more discriminative and easier to interpret, the CFTPQ index was calculated by the following formula:

$$CFTPQ\ index = \left[\left(\frac{Sum\ of\ the\ scores\ of\ the\ valid\ pairs}{Total\ number\ of\ valid\ pairs}\right) - 1\right] * 100$$

This resulted in a CFTPQ index ranged from 0 to 100, with higher scores representing a preference for the harder foods category. A similar calculation was done for the parents of the children considering all of the 17 food pairs as valid.

The frequency distribution of the CFTPQ index was calculated over all countries and by country. Children were grouped according to their texture-liker status in Soft- and Hard-likers considering, respectively, the 25th and 75th percentiles of the overall distribution as cut-off (see Section 3.3.1 for details).

The correlation between test and retest assessment as well as parental and child CFTPQ indices was investigated through Pearson's correlation. The effect of age, gender and country of origin was explored through ANOVA considering gender, age (categorical variable: 9–10 years old children, n = 329; 11–12 years old children, n = 241), country and their 2-way interactions as factors and CFTPQ index as dependent variable. The effect of dental status on CFTPQ index was investigated through ANOVAs considering either completion of teeth-change phase (Yes/No) or dental brace (Yes/No), country and their interaction as factors and CFTPQ as dependent variable. The effect of weaning practices on CFTPQ index was investigated through ANOVAs considering either introduction period of semi-solids (< 4 months, 4–6 months, 7–9 months or > 9 months) or solids (< 4 months, 4–6 months, 7–9 months or > 9 months), country and their interaction as factors and CFTPQ as dependent variable.

When ANOVAs showed a significant effect ($p < 0.05$), *post-hoc* comparison using the Bonferroni test adjusted for multiple comparison was used.

2.3.2. Food neophobia

The answers to the 8 items of the FNS were summed up (after reversing scores of the four neophilic items) to have a food neophobia score ranged from 8 to 40. A higher score indicates a higher level of food neophobia.

The reliability of the FNS was investigated by calculating internal consistency (Cronbach's α), temporal stability by test–retest evaluation and external validity. The results of the reliability of the FNS were satisfactory for almost all countries and are reported in another publication (Laureati et al., submitted; Proserpio et al., submitted for publication).

The frequency distribution of FN scores was calculated over all countries and by country. According to Shapiro Wilk test, the distributions were always normal. The association between the CFTPQ

index and food neophobia was investigated through Pearson's correlation.

2.3.3. Food frequency consumption

The frequency consumption of the food items was converted to Daily Frequency Equivalents (DFE) calculated by allocating proportional values to the original frequency categories with reference to a base value of 1.0, equivalent to once a day (Cattaneo, Riso, Laureati, Gargari, & Pagliarini, 2019; Daly, Parsons, Wood, Gill, & Taylor, 2011; Ireland et al., 1994; Jayasinghe et al., 2017). The scores were calculated as follows: DFE of 0 = less than once a month or never, DFE of 0.07 = 1–3 times a month, DFE of 0.28 = 1–3 times a week, DFE of 0.71 = 4–6 times a week, DFE of 1 = once a day, DFE of 2.5 = multiple times a day. The association between the CFTPQ index and food frequency consumption was investigated through Pearson's correlation.

3. Results

The final sample – for which a CFTPQ could be calculated – consisted of 570 children. The minimum number of children involved by country was ≥70.

3.1. Characteristics of the population

3.1.1. Socio-demographics

The characteristics of the children and their families are reported in Table 1.

Children were balanced for gender across countries, with the exception of Finland, which had a higher proportion of girls (81.4%) than boys due to a misbalance in the class compositions at the school.

On average, 62% (n = 357) of the parents completed the parental questionnaire. Occasionally, some parent did not answer specific questions (e.g. economic status, parental age) thus, the parental responses varied from N = 345 to N = 357. Mothers (81.4% of the parental respondents) more frequently completed the questionnaire than fathers. The perceived economic status was on average moderate or high and most of the families lived in a medium or large city.

3.1.2. Weaning practices and dental status

Looking at Table 1, the percentage of children having completed the teeth-changing phase was similar across countries and ranged from 18.7 to 34.4%, with the exception of Finland (81.8%). Only a minority of children was wearing a dental brace (range: 0–22%).

Most of the parents introduced semi-solid foods into their child's diet at 4–6 months (62.1%), 22.2% at 7–9 months, 8.4% did so before 4 months, and 1.7% after 9 months (the remaining 5.6% of the parents did not remember) (data not shown). Concerning the introduction of solid foods into the child's diet, 44% of parents started at 7–9 months, 28% later than 9 months, 17.1% at 4–6 months and the 0.6% before 4 months (data not shown). The remaining 10.3% of parents did not remember. The variation across countries in the introduction of solids and semi-solids in the child's diet was of minimal size.

Table 2
Mean value (standard error of mean, SEM) and significance of the difference of the CFTPQ index in the test–retest evaluation.

Country	Test	Retest	*p*-value
Austria (n = 30)	56.2 (2.1)	58.0 (2.4)	0.40
Italy (n = 18)	51.9 (3.0)	47.0 (3.9)	0.09
Sweden (n = 20)	53.0 (3.5)	49.6 (3.9)	0.26
UK (n = 22)	48.9 (3.1)	49.0 (3.4)	0.59
Total (n = 90)	52.8 (1.4)	51.7 (1.7)	0.53

3.2. Test retest assessment of the CFTPQ

Pearson's correlation showed a significant positive correlation of the two measurements both when calculated over all countries (n = 90, r = 0.70, $p < 0.001$) and by country (Austria: n = 30, r = 0.54, $p < 0.01$; Italy: n = 18, r = 0.73, $p < 0.001$; Sweden: n = 20, r = 0.69, $p < 0.001$; UK: n = 22, r = 0.78, $p < 0.001$). Paired t-tests were also applied over all countries and by country with no significant differences between the first and the second CFTPQ measurement in all cases (Table 2). These results indicate a good reliability between the measurements.

3.3. Association between CFTPQ index and background variables

3.3.1. Individual differences in texture preferences among countries

The distribution of the CFTPQ index was calculated over all countries and by country (Fig. 1a–g). According to Shapiro-Wilk test, the distributions were always normal (for all countries $W > 0.98$ with p-values ranged from 0.14 to 0.59). The global score distribution (Fig. 1g) had a skewness of 0.05, a kurtosis of −0.40, a mean score of 49.7 (n = 570, SD = 15.8, range = 7.7–91.7) and a median score of 50.

Looking at the distributions of the various countries, rather large differences emerged. Northern Europe countries such as Finland and Sweden (Fig. 1b and e, respectively) showed a lower percentage of Soft-Likers (10% and 20.3%, respectively), i.e., children with CFTPQ score below the 25th percentile of the total distribution, than Hard-Likers (34.3% and 37.3%, respectively), i.e., children with CFTPQ score above the 75th percentile of the total distribution. On the contrary, countries

Table 1
Characteristics of the participants.

Participant	Variable	Austria	Finland	Italy	Spain	Sweden	UK	Total
Child	N	75	70	82	100	118	125	570
	Gender (% girls)	46.7	81.4	48.8	54.0	44.1	52.0	53.2
	Age (mean; SD; range)	10.1; 0.8 (9–11)	10.6; 0.9 (9–12)	10.1; 0.3 (10–11)	10.5; 1.0 (9–12)	10.3; 0.5 (10–11)	10.5; 0.5 (9–11)	10.4; 0.7 (9–12)
	Completion teeth change phase (% yes)	24.3	81.8	22.0	28.8	18.7	34.4	31.7
	Dental brace (% yes)	18.9	12.1	22.0	10.0	5.3	0	9.0
Parent	N	38	33	41	80	75	90	357
	Gender (% females)	80.6	93.8	80.5	78.8	76.0	84.4	81.4
	Age (mean; SD; range)	41.8; 5.0 (30–51)	42.1; 5.7 (33–55)	45.0; 5.1 (29–59)	45.8; 4.2 (36–60)	42.8; 5.2 (29–56)	41.9; 6.2 (31–63)	43.3; 5.5 (29–63)
	Perceived economic status[1] (mean; SD)	4.4; 1.0	4.4; 1.1	5.2; 1.2	5.1; 1.3	5.6; 1.4	4.7; 1.3	5.0; 1.3
	Urbanization (% medium or large city)	94.3	96.9	100	98.7	68	100	92.1

[1] Measured on a 7-point scale: 1 = difficult, 4 = moderate, 7 = well-off.

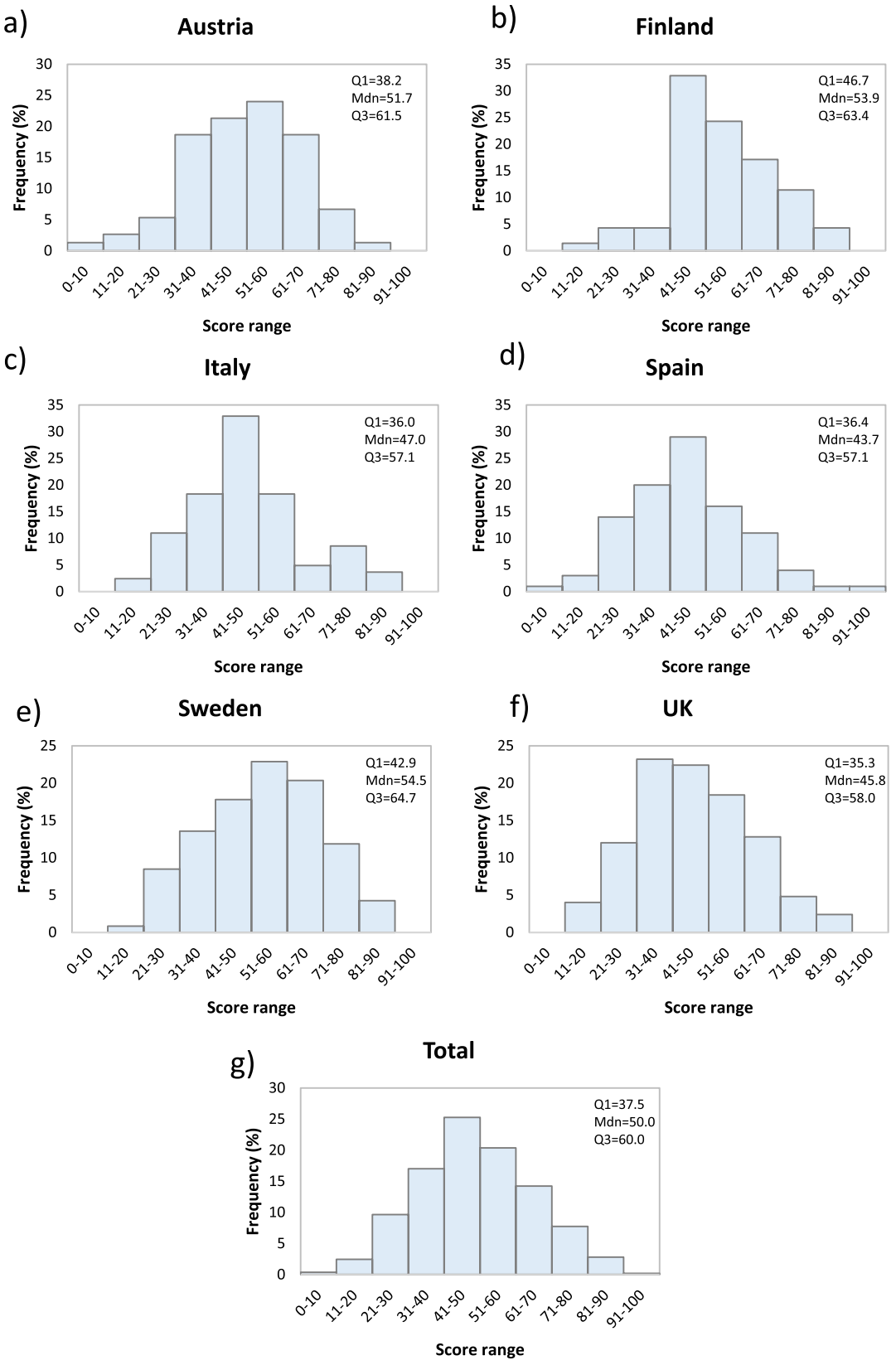

Fig. 1. (a–g). Total and by country CFTPQ scores distribution (Q1 = 25th percentile, Mdn = median, Q3 = 75th percentile).

from Southern Europe, like Italy and Spain, but also UK (Fig. 1c, d and f, respectively), showed a contrary trend with a low proportion of Hard-liker (Italy = 18.3%, Spain = 19.0%, UK = 23.2%) and more Soft-liker children (Italy = 26.8%, Spain = 29.0%, UK = 36%). Austria (soft-likers = 24.0%, hard-likers = 29.5%, Fig. 1a) showed a distribution similar to the total distribution (soft-likers = 25.4%, hard-likers = 26.8%, Fig. 1g).

This pattern was confirmed by ANOVA, which revealed a significant

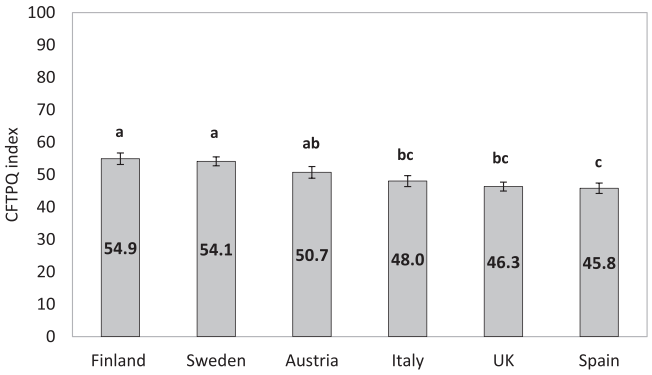

Fig. 2. Mean CFTPQ index by country. Different letters indicate significant differences ($p < 0.0001$) according to ANOVA.

effect of the main factor country ($F_{5,551} = 5.72$, $p < 0.0001$) on the CFTPQ index. The mean values of the CFTPQ index by country are reported in Fig. 2. Finland and Sweden had the highest CFTPQ scores with no significant difference between the two countries, and were significantly different from Italy, UK and Spain, which had the lowest mean score. Austria had an intermediate score comparable to Finland, Sweden and Italy.

3.3.2. Age and gender effects on texture preference

ANOVA results showed no effect of age ($F_{(1,551)} = 0.03$; $p = 0.86$), gender ($F_{(1,551)} = 0.63$; $p = 0.43$) or their interaction with country (Country*age: $F_{(5,551)} = 2.10$, $p = 0.06$; Country*gender: $F_{(5,551)} = 1.23$, $p = 0.30$) when performed on all countries. The same outcome was obtained when Finland, which had an unbalanced ratio girls:boys, was omitted from the analysis.

3.3.3. Weaning practices and dental status effects on texture preference

ANOVA results showed no effect of the introduction of solids ($F_{(3,316)} = 1.00$; $p = 0.39$) and semi-solids ($F_{(3,302)} = 0.65$; $p = 0.58$) as well as no effect of completion of the teeth-changing phase ($F_{(1,344)} = 1.73$; $p = 0.19$) and usage of dental braces ($F_{(1,345)} = 0.15$; $p = 0.70$) on the CFTPQ index, indicating that texture preference, as measured with our tool, was not influenced by weaning practices and dental status. Interaction effects were also not significant.

3.3.4. Children and parental texture preferences

Over all countries, the correlation between children's and parental CFTPQ index was low but positive and significant ($n = 353$, $r = 0.19$, $p < 0.001$). Parental index ($M = 62.6$) was considerably and significantly higher ($F_{(1,688)} = 106.22$, $p < 0.0001$) than child's index ($M = 50.4$), indicating a general preference for harder textures in the adults compared their children. This trend was observed for all tested countries. The correlation of the indices by country was significant for Austria ($n = 35$, $r = 0.36$, $p < 0.05$) and UK ($n = 89$, $r = 0.30$, $p < 0.01$).

3.3.5. Association between CFTPQ index and food neophobia

FNS scores across all children varied from 8 to 37, with a mean score of 20.7 ($SD = 5.3$). Total FNS internal consistency was 0.72 ($n = 570$), comparable to the suggested value of 0.70 given by Nunnally and Bernstein (1988). When calculated by country, internal consistency was satisfactory for all countries except Austria ($\alpha = 0.32$), which was omitted from further analysis. The total FNS internal consistency - when omitting Austria - increased to 0.76 ($n = 495$).

The correlation between food neophobia and the CFTPQ index was modestly negative and significant ($n = 495$, $r = -0.12$, $p < 0.01$), indicating that neophobic children tended to prefer softer textures. Correlation analysis performed by country revealed that this relationship was driven by Spain ($n = 100$, $r = -0.30$, $p < 0.01$) and the UK ($n = 124$, $r = -0.25$, $p < 0.01$).

3.3.6. Association between CFTPQ index and food frequency consumption

There was a significant and positive correlation between CFTPQ index and frequency of consumption of vegetables ($n = 328$, $r = 0.11$, $p < 0.05$), indicating that children whit higher CFTPQ scores (i.e., Hard-likers) eat vegetables more frequently than children with lower CFTPQ scores (i.e., Soft-likers). Additionally, there were two significant and negative correlations between CFTPQ index and consumption, where Soft-likers consumed white bread ($n = 327$, $r = -0.13$, $p < 0.05$), and legumes ($= 325$, $r = -0.15$, $p < 0.01$), more frequently than Hard-likers. Correlation analysis performed by country, showed a significant and positive correlation for fresh fruits ($n = 77$, $r = 0.32$, $p = 0.0043$) in Spain meaning that, in this country, Hard-liker children more frequently eat fresh fruits than Soft-liker children.

4. Discussion

The main aim of the present study was to develop a tool to explore texture preferences among school-aged children in different European countries. The CFTPQ method developed in this study was child-friendly, showed high test–retest reliability, allowed us to reveal country-related differences and was able to distinguish segments of children with different texture preferences. These segments differed in consumption frequency of healthy food and in food neophobia.

4.1. The CFTPQ is a child-friendly, cross-nationally valid and reliable tool to explore food texture preferences

The CFTPQ was developed in order to be an easy tool to be self-administered to school-aged children. When conducting sensory and consumer research with pediatric populations, it is important to keep in mind that this consumer target has specific needs, as children have limited cognitive and motor skills and reduced attention span (Guinard, 2001; Laureati & Pagliarini, 2018). In the present study, children were in a relatively homogeneous age range (i.e. 9–12 years), and old enough to be able to understand most sensory tests and to complete simple questionnaires in autonomy (Laureati, Pagliarini et al., 2015). No age-related effects were observed in the CFTPQ index and we could observe that our younger participants handled the test as comfortably as our elder participants. This is coherent with the fact that, at this age, most children have already developed masticatory and swallowing skills so that they can manage complex textures in the mouth (Szczesniak, 1972).

In the present study, attention was also devoted to the context in which the tool was administered. In every country, the CFTPQ was presented in a real-world and familiar setting, i.e. the school. The use of tablets was also a successful choice as children were very at ease with these devices, which contributed to make the task engaging and to keep children's attention high. Moreover, tablets contributed to reduce the time of test completion, which was approximately 10 min for the CFTPQ.

The CFTPQ was developed with the goal to be culturally appropriate for the different countries involved in the study. In order to achieve both cultural appropriateness and child-friendliness, the use of images combined with a brief designation of the item was chosen to present the food pairs. The use of non-verbal methods is reported to be a good way to overcome language differences (Ares, 2018). Achieving cross-cultural appropriateness was not an easy task as all the selected items had to be familiar to children in every nation. The familiarity of the items was ensured by only selecting foods that were familiar to the majority of the children in a pretest. This approach was satisfactory since only 7% of the children were excluded from the calculation of the CFTPQ index due to low familiarity of the items.

Currently, there are no tools developed for children to categorize them according to their texture preference. The only tool available is

the one developed by Jeltema et al. (2015) for adults. However, this tool does not use pairs for each food item but, instead, uses different food categories (e.g. ice chips, crispy vegetables and granola are some of the foods used to define Crunchers) to represent different mouth behaviors. In this context, the forced choice pair method of the CFTPQ may ensure that children choices are based on texture and not on food categories that may vary considerably for flavor and other sensory properties. However, in this study, our tool was not compared to prior texture preference scales for adults. Further research is recommended to check if the CFTPQ is able to capture similar constructs to adult scales such as the recent tool proposed by Jeltema et al. (2015).

4.2. Association between texture preferences and background variables

Previous research has shown that children prefer food that can be easily manipulated in the mouth (Szczesniak, 1972). More specifically, it is common opinion that soft, smooth foods are preferred to hard, spongy and lumpy foods (Guinard & Mazzucchelli, 1996; Laureati et al., 2017; Werthmann et al., 2015). In this context, the CFTPQ revealed that this trend is not universal and children may vary considerably in their texture preference. The limit of considering people as a whole, comparable group (i.e. the fallacy of consumers' uniformity) has been highlighted by Köster (2003) and seems especially relevant for young consumers who are still in a developmental phase that may influence their food preference and behavior.

One of the most interesting results of the present study is probably the different distribution of Soft- and Hard-likers across Europe. Cross-national differences in texture preferences have been highlighted in previous research in adult populations. For instance, in a review by Guinard and Mazzucchelli (1996), it was reported that for North Americans, the most desirable textural characteristics are crispness, crunchiness, tenderness, juiciness and firmness, whereas Japanese like crispy, crunchy, hard, soft and sticky foods, and they may be more sensitive to different degrees of crispness than North Americans. These differences in preference and perception are also reflected in country-related differences in terminology as Japanese have a significantly more developed vocabulary for describing crispness and crunchiness in foods than that in American English. It is not easy to formulate a hypothesis to explain this outcome in young populations as not previous research has been done to compare texture preferences in children from different countries. In our study, the fact that Northern countries, such as Finland and Sweden, had a higher proportion of children with a tendency to prefer hard and particulate food than Southern countries (i.e., Italy and Spain) may be explained by differences in culinary habits and variation in food selection. Hard-likers had a lower consumption of legumes, which are commonly eaten cooked, and white bread, which usually has a soft and uniform texture. Both product categories are also more typically consumed in southern than in northern European countries. On the other hand, Hard-likers showed a higher consumption of vegetables, which may be related to country differences in the way vegetables are consumed (often raw in the north *vs.* often cooked in the south) or to the fact that Hard-liker children are predominantly characterized by neophilic attitudes toward food. In this context, further research is needed to better understand the interplay between perceptive, psychological and environmental factors underlying cross-cultural differences in texture perception and preferences.

The association between texture preference and food neophobia is another interesting outcome of the present study. Previous research has shown that tactile sensitivity was associated with a higher aversion to food textures in children aged 3–10 years (Smith, Roux, Naidoo, & Venter, 2005) and that texture and appearance could influence picky eating in children (Russell & Worsley, 2013). In this context, it should be highlighted that the CFTPQ index reflects not only a tendency to prefer hard but also lumpy food, so the outcome that more neophobic children are those who prefer soft and uniform food textures seems reasonable and in line with previous literature.

Although further studies are needed to confirm this hypothesis, Hard-likers seem to have a healthier eating behavior since they are generally less neophobic and consume more frequently vegetables, fresh fruits and legumes than Soft-likers. Recent evidence showed that food texture may be associated with human health in that modulating food texture could be used to reduce consumption's rate and, thus, the energy intake in adults (McCrickerd et al., 2017). In this context, it would be interesting to investigate if the Hard-likers are also those children who have a reduced speed of food consumption and a lower caloric intake.

Finally, results of the present study also suggest that preference for texture evolves over the lifespan. In line with previous research (Lukasewycz & Mennella, 2012), the parental index in our study was considerably higher than child's index, reflecting a progressive shift from childhood to adulthood towards a preference for harder and lumpier foods. Traditionally, flavor and taste are reported to be the main determinants of food acceptance in the adult population. Taste perception and preference differences between children and adults have been reported in previous studies (see Hoffman, Salgado, Dresler, Williams Faller, & Bartlett, 2016 for review), whereas limited information is available on texture differences (Lukasewycz & Mennella, 2012). Age-related differences in texture preferences are not surprising, considering that texture perception is a highly dynamic process. In fact, the physical properties of foods change continuously when they are manipulated in the mouth (Guinard & Mazzucchelli, 1996) and oral processing may vary considerably between adults and children. In this context, a better understanding of differences in texture perception and preference over the lifespan could be a key point for manufacturers to develop foods that meet the expectations of consumer targets with specific needs (i.e. children but also elderly people).

4.3. Strengths and limitations of the study

A strength of our study is that the CFTPQ tool was developed with input from, and tested in, various European countries. As such, it provides a relatively broad picture to the scarce literature about this topic. Although texture can be a major reason for food rejection, especially for children (Szczesniak, 2002), very little research has explored texture perception and its role on food preference (Zeinstra et al., 2010). However, we acknowledge the fact that our tool encompasses different dimensions of food texture, i.e. hardness/softness and presence/absence of particles, which can have a different impact on texture preference and background variables. Developing tools that measure different aspects of texture and mouthfeel sensations could provide more detailed information about oral processing and its impact on food preference, selection and, thus, health.

Another strength is that the tool enabled finding associations between the CFTPQ index and background variables, such as neophobic reactions and food consumption, in a reasonable direction and in line with previous studies, thus providing indication of the validity of the tool.

A limitation of the questionnaire is that the familiarity has been evaluated as a binary answer (yes/no) to the question "Have you already tasted this food?". Therefore, we cannot rule out that, although both items are familiar, one is more familiar than the other and that this higher familiarity has driven the choice of the item instead of a difference in texture. Another possible approach could be adding answer categories to the scale to have more fine-tuned answers (yes often, yes rarely, no) or to collect information from the parent on the consumption frequency of each food item in the questionnaire.

Moreover, the association between texture preference and food frequency consumption has been explored with a questionnaire focused on a limited range of food products (i.e. refined *vs.* wholegrain products). It would be interesting to develop a more specific food consumption frequency questionnaire including food with different or extreme textures.

Future research should not only consider variation between countries but also within a specific country taking into account differences in ethnicity, religion and/or dietary habits (e.g. Muslims, vegetarians). In this context, we suggest avoiding items representing meat products, or modifying the structure of the questionnaire by asking familiarity prior to preference in order to adapt the display of food pairs for each subject. Finally, despite in the present study the sample size was appropriate overall (approx. 600 children tested), we acknowledge the fact that the statistical power for some variables (e.g. background variables) was not optimal. Future studies should confirm and extend our findings.

5. Conclusion

This study successfully addressed the purpose of developing and validating a child-friendly tool, the CFTPQ, able to explore individual differences in texture preferences in European school-aged children. The tool was easily understood in all countries and showed proper internal and external validity. Considering the important role of texture in food appreciation, selection and behavior among the pediatric population, the tool can be used among European children to investigate their texture-liker status and, potentially, address food texture interventions to reduce neophobic reactions.

Moreover, since texture may be more important in younger children (< 8 years) compared to older children (Rose et al., 2004; Zeinstra, Koelen, Kok, & de Graaf, 2007), additional research is recommended to further validate the CFTPQ in children of different age groups and cultures. Finally, it could be interesting to investigate the association between texture-liker status and physiological measurements such as eating rate, emotional eating, texture responsiveness and nutritional status.

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Appendix A. Supplementary data

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