



A forced-choice pictographic method to measure food texture preferences among schoolchildren

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ABSTRACT

Methods for measuring food texture preferences in children are based on forced-choice questionnaires where children select their preferred texture within food pairs. However, the validity of these methods has not been well documented. This study aims to develop and validate a questionnaire based on pictographic drawings of 12 pairs of foods differing in hardness or particle content. Children aged 7 to 10 years ($n = 97$) completed the questionnaire. Three weeks later, a subgroup of these children ($n = 75$) performed a paired comparison preference test using actual food stimuli corresponding to 6 food pairs in the questionnaire and an acceptance test on two foods varying in the level of hardness (cheese) or particle content (yogurt). Another group of the children ($n = 21$) was retested with the questionnaire. The average probability of agreement between children's choices in the questionnaire and paired-preference test was 0.67, while the retesting was 0.83. In both assessments, the agreement probability was significantly above the chance level, and there was no significant effect of food pair, age or gender. The questionnaire results revealed differences in preferences for the two textural dimensions. Children showed a lack of a common pattern of hardness preference but a preference for foods without particles. Individual differences in particle preferences were related to food neophobia level, and liking of yogurt varying in the amount of added fruit pieces. The results demonstrated the validity and usefulness of the forced-choice pictographic method to study differences in children's texture preferences.

1. Introduction

Texture is a salient attribute that plays a key role in food acceptance in children. [Szczeniak \(1972\)](#) suggested that children have innate preferences for textures that are easy to control and manipulate in the mouth. Studies have investigated specific parameters of texture and their influences on food acceptability. Particulate ([Lukasewycz & Mennella, 2012](#); [Wardle & Cooke, 2008](#); [Werthmann et al., 2015](#)), gritty and tough ([Donadini et al., 2012](#); [Szczeniak, 1972](#)), and mushy and slimy ([Baxter et al., 1998](#); [Boquin et al., 2014](#); [Estay et al., 2019](#)) textures were reported as drivers for food rejections in children. The development of texture preferences in children is important for acquiring healthy eating habits. Food texture sensitivity in children has been associated with picky eating and lower food intake ([Ross et al., 2021](#)). Preferences for

soft and smooth textures are also associated with reduced consumption of vegetables in children ([Laureati et al., 2020](#)). However, there are limited tools available to assess food texture preferences in children comprehensively.

Existing methods for measuring texture preferences in children are based on forced-choice questionnaires. Children select their preferred foods within food pairs differing in textures (i.e., hard *versus* soft or lumpy *versus* smooth) ([Laureati et al., 2020](#); [Lukasewycz & Mennella, 2012](#)). These measures provided insight into inter-individual differences, such as the effect of gender, age, and cultural background on texture preferences. Relating the measure with other developmental aspects in children may also identify factors underpinning texture rejections, for instance, sensitivity towards food textures, oral tactile perceptions, food neophobia, and picky eating ([Appiani et al., 2020](#);

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Table 1
Participant characteristics.

	First grade	Third grade	Total
Number of children (n)	56	41	97
Age (mean)	7	9	8
Gender (girls / boys)	28 / 28	21 / 20	49 / 48

Cappellotto & Olsen, 2021; Lukasewycz & Mennella, 2012; Ross et al., 2021). In previous studies (Laureati et al., 2020; Lukasewycz & Mennella, 2012), preferences were quantified by counting the number of ‘hard’ foods selected over ‘soft’ foods or the number of ‘with particles’ foods selected over ‘no particles’ foods by each participant and calculated as a ratio or score. It was reported that children have a general preference for softer and non-particulate textures compared to adults. Recently, the Child Food Texture Preference Questionnaire (CFTPQ) identified segments of children with different texture preferences (i.e., hard- versus soft-likers) that varied in their consumption of healthy foods and levels of food neophobia (Laureati et al., 2020).

The CFTPQ developed by Laureati et al. (2020) assessed the test-retest reliability and found an association with behavioral measurements (i.e., food neophobia) in an expected direction that neophobic children tended to prefer smoother and softer textures. The result indicated the appropriateness of the questionnaire, however, no work has been reported on validating forced-choice questionnaires with actual food stimuli. Research on the reliability of hedonic measurement showed that for children, age-related changes in cognitive skills influence repeatability of their choice during experiments (Köster et al., 2003; Léon et al., 1999). Children could be inconsistent with their choice in the questionnaire and food tasting. Therefore, there is a need to update the existing methods to improve the validity. The criteria used to assess the validity of a forced-choice questionnaire could be to verify the ability of the measurement to predict children’s preferences measured with actual food stimuli within a short period. Moreover, evaluating children’s agreement in retesting the same questionnaire would indicate the repeatability of the measurement (DeVellis, 2017). Kildegaard et al. (2011) compared children’s visual food preferences measured in a picture-based conjoint layout with their actual choice with real products. Children performed an incomplete ranking of eight smoothies that varied in color, portion size, and the presence of fruit pieces. It was reported that 50.2 % of children chose the same product in the two choice tests, and there was an effect of food appearance factors on the consistency between visual and actual food choices. A high correlation was observed between choices of portion size and visible fruit between the two tests, but a low correlation between choices of color.

It is widely believed that presenting text with illustrations helps enhance children’s attention and facilitate their understanding of the information, e.g., the prevalence of illustrations in children’s storybooks or the use of representational pictures in textbooks to improve children’s comprehension and recall (Carney & Levin, 2002). The forced-choice methods developed by Laureati et al. (2020) and Lukasewycz & Mennella (2012) used photographs to present food pairs differing in textures. In contrast, pictographic drawings may allow a more general presentation of food concepts and recognition in children. For example, a drawing of sliced bread can be more versatile in communicating the concept of “bread in general” than a photo of “real, specific bread”.

The present study aims to assess a new forced-choice method to measure texture preferences in children. For this purpose, a questionnaire consisting of pictographic drawings of 12 food pairs was developed and completed by schoolchildren aged 7 to 10 years. The validity of the method was assessed by paired comparison preference and acceptance tests using actual food stimuli corresponding to the food pairs and retesting the questionnaire. Individual differences in texture preferences among children were also investigated.

2. Materials and methods

2.1. Participants

Children from the first and third grades (7 to 10 years) were recruited from elementary schools in Copenhagen, Denmark. Children’s participation in the study was voluntary, and their parents were thoroughly informed about the research. The parents gave written consent to their children’s participation and the use of data for research, and the invited children also gave verbal consent. A total of 109 children participated in the study, of which data from 97 children were included in the analysis. Data from 7 children were excluded because of lacking parental consent to use data for research. The children’s characteristics per grade is reported in Table 1. The study protocol was submitted to the Danish National Committee on Biomedical Research Ethics for review. It was concluded that further ethical approval of the study was not required (reference no.: 19071689).

2.2. Development of the pictographic questionnaire

The forced-choice pictographic questionnaire presented drawings and descriptions of 12 pairs of foods that varied in hardness (soft versus hard) and particle content (no-particles versus with-particles) (Table 2). Children had to choose their favorite food between the two. Thus, the questionnaire was developed as a series of paired comparison tests, which is suitable for testing with children over 2 years (Guinard, 2000). The textural differences within food pairs aligned with the common textural descriptor classes – mechanical and geometrical properties of foods (Szczesniak, 1963). In the initial phase of questionnaire development, attention was put on generating appropriate food pairs that met the following criteria:







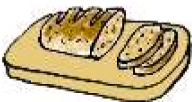

















1. Items within food pairs were contrasted in the textural properties. Differences in other sensory properties (i.e., flavor and taste) should be minimal.
2. The food items should often be consumed by schoolchildren such that children would be familiar with the textures in pairs.
3. The ‘hard’ or the ‘with-particles’ items represented a range of hardness/particle sizes available in foods.
4. The food pairs represented a balanced variety of foods for daily consumption, e.g., fruit and vegetables, dairy, cereals, and sweets.

The pictographic drawings were specifically developed for the questionnaire by a children’s book illustrator. Three principles were used in the design process to highlight the textural differences in foods: (1) good visual representation, (2) similar portion size, and (3) similar food presentation. Food items should be easily depicted by the viewers. Foods within a pair were displayed in similar portions, e.g., an equal number of vegetable pieces on the plate or a similar amount of spread on bread. The same principle applied to the choice of plates, utensils, or spread jars included in the drawings. These measures prevented children from making food choices based on differences in portion size or presentation style.

2.3. Procedures

Children took part in two sessions that were conducted three weeks apart. In the first session, children completed the pictographic questionnaire and the Child Food Neophobia Scale (Pliner, 1994). In the second session, the validity of the pictographic questionnaire was assessed using a combined approach. A subgroup of children ($n = 75$) completed two taste tests, including a paired comparison texture preference test (hereafter referred to as paired-preference test) and an acceptance test, whereas another group of children ($n = 21$) was retested with the questionnaire. Children were randomly assigned to the two groups. The numbers of children assigned in each group represented

Table 2
Description and pictographic drawings of the hardness and particle food pairs.

Hardness dimension			Particle dimension		
Food pair	Hard	Soft	Food pair	With-particles	No-particles
Carrot*	 Raw carrot pieces	 Cooked carrot pieces	Orange juice*	 Orange juice with pulp	 Orange juice without pulp
Broccoli	 Raw broccoli	 Boiled broccoli	Bread 2	 Bread with grains	 Bread without grains
Bread 1*	 Crispbread	 Toast bread	Peanut butter	 Chunky peanut butter	 Smooth peanut butter
Cheese*	 Cheese in slices	 Spreadable cream cheese	Strawberry jam*	 Strawberry jam with pieces	 Strawberry jam without pieces
Apple	 Raw apple	 Apple puree	Strawberry yogurt*	 Strawberry yogurt with pieces	 Strawberry yogurt without pieces
Cake	 Chocolate biscuit	 Chocolate cake	Tomato soup	 Tomato soup with pieces	 Tomato soup without pieces

* Food pairs included in the paired comparison texture preference test with actual foods (see Section 2.3.2 for details).

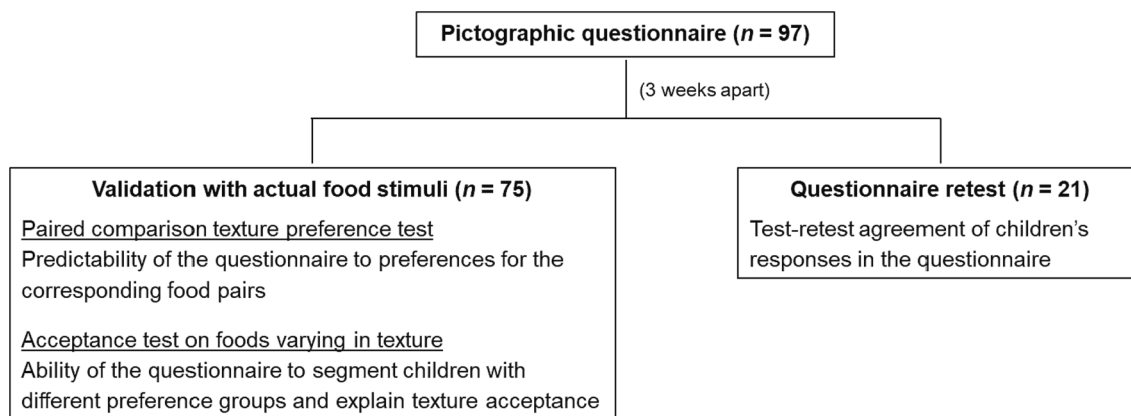


Fig. 1. A combined approach to validate the pictographic questionnaire, including the provision of actual foods for the paired comparison texture preference test and acceptance test, and questionnaire retest.

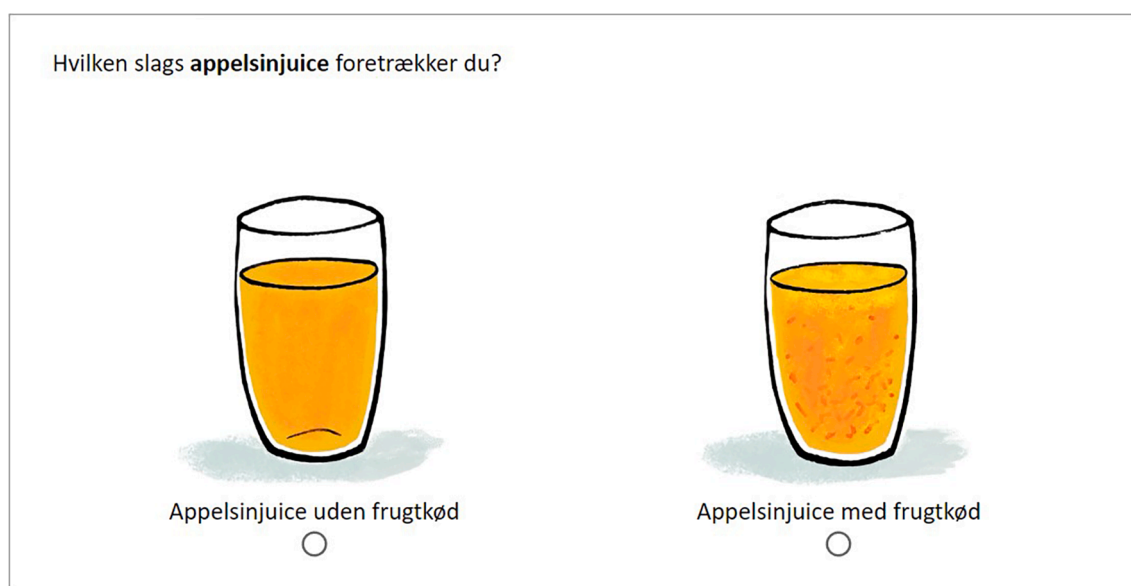


Fig. 2. A screenshot from the pictographic questionnaire on texture preferences.

approximately 80 % (i.e., taste tests) and 20 % (i.e., questionnaire retest) of the sample size. Fig. 1 shows the study design, aim, and details of each test.

All sessions were conducted in classroom settings. Before the start of each session, an experimenter explained the procedures to the class. Teachers and assistants stayed in the classroom to assist children in completing the tests. The children completed questionnaires and taste tests individually using laptops or tablets available in schools. They were told not to exclaim their preferences or liking aloud when answering questions.

2.3.1. Session 1: Completing the questionnaires

Children were provided an oral definition of food texture as “*how the food feels in the mouth: it can for example be hard or soft, and with or without pieces*”. Children reported their age, gender, grade, and the number of teeth missing (counted if half or less of a new tooth had grown out). Children also completed the 6-item Child Food Neophobia Scale (Pliner, 1994). Each item was scored on a 5-point scale from ‘strongly disagree’ to ‘strongly agree’, with the total scores ranging from 6 (neophilic) to 30 (neophobic).

Subsequently, children completed the pictographic questionnaire on food texture preferences. For each food pair, children were presented

with the drawings of the two foods in sequence and were asked to indicate their familiarity: “*Have you tasted food name before? Yes, I have tasted it before / No, I have never tasted it*”. Then, the drawings of that food pair were displayed side-by-side (see Appendix B). The child was asked to select the food they preferred: “*Which product name do you prefer?*”. Fig. 2 shows a screenshot of the preference question asked to the children. The presentation of the 12 food pairs and the pair members were randomized between classes. The experimenter read the questions for the first food pair loud in the plenum to ensure the children understood the test. The children completed the remaining questions individually.

2.3.2. Session 2: Method validation

The method validation consisted of paired-preference and acceptance tests with actual food stimuli and the questionnaire retest (Fig. 1). All tests were conducted at the same time in the classrooms. Children were seated in groups according to their assigned tests, and their participation in each test was voluntary.

- (1) *Paired-preference test.* The test assessed the predictability of the questionnaire to children’s preferences for the corresponding food pairs in reality. The test was based on six food pairs selected from the questionnaire, representing the hardness and particle

Table 3

Inter-session agreement between children's responses in the questionnaire and paired-preference test ($n = 75$) or retesting ($n = 21$).

Food pair	Probability of agreement (95 % CI)			
	Paired-preference test	<i>p</i> -value	Retesting	<i>p</i> -value
<i>Hardness dimension</i>				
Carrot	0.72 (0.61, 0.82)	0.00026	0.86 (0.64, 0.96)	0.0042
Bread 1	0.57 (0.46, 0.68)	0.21	0.72 (0.49, 0.87)	0.064
Cheese	0.60 (0.49, 0.71)	0.087	0.76 (0.54, 0.90)	0.026
Broccoli	–	–	0.76 (0.54, 0.90)	0.026
Apple	–	–	0.76 (0.54, 0.90)	0.026
Cake	–	–	0.91 (0.69, 0.98)	0.0024
<i>Particle dimension</i>				
Orange juice	0.72 (0.61, 0.82)	0.00026	0.86 (0.64, 0.96)	0.0042
Strawberry jam	0.67 (0.55, 0.77)	0.0048	0.81 (0.59, 0.93)	0.0099
Strawberry yogurt	0.71 (0.60, 0.80)	0.00056	0.76 (0.54, 0.90)	0.026
Tomato soup	–	–	0.86 (0.64, 0.96)	0.0042
Peanut butter	–	–	0.86 (0.64, 0.96)	0.0042
Bread 2	–	–	1.0 (–)	–

The chance level was 0.5. An agreement probability below this value would correspond to no agreement between the two tests. *P*-values were not adjusted for multiplicity.

dimension of texture: carrot, bread (hardness dimension), cheese, orange juice, strawberry jam, and strawberry yogurt (Table 2). Details of the food samples are given in Appendix Table A. For each food pair, the two samples were placed on a plate and labeled with descriptions identical to the pictographic questionnaire. The presentation of the 6 food pairs and the position in the pair were randomized between classes. Children received one food pair at a time. After evaluating the two samples, children indicated their preferred sample. The next food pair was served when all children in the classroom had indicated their preferences for the current food pair. Children were instructed to drink water between tastings for palate cleansing.

- (2) **Acceptance test.** The test examined the questionnaire's predictive validity to explain children's acceptance of foods differing in the levels of hardness or particle content. The test was conducted following the paired-preference test; children were asked to evaluate their liking of cheese and yogurt. The cheese was presented in three levels of hardness: soft, semi-hard, and hard using Havarti cheese (Arla Foods, Denmark) cut into grated, sliced, and piece forms, respectively. The yogurt was presented in three levels of particle content: no particles (0 % w/w), some particles (1 % w/w), and many particles (2 % w/w). The samples were prepared by adding a weighed amount of strawberry fruit pieces into homogenous strawberry yogurt (Arla Foods, Denmark). Details of the food samples are given in Appendix Table A. For each product, the three samples were presented on a plate in sequence. Children rated their liking on a 7-point smiley scale (Chen et al., 1996). The cheese and yogurt samples were served in a random order per class. By the end of the test, children have assessed 18 samples (i.e., 12 samples in the paired-preference test and 6 samples in the acceptance test).
- (3) **Questionnaire retest:** The test assessed the repeatability of children in completing the pictographic questionnaire within a short

period. Children completed the pictographic questionnaire following the same procedures as in the first session.

2.3.3. Pilot study

A pilot study was designed to investigate children's understanding of food pairs, drawings, and test procedures. Six children aged between 6 and 10 years were pre-tested with the pictographic questionnaire and validation tests. All children reported that they could see what the drawings depicted easily, and the display size of the drawings was appropriate. Minor modifications were made concerning the scale use and test instructions.

2.4. Data analysis

To access the validity of the pictographic method, children's agreement between their responses in the questionnaire and the paired-preference test with actual foods, as well as in the test-retest, was computed for each food pair (i.e., Yes or No). For both assessments, the probability of agreement was examined by a generalized linear mixed model (GLMM) logistic regression. The model used agreement as the outcome, including fixed effects of Food pair, School grade, and Gender and random effects of Children and Class. In both models, the estimated probability of agreement for each food pair was compared with the chance level of 0.5.

Children's texture preference for each food pair, measured in the pictographic questionnaire and the paired-preference test, was coded 1 for the 'hard' or 'with-particles' food and 2 for the 'soft' or 'no-particles' food. A GLMM logistic model considering Preference (1 or 2) as the outcome, fixed effects of Texture dimension (hardness or particle content), Food pair, Missing teeth (with or without), and Food neophobia score was used. The model was adjusted for School grade and Gender and included random effects of Children and Class. To better understand the relative contribution of children's background variables on preferences, data were further analyzed separately for the hardness and particle dimension with the same fixed effects (except for Texture dimension) and random effects as above.

To further identify major differences in texture preferences among children, a Latent Class Analysis (LCA) with two classes was performed on the questionnaire data separately for the hardness and particle dimensions. For each texture dimension, differences across the two identified clusters were compared by the Wald test (χ^2) along with *p*-values and R^2 . The distributions of school grade and gender between the two clusters were further compared with Pearson's chi-squared test.

Children's liking of yogurt was analyzed using a linear mixed model, with Level of particles in yogurt (No particles, some particles, or many particles), Particle preference cluster identified from the LCA, and their interactions as fixed effects, Children and Class as random effects, and adjusted for School grade and Gender. Since no hardness preference clusters were identified from the LCA, the liking of cheese was analyzed using a similar model as above. However, it only included Level of hardness in cheese (Soft, Medium-hard, or Hard) as a fixed effect. Tukey's HSD test was used for post hoc comparison when appropriate.

Significance was set at $p < 0.05$ for all analyses. Estimated marginal means (EMM's) were used to report the effects of categorical variables. Statistical analysis was performed using R version 3.6.3 (R Core Team, 2020). Latent class analysis was carried out in Latent Gold 5.1 (Statistical Innovation, Belmont, USA).

3. Results

3.1. Inter-session agreement

After answering the questionnaire in the first session, each child either completed the paired-preference test with actual food stimuli or retested the questionnaire in the second session. Table 3 shows the probability of agreement between the two sessions.

Table 4

Probability of children preferring the hard or the with-particle food within a food pair in the pictographic questionnaire ($n = 97$).

Food pair	Probability of preferring the hard / with-particles food (95 % CI)	Preferred texture
<i>Hardness dimension</i>		
Carrot	0.70 (0.60, 0.79)	Hard
Bread 1	0.22 (0.14, 0.31)	Soft
Cheese	0.60 (0.49, 0.69)	None
Broccoli	0.38 (0.28, 0.48)	Soft
Apple	0.73 (0.63, 0.82)	Hard
Cake	0.25 (0.17, 0.35)	Soft
<i>Particle dimension</i>		
Orange juice	0.19 (0.13, 0.29)	No-particles
Strawberry jam	0.36 (0.27, 0.47)	No-particles
Strawberry yogurt	0.37 (0.28, 0.48)	No-particles
Tomato soup	0.18 (0.13, 0.29)	No-particles
Peanut butter	0.17 (0.11, 0.26)	No-particles
Bread 2	0.23 (0.15, 0.32)	No-particles

A value above 0.5 corresponds to preferences for the hard food or with-particles food in the food pair.

For children who completed the paired-preference test, the average probability of agreement across the 6 food pairs was 0.67 (95 % CI: 0.62 – 0.72), which was significantly different from the chance level of 0.5 ($p < 0.0001$). There was no significant effect of food pair on the probability of agreement ($p = 0.22$). The effect of gender and school grade was not significant. The bread 1 showed the lowest level of agreement (0.57), followed by the cheese (0.60). *Post-hoc* comparisons showed that the probability of agreement for these two food pairs was not significantly different from chance.

The average probability of agreement in the questionnaire test–retest across all food pairs was 0.83 (95 % CI: 0.77 – 0.87). The value was significantly different from 0.5 ($p < 0.0001$). There was no effect of food pair on the probability of agreement ($p = 0.25$) (Table 3).

3.2. Food texture preferences

The probability for children to prefer hard food to soft food or with-particles food to no-particles food in the pictographic questionnaire was estimated (Table 4). A value above 0.5 corresponds to preferences for hard foods or with-particles foods.

The average probability for preferring the hard food was 0.47 (95 % CI: 0.42 – 0.52) and for preferring the with-particles food was 0.24 (95 % CI: 0.20 – 0.29). The difference between the two texture dimensions was significant ($p < 0.0001$). These results suggested that children did not show directions of preferences for hard or soft foods but a clear preference for foods without particles. Children who scored higher in food neophobia (i.e., more neophobic) had a significantly higher likelihood to prefer soft/no-particles foods ($p = 0.042$).

The same model, conducted separately on each texture dimension, further revealed that the effect of food neophobia was only significant for particle preferences ($p = 0.023$) but not for hardness preferences ($p = 0.62$). A unit increase in the food neophobia score was estimated to lower the odds of preferring with-particles foods by 8.5 % (95 % CI: 1.3 % – 15.2 %). For each texture dimension, the preference for individual food pairs was significantly different (hardness: $p < 0.0001$, particle: $p = 0.0002$). There was no effect of gender, school grade, or the presence of missing teeth on preferences in any of the models.

Analysis of the paired-preference test showed a similar pattern of texture preferences. Among the 6 food pairs evaluated, the average probability for preferring the hard food was 0.53 (95 % CI: 0.45 – 0.60) and for preferring the with-particles food was 0.32 (95 % CI: 0.26 – 0.39). Likewise, the effect of food neophobia was significant for particle preferences ($p = 0.002$), in which a unit increase in the food neophobia score was estimated to lower the odds of preferring with-particles foods by 12.7 % (95 % CI: 4.2 % – 20.4 %), whereas hardness preferences were not related to food neophobia level ($p = 0.26$).

3.3. Preference segmentation

LCA was used to identify two subgroups of children with similar

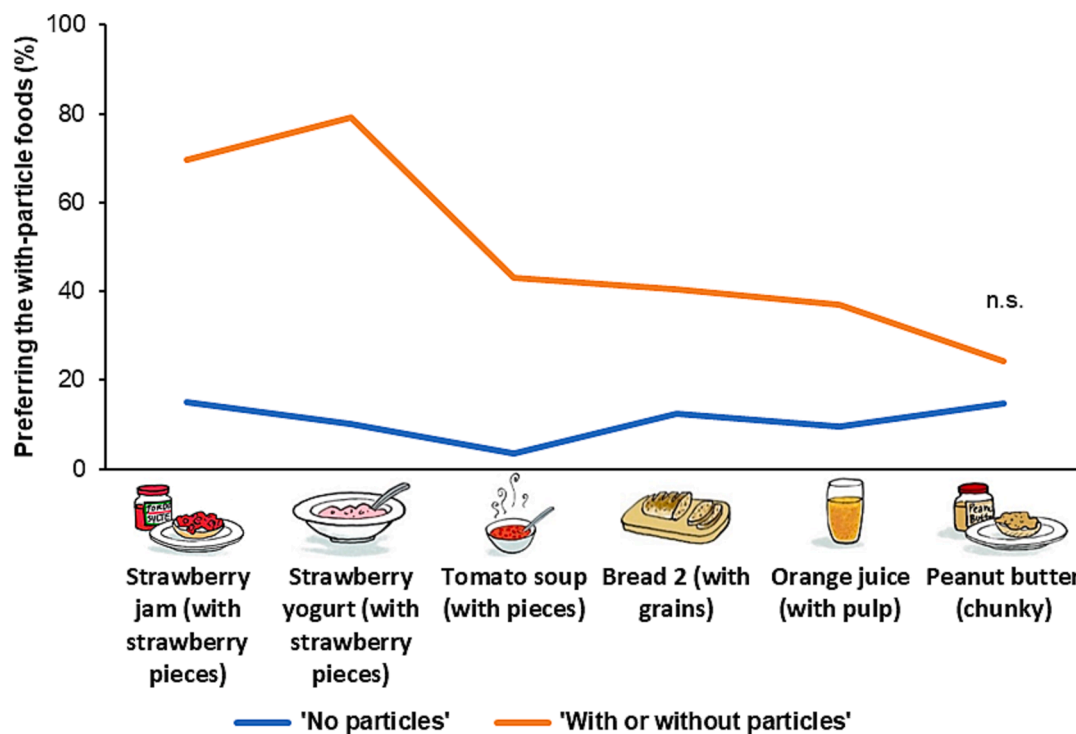


Fig. 3. Latent Class Analysis output on the particle dimension showing the percentage of children preferring the with-particle foods in the 'no particles' and 'with or without particles' clusters. Significant differences ($p < 0.05$) between the two clusters were identified for all particle pairs except for peanut butter.

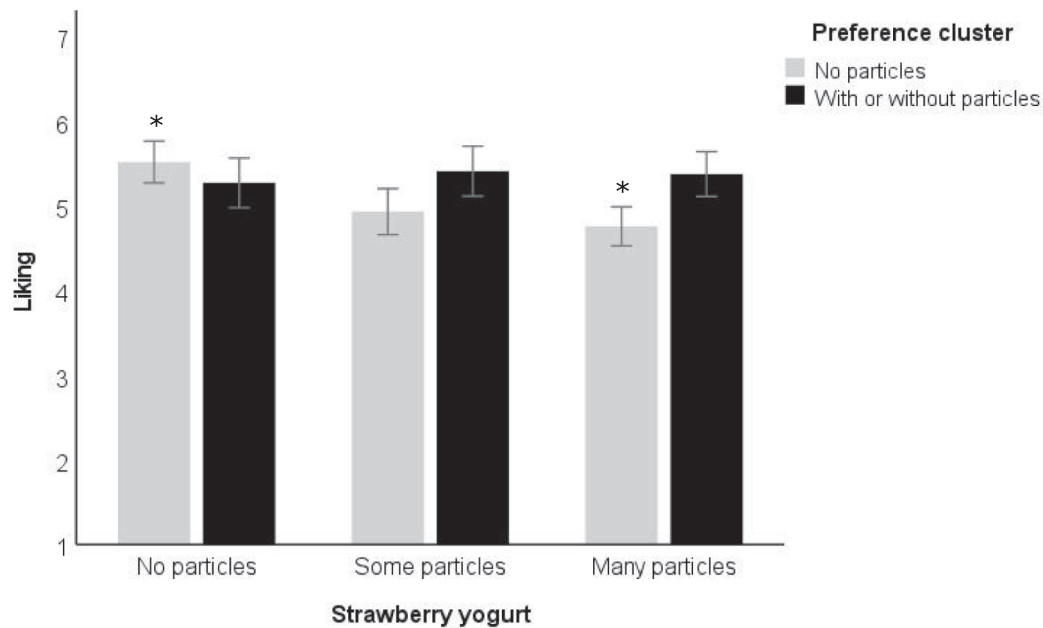


Fig. 4. Estimated mean liking of 3 yogurt samples (no particles, some particles, and many particles) by children characterized in the ‘no particles’ or in the ‘with or without particles’ preference cluster. Error bars represent the standard error of the mean. (*) A significant difference at $p < 0.05$ between samples.

response patterns on the hardness and particle dimensions of the pictographic questionnaire, respectively (**Appendix Table B1 and B2**). Food pairs in each dimension are sorted according to the size of the difference between clusters.

In the hardness dimension, the results showed cluster sizes of 74 % ($n = 72$) and 26 % ($n = 25$), which however could not be identified by a specific texture preference as a significant difference between the two clusters was identified only for the apple pair ($p = 0.035$). Because of the lack of differences between the two clusters, they were not used for further analysis as a measure of hardness preference clusters.

Two distinct clusters were identified for the particle dimension: the ‘no particles’ with 60 children (62 %) and the ‘with or without particles’ with 37 children (38 %). Significant differences between the two clusters were identified for 5 of the 6 food pairs: orange juice ($p = 0.036$), tomato soup ($p = 0.0027$), strawberry jam ($p = 0.0002$), strawberry yogurt ($p = 0.0003$), and bread 2 ($p = 0.015$) (**Fig. 3**).

Children in the ‘no particles’ cluster had strong preferences for foods without particles. The percentage of preferring no-particles foods ranged from 85 % to 94 %. In the ‘with or without particles’ cluster, the no-particles foods in orange juice, tomato soup, and bread were also preferred by most children, but to a lesser extent than children in the ‘no particles’ cluster. However, children in the ‘with or without particles’ cluster showed reversed responses for the strawberry yogurt and strawberry jam pairs, where the majority preferred the with-particles versions. The peanut butter pair was not discriminated between the two clusters.

The results of chi-square tests showed that the relation between particle preference clusters and gender was significant ($p = 0.05$). Girls were more likely than boys to be segmented into the ‘no particles’ cluster. There was no significant association between particle preference cluster and school grade ($p = 0.79$).

3.4. Acceptance of cheese and yogurt differing in textures

To assess the link between the questionnaire responses and children’s acceptance of texture, children also completed an acceptance test to evaluate their liking of foods differing in hardness (i.e., cheeses) and particle content (i.e., yogurts).

No effect of the level of particles was found on the liking of yogurts. However, there was a significant interaction effect between the particle preference cluster and the level of particles ($p = 0.036$). *Post-hoc* tests revealed that children in the ‘no particles’ cluster had a significantly lower liking for the sample with many particles than with no particles ($p = 0.009$, mean value 4.8 vs 5.8), whereas children in the ‘with or without particles’ cluster expressed the same liking to all samples (no particles: 5.4, some particles: 5.3, many particles: 5.4; **Fig. 4**).

Since LCA did not identify specific preference clusters in the hardness dimension (see **Section 3.3**. for more details), the liking of cheese was analyzed using the hardness level of cheese as the main factor. The effect was statistically significant ($p = 0.0006$). *Post-hoc* tests showed that the soft sample received a significantly higher liking than the hard sample ($p = 0.003$, mean value 4.2 vs 3.5). The difference between the liking of the semi-hard sample and the hard sample also tended to be significant ($p = 0.051$, mean value 3.9 vs 3.5).

4. Discussion

With the focus on evaluating the validity of forced-choice methods to measure texture preferences in children, the present study developed a pictographic questionnaire consisting of drawings of 12 food pairs differing in hardness or particle content. The questionnaire was administrated to schoolchildren aged between 7 and 10 and subsequently validated among the same group of children through paired-preference and acceptance tests with actual foods and questionnaire retesting.

4.1. Validity of the pictographic questionnaire

The results from the paired-preference test indicated the predictability of the pictographic method to the corresponding food pairs, i.e., whether children's responses in the questionnaire corresponded to their texture preferences in reality. The level of agreement between the two sessions was not differed by the food pair, gender, or school grade of the children. The probability for children to choose foods in the questionnaire that were consistent with their choice in the taste test was on average 67 %, which was above the chance level. This value can be compared to those obtained by Kildegaard et al. (2011), which assessed children's visual preferences in a picture-based conjoint layout and the consistency with actual product choice. The study reported that 50.2 % of children chose the same products in the two choice tests, and there was an effect of food appearance factor on consistency. The research design could explain the higher level of consistency obtained in the present study. In Kildegaard et al. study, children performed an incomplete ranking of 8 smoothies, whereas in this study, children performed 6 paired-preference tests based on different products. Another study by Köster et al. (2003) measured the repeatability of hedonic judgments in children. In the experiment, children evaluated 6 pairs of crackers and chocolate cream using the paired comparison method over three sessions. The results showed that for children aged 7 to 10, the percentage of agreement between the first two sessions was approximately 60 %.

During the paired-preference test, children may attend to the multisensory experience of foods in making choices. On the contrary, the pictographic questionnaire highlighted the textural differences between foods via drawings. The sensory differences between items in each food pair and the importance of texture in driving preferences could explain the moderate strength of agreement between the two tests (Table 3). For example, cream cheese could be associated with a milder taste and flavor than sliced cheese. Also, both products are usually eaten in combination with bread. Food choices made during tasting might be less texture-orientated compared to the pictographic questionnaire. To further improve the validity of the pictographic questionnaire, it is recommended for future research to minimize the non-texture-related sensory differences in certain food pairs, such as updating the current cheese pair from 'sliced cheese vs. cream cheese' to 'cheese block vs. sliced cheese'.

Furthermore, cheese was identified during experiments as a food pair that needed improvement. As observed by the experimenters, the term "spreadable cream cheese" was confusing for the children. The use of a more generic term was intended to include different types and brands of cream cheese available in the market, yet it might not be the most common expression for children in Denmark. In order to obtain valid results with the forced-choice methods, it is important to match the information conveyed in the food pairs (i.e., drawings and descriptions) with children's expectations of the actual food stimuli.

For the questionnaire retesting, the average level of agreement was 0.83 for the 12 food pairs. The result indicated that the probability for children to choose the same food between the two tests was 83 %. In line with previous research (Laureati et al., 2020), the test-retest assessment in this study showed good repeatability.

4.2. Individual differences in texture preferences

In order to better understand the relative contribution of background variables on preferences, questionnaire data were first analyzed based on all food pairs, then separately for the two textural dimensions.

The results of the first analysis revealed that preferences for hardness and particle content of food were significantly different. Children did not show clear directions of preferences for hard or soft foods, but preferences for foods without particles were observed. These results confirmed the study by Szczesniak (2002) to recognize that texture is a multi-parameter attribute.

The second analysis revealed interesting aspects of food neophobia on texture preferences, which had a significant influence on the particle dimension but not the hardness dimension. Analysis of the paired-preference test, where actual food stimuli were used, also showed similar patterns of results. The findings were consistent with previous research showing that children who were high in pickiness and neophobia tended to prefer fewer foods containing particles, but not foods differing in hardness (Lukasewycz & Mennella, 2012).

In this study, preference data were analyzed using logistic regression. The results were expressed as the probability of preferring hard to soft food or with-particle to no-particles food (Table 4). This approach was different from that proposed by Laureati et al. (2020) and Lukasewycz & Mennella (2012), which calculated a score (i.e., the CFTPO index) or ratios for each participant. The current approach took into consideration the binary response pattern of forced-choice methods. It allowed assessments of preferences at the level of textural dimension, as well as individual food pairs. For instance, the average probability for children to prefer hard to soft food was nearly 0.5, which could be interpreted as having no general preferences for foods differing in hardness. However, a significant preference for hard or soft texture was found in 5 out of the 6 hardness food pairs (Table 4). In line with the literature showing mixed results on the role of mechanical textural properties on children's food acceptance (Chow et al., 2022), it could be that preferences for the hardness of foods are product-specific.

In contrast, the average probability for children to prefer with-particles to no-particles food was 24 %. The tendency for children to prefer no-particles foods can be observed in all particle pairs. Previous studies have shown that children dislike textural contrast and reject lumpy textures or foods with 'things in it' (Kildegaard et al., 2011; Laureati et al., 2017; Sandvik et al., 2021; Szczesniak, 1972; Werthmann et al., 2015). The particle food pairs used in the questionnaire belonged to different categories of products (e.g., dairy products, juice, spreads, bread, and soup). Therefore, children's preferences for foods without particles appear to be a generic phenomenon.

The present study used LCA to categorize children into different preference clusters based on their questionnaire responses. Using LCA to segment children also had the advantage of being probability-based. The statistical method has been used to understand preferred mouth behavior in adult consumers (Cattaneo et al., 2020). In line with the overall results, patterns for hardness preferences were not identified from LCA. In contrast, two distinct preference clusters for the particle dimension were found, i.e., 'no particles' versus 'with or without particles'.

The results from the pictographic questionnaire showed that there were no age-related differences in children's texture preferences. However, the effect of gender was inclusive. The LCA showed an indication that girls were more likely than boys to prefer foods without particles ($p = 0.05$), but no gender effect was found when the same data were analyzed with logistic regression. A recent study showed that in early adolescence, girls identified the dislike of texture as a more important reason for food rejection than boys (Sick et al., 2019). Further studies using a larger number of participants are needed to elucidate the effect of gender on children's texture preferences.

In the pictographic questionnaire, the drawings were presented as a

proxy of foods in daily life that could help set up expectations for the actual sensory perception (Gamble et al., 2006; Kildegaard et al., 2011; Léon et al., 1999), elicit associations and memories, or express food concepts to children. It was expected that children could indicate their preferences based on their overall experiences or impressions of the foods, drawings, or descriptions and that the nuance of the choice-making process could not be completely explained by food familiarity. Therefore, children's familiarity with food pairs was not used as inclusion criteria for preference analysis. This approach differed from existing methods, in which the response of a given food pair was excluded if children indicated that they were not familiar with either pair member (Laureati et al., 2020; Lukasewycz & Mennella, 2012).

In the acceptance test, children's liking for yogurt differing in levels of particles was coherent with the results obtained with LCA. Children in the 'no particles' cluster gave significantly higher scores with lower levels of particles in yogurts. Contrarily, children in the 'with or without particles' cluster expressed similar liking regardless of the levels of particles (Fig. 3). These results further validated the questionnaire to measure texture preferences in children.

Since distinct preference clusters were not identified in the hardness dimension, children's liking for cheese was analyzed using the level of hardness as the main factor. The liking scores significantly decreased with increasing levels of hardness. The results suggested that the acceptance of the hardness in cheese may relate to oral processing. Hence, food textures that require less manipulation in the mouth are more readily accepted by children (Szczeniak, 1972).

4.3. Limitations and future research

The present study assessed the robustness of forced-choice methods to measure children's texture preferences using a combined approach that included the provision of actual food and test-retest assessment. However, limitations of the study should be acknowledged. The study used a relatively small sample size. While the pictographic questionnaire shows overall good validity and results comparable to existing methods (Laureati et al., 2020; Lukasewycz & Mennella, 2012), the findings may not be generalized to the entire Danish or European context. A larger number of participants is needed to obtain a more robust outcome and elucidate the effect of gender on texture preferences. The pictographic questionnaire can be further adapted for younger children, as texture has been reported to be more important in this age group (Rose et al., 2004; Zeinstra et al., 2007).

Using pictographic drawings to present food pairs may allow a more generalized expression of product concept and highlight the textural differences between the pair members. The versatility of drawings suggests the potential for adapting the pictographic method to other research, in which the selection and development of drawings could be modified for specific study objectives and cultural/country contexts. For example, the current bread (hardness) drawings are based on European-style loaves that feature a crunchy crust, and the presentation might not be culturally appropriate to children in other countries where sandwich bread is more often consumed. Also, it could be interesting to compare the use of pictographic drawings and photographs in forced-choice questionnaires to reveal optimal presentation forms to measure texture preferences in children.

5. Conclusions

This study developed and validated a forced-choice questionnaire based on pictographic drawings to measure food texture preferences in children. Children aged between 7 and 10 provided moderately

consistent responses in completing the questionnaire and paired-preference test where food stimuli of the corresponding food pairs were used. The questionnaire retesting showed good repeatability of the method. Using pictographic drawings to present food pairs could be a child-friendly way to facilitate their understanding. However, more studies on food texture and its conceptualization in children could reveal optimal graphical presentation forms to measure texture preferences.

The results from the questionnaire revealed distinct preferences for hardness and particle content of foods among children. Most children preferred foods without particles, and the differences in preferences were related to food neophobia. Preferences for hard or soft foods tended to be product-specific, in which a general preference for the hardness of foods was not observed. The pictographic method could be further adapted for younger children (< 7 years) or different cultural groups. This could concern the selection and development of food pairs and drawings relevant to the target populations.

CRedit authorship contribution statement

Sigrid Skouw: Methodology, Investigation, Visualization, Formal analysis, Writing – review & editing. **Ching Yue Chow:** Visualization, Formal analysis, Writing – original draft. **Helle Sørensen:** Visualization, Formal analysis, Writing – review & editing. **Anne C. Bech:** Conceptualization, Methodology, Supervision, Writing – review & editing. **Monica Laureati:** Methodology, Writing – review & editing. **Anne-marie Olsen:** Conceptualization, Methodology, Supervision, Writing – review & editing. **Wender L.P. Bredie:** Conceptualization, Methodology, Supervision, Writing – review & editing, Project administration, Funding acquisition.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Ching Yue Chow reports financial support was provided by Arla Foods amba. Anne C. Bech reports financial support was provided by Arla Foods amba.

Data availability

Data will be made available on request.

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Appendix A

Table A1 and Table B1 and B2

Table A1

List of the food samples used for method validation.

Samples	Description	Supplier information
<i>Paired-preference test</i>		
Raw carrot	Single piece served on a disposable plate	purchased from local supermarkets
Cooked carrot	Single piece served on a disposable plate	purchased from local supermarkets
Crispbread	½ slice of wholegrain crispbread	Minimum, Denmark
Toast bread	¼ slice of wholegrain toast bread	Salling, Denmark
Sliced cheese	¼ slice of Danbo cheese served on toast bread	Arla Klovborg, Denmark
Spreadable cream cheese	Cream cheese spread on ¼ of toast bread	BUKO, Arla Foods, Denmark
Orange juice with pulp	100 mL of juice served in a disposable cup	Innocent Drinks, Denmark
Orange juice without pulp	100 mL of juice served in a disposable cup	Innocent Drinks, Denmark
Strawberry jam with pieces	Jam served on ¼ toast bread	Den Gamle Fabrik, Denmark
Strawberry jam without pieces	Jam served on ¼ toast bread	Den Gamle Fabrik, Denmark
Strawberry yogurt with pieces	50 mL yogurt served in a disposable cup	Arla Yoggi, Denmark
Strawberry yogurt without pieces	50 mL yogurt served in a disposable cup	Arla ØKO, Denmark
<i>Acceptance test</i>		
Cheese	Havarti cheese cut into 3 forms: grated, sliced, and piece; 7 g each served on a disposable plate	Arla Foods, Denmark
Yogurt	Smooth strawberry yogurt added with 3 levels of strawberry fruit pieces extracted from Arla Yoggi strawberry yogurt: 0 %, 1 %, and 2 %; 50 mL each served in a disposable cup	Arla ØKO, Denmark

Table B1Segmentation of hardness food pairs with distribution, Wald statistics, p-values, and R². Food pairs are sorted according to the size of the difference between clusters.

Food pair	Cluster 1 (n = 72, 74 %)		Cluster 2 (n = 25, 26 %)		Wald	p-value	R ²
	Hard	Soft	Hard	Soft			
Apple	0.81	0.19	0.48	0.52	4.44	0.035	0.10
Cake	0.06	0.94	0.82	0.18	3.58	0.058	0.58
Bread 1	0.16	0.84	0.41	0.59	3.44	0.064	0.068
Cheese	0.64	0.36	0.43	0.57	1.47	0.23	0.037
Carrot	0.71	0.28	0.62	0.38	0.45	0.50	0.008
Broccoli	0.40	0.60	0.34	0.66	0.14	0.71	0.002

P-values were not adjusted for multiplicity.

Table B2Segmentation of particle food pairs with distribution, Wald statistics, p-values, and R². Food pairs are sorted according to the size of the difference between clusters.

Food pair	Cluster 1 – ‘No particles’ (n = 60, 62 %)		Cluster 2 – ‘With or without particles’ (n = 37, 38 %)		Wald	p-value	R ²
	With-particles	No-particles	With-particles	No-particles			
Strawberry jam	0.15	0.85	0.70	0.30	14.2	0.0002	0.31
Strawberry yogurt	0.10	0.90	0.79	0.21	13.2	0.0003	0.49
Tomato soup	0.04	0.96	0.43	0.57	9.01	0.0027	0.24
Bread 2	0.12	0.88	0.40	0.60	5.91	0.015	0.11
Orange juice	0.09	0.91	0.37	0.63	4.39	0.036	0.11
Peanut butter	0.15	0.85	0.24	0.76	0.98	0.32	0.015

P-values were not adjusted for multiplicity.

Appendix B. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.foodqual.2022.104783>.

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