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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 re-tested with the questionnaire. The average probability of agreement between children's choices in the questionnaire and paired-preference test was 0.64, while the re-testing was 0.83. In both assessments, the agreement probability was significantly above the chance level, and there was no significant effect of age or gender. The questionnaire results showed 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, gender, and liking of yogurt varying in the amount of added fruit pieces. The results demonstrated the validity and usefulness of the pictographic method to study differences in children's texture preferences.
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Cover Letter

UNIVERSITY OF COPENHAGEN
DEPARTMENT OF FOOD SCIENCE

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Dear Editor,

We are submitting our manuscript entitled "A forced-choice pictographic method to measure food texture preferences among schoolchildren" by Sigrid Skouw, Ching Yue Chow, Helle Sørensen, Anne C. Bech, Monica Laureati, Annemarie Olsen, Wender L.P. Bredie for consideration for publication in Food Quality and Preference.

The study developed and validated a forced-choice questionnaire based on pictographic drawings to measure texture preferences in children. This is the first study to show the consistency of children's food choices in the questionnaire and actual tasting and test-retest repeatability on the questionnaire. The study demonstrated the usefulness of the pictographic method to study individual differences in children's texture preferences.

The manuscript presents original, unpublished results that are not under consideration for publication elsewhere. All authors have approved the submission of this paper and declare no conflicts of interest to disclose the research results.

Thank you for your consideration. We appreciate your time and look forward to receiving your response.

Yours sincerely,

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Highlights

- A pictographic questionnaire was developed and validated to measure children’s texture preferences.
- Children showed consistency in food choice between questionnaire and tasting.
- The questionnaire demonstrated test-retest repeatability and validity.
- Differences in preferences for hardness or particle content of foods were identified.

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 re-tested with the questionnaire. The average probability of agreement between children's choices in the questionnaire and paired-preference test was 0.64, while the re-testing was 0.83. In both assessments, the agreement probability was significantly above the chance level, and there was no significant effect of age or gender. The questionnaire results showed 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, gender, and liking of yogurt varying in the amount of added fruit pieces. The results demonstrated the validity and usefulness of the pictographic method to study differences in children's texture preferences.

Keywords: Children, Texture, Preference, Questionnaire, Food neophobia, Research methods

1. Introduction

Texture is a salient attribute that plays a key role in food acceptance in children. Szczesniak (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; Szczesniak, 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; 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 (e.g., food neophobia) in an expected direction, which 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 are an important factor in the repeatability of their choice during experiments (Köster et al., 2003; Léon et al., 1999). In like manner, 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. For instance, the conjoint layout to measure children's visual preferences was compared with their actual choice with real products (Kildegaard et al., 2011). Evaluating children's agreement in re-testing the same questionnaire would indicate the repeatability of the method (DeVellis, 2017).

It is widely believed that presenting text with illustrations helps enhance children's attention and facilitates their understanding of the information, for example, 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 re-testing 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 characteristic 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 formal approval of the study was not required (reference no.: 19071689).

2.2. Development of the pictographic questionnaire

The pictographic forced-choice 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**). These drawings were specifically developed for the questionnaire to highlight the texture differences in foods.

Children had to choose their favorite food among 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 in 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 size 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.

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 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 the other group of children (n = 21) was re-tested with the questionnaire. Children were randomly assigned to the two groups. **Fig. 1** shows the study design, the 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 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 texture as "*the texture of the food is how the food feels in the mouth: it can for example be hard or soft, and with or without pieces*". Children had to fill in a questionnaire concerning 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. The child was asked to select the one food they preferred: "*Which one do you prefer?*". 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.

The paired-preference test assessed the predictability of the questionnaire to children's preferences for the corresponding food pairs in reality. The test was based on 6 food pairs selected from the questionnaire, representing the hardness and particle dimension of texture: carrot, bread (hardness dimension), cheese, orange juice, strawberry jam, and strawberry yogurt. The food samples were presented with descriptions (see **Table 2** for more details). Children received one food pair placed on a plate at a time, tasted both samples, and answered which samples they preferred. Children were instructed to drink water between tastings for palate cleansing. The next food pair was served when all children in the classroom had indicated their preferences on the current food pair. The presentation of the 6 food pairs and the position in the pair were randomized between classes.

The acceptance test examined the questionnaire's predictive validity to explain children's acceptance of foods differing in the levels of hardness or particle content. In the test, children were asked to evaluate their liking of cheese and strawberry yogurt. Cheese samples with three levels of hardness (i.e., soft, medium-hard, and hard) were prepared by different cutting: grated, sliced, and cubed of the same type of cheese. Yogurt samples with three levels of particle content (i.e., no particles, some particles, and many particles) were prepared by varying the amount of the added fruit pieces. The samples were presented on a plate in sequence. For each sample, 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.

For the questionnaire retest, children completed the questionnaire following the same procedures as in the first session.

2.3.3. Pilot study

A pilot study was designed to learn children's understanding of food pairs and their drawings and the test procedures. Five children aged between 6 and 10 years were pre-tested with the pictographic questionnaire and validation tests. Minor modifications were made concerning the scale use and test instructions.

2.4. Data analyses

To access the validity of the pictographic method, children's agreement between their responses in the questionnaire and the paired-preference test with actual food, 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 was coded 1 for the 'hard' or 'with-particles' food and 0 for the 'soft' or 'no-particles' food. A GLMM logistic model considering Preference (1 or 0) 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 clusters identified were compared by the Wald test ($\chi 2$) 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 filling out the questionnaire in the first session, each child either completed the paired-preference test with actual food or re-tested the questionnaire in the second session. **Table 3** shows the probability of agreement between the two sessions.

For children who completed the paired-preference test with actual food, the average probability of agreement across the 6 food pairs was 0.64 (95% CI: 0.59 – 0.69), which was significantly different from the chance level of 0.5 ($p < 0.0001$). The probability of agreement differed significantly between food pairs ($p = 0.0001$). There was no significant effect of gender or school grade. The cheese showed the lowest level of agreement (0.40), followed by the bread (0.58). *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 within each food pair is shown in **Table 4**. In the table, 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 score (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 FNS 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.

3.3. Preference segmentation

Two clusters were identified by LCA on the hardness and particle dimension, respectively (**Appendix Table 1 and 2**). The food pairs are sorted in the table according to the size of the difference between clusters.

In the hardness dimension, the results showed cluster sizes of 74% and 26%, 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: '*no particles*' with 57 children (60%) and '*with or without particles*' with 38 children (40%). 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. 2**).

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 particle preference cluster and 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. 3**).

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 of hardness level on cheese liking was 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 comparison texture preference and acceptance tests with actual foods and questionnaire re-testing.

4.1. Validity of the pictographic method

The results from the paired comparison texture 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 affected by the 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 64%. This value can be compared to those obtained by Köster et al. (2003). One of the experiments reported in Köster et al. measured the repeatability of hedonic judgments in children. Children evaluated 6 pairs of crackers and chocolate cream using the paired comparison method over three sessions. The percentage of agreement between the first two sessions was approximately 60% for children aged 7 to 10. Another study showed a high correlation between children's food choices in a conjoint layout and actual product choices, with Gamma's correlation coefficients ranging from 0.38 to 0.82 (Kildegaard et al., 2011).

For the questionnaire re-testing, 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.

The cheese and bread (hardness) were identified as the food pairs where improvement on the descriptions and drawings is needed. In particular, the cheese had the lowest probability of agreement over the two sessions. An explanation for the results is that the term "spreadable cream cheese" gave rise to confusion among children, as observed by the experimenters during the tests. 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.

4.2. Individual differences in texture preferences

In order to better understand the relative contribution of background variables on preferences, 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.

Interestingly, from the first analysis, food neophobia was shown to be related to preferences for soft/no-particles. However, further analysis indicated that it had a significant influence only on particle preferences. The result is similar to previous research showing that children who were high in pickiness and neophobia tended to prefer fewer foods containing particles but not for 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 foods or with-particle to no-particles foods (**Table 4**). This approach was different from that proposed by Laureati et al. (2020) and Lukasewycz & Mennella (2012), who calculated a score (i.e., the CFTPQ 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 foods 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 foods 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 (i.e., 'no particles' versus 'with or without particles') were found.

Interestingly, the results showed an indication that girls were more likely than boys to prefer foods without particles. 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). Future studies could investigate the effect of gender using larger samples.

In this study, it was expected that children could indicate their preferences based on their overall experiences of the foods, as well as the food concepts expressed through drawings and descriptions. Children's familiarity with food pairs was therefore not used as inclusion criteria for the analysis of texture preferences, of which a given food pair would be excluded from analysis if children indicated that they were not familiar with either of the foods (Laureati et al., 2020; Lukasewycz & Mennella, 2012). It could be interesting to investigate the conceptualization of food textures in children and the associated expectations and preferences for foods to extend the current findings.

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. 2**). 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 mouths are more readily accepted by children (Szczesniak, 1972).

The present study is the first to assess the robustness of forced-choice methods to measure and study differences in children's texture preferences using a combined approach that included both the provision of actual food and test-retest assessment. Since children could be inconsistent or change their choices between answering the questionnaire and tasting, it is important to measure the external validity of the questionnaire with the corresponding food stimuli. Schoolchildren showed moderate agreement between completing the pictographic questionnaire and tasting a similar sample and good test-retest agreement on the questionnaire. The validation helped identify that the cheese pair, of which inconsistent results between the questionnaire and tasting were obtained, required revision. Future studies could examine the validity of the pictographic method with other related measures, such as the recently developed tool for classifying food texture sensitivity in children (Ross et al., 2021).

Using pictographic drawings to present food pairs may allow a more generalized expression of product concept and highlight the textural difference between the pair members. The questionnaire showed overall good validity and repeatability, and these

results suggested that the drawings could facilitate children's comprehension of the food pairs. The 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).

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 re-testing 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 gender and 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 choosing food pairs and drawings relevant to the target populations.

Conflict of interest statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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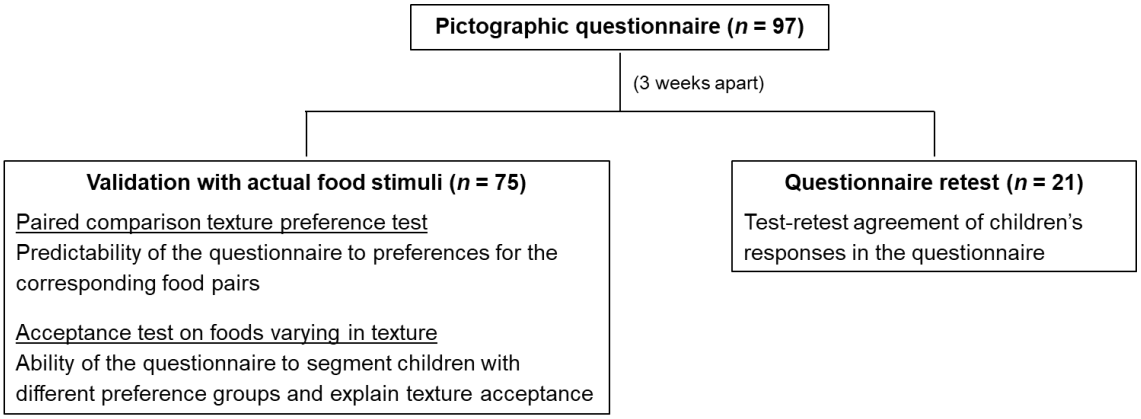


Fig. 1. A combined approach to validate the pictographic questionnaire, including the provision of actual foods for the paired comparison texture preference test and acceptance test, and questionnaire retest.

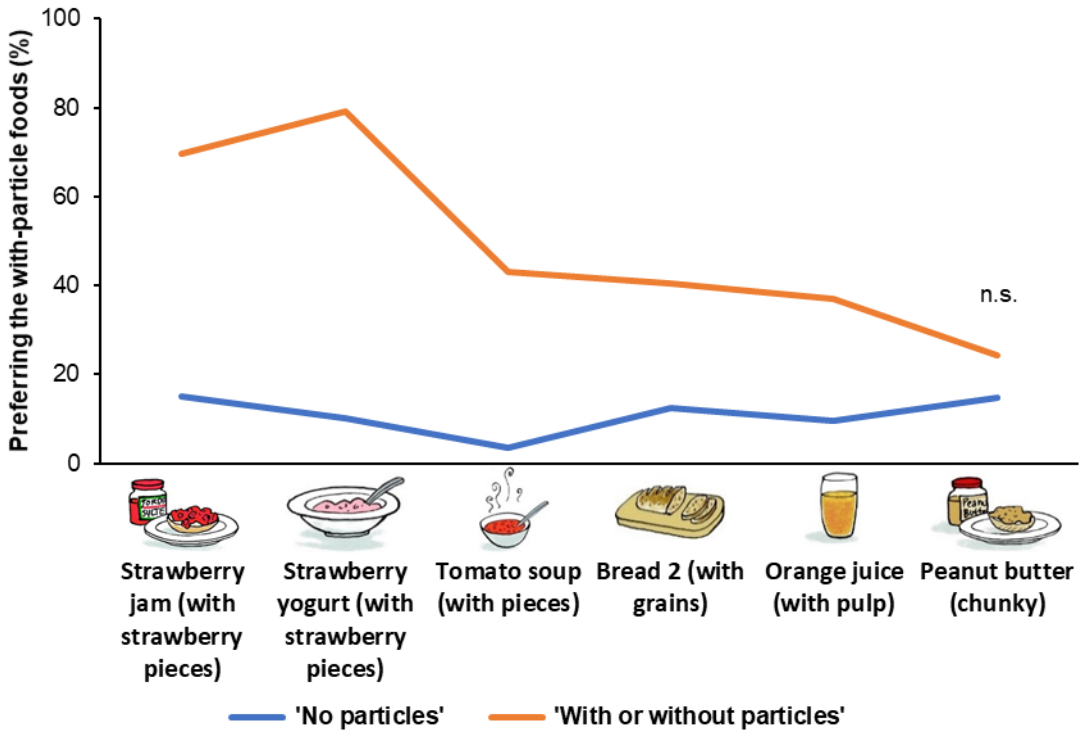


Fig. 2. The LCA clusters on the particle dimension concerning the percentage of preferring the with-particles foods among children in the 'no particles' and 'with or without particles' clusters.

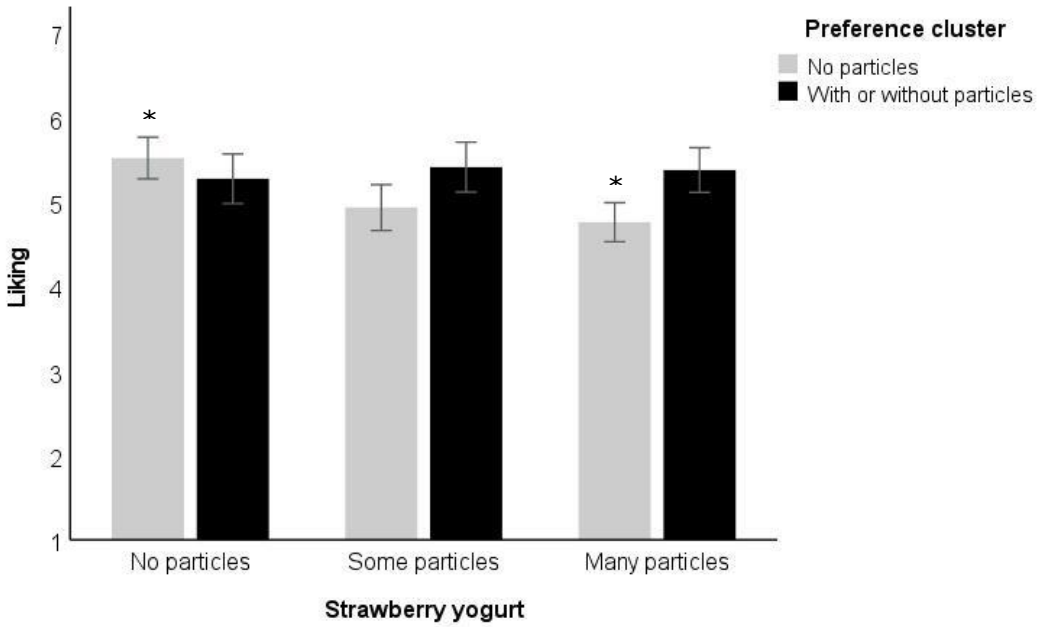
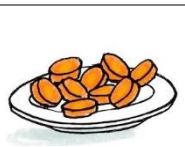
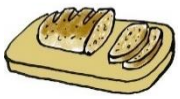


Fig. 3. Estimated mean liking of 3 yogurt samples (no particles, some particles, and many particles) by children characterized in the '*no particles*' or in the '*with or without particles*' preference cluster. Error bars represent the standard error of the mean. (*) A significant difference at $p <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

Table 1. Participant characteristics

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

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 (particle)	 Bread with grains	 Bread without grains
Bread 1* (hardness)	 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).

Table 3. Inter-session agreement between children's responses in the questionnaire and paired-preference test (n = 75) or re-testing (n = 21).

Food pair	Probability of agreement (95% CI)			
	Paired-preference test	p-value	Re-testing	p-value
Hardness dimension				
Carrot	0.73 (0.61, 0.82)	0.00018	0.86 (0.64, 0.96)	0.0042
Bread 1	0.58 (0.46, 0.69)	0.18	0.72 (0.49, 0.87)	0.064
Cheese	0.40 (0.30, 0.52)	0.10	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
Particle dimension				
Orange juice	0.73 (0.61, 0.82)	0.00018	0.86 (0.64, 0.96)	0.0042
Strawberry jam	0.67 (0.56, 0.77)	0.0036	0.81 (0.59, 0.93)	0.0099
Strawberry yogurt	0.71 (0.60, 0.80)	0.00039	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.

Table 4. Probability of children preferring the hard or the with-particle food within a food pair (n = 97).

Food pair	Probability of preferring the hard / with-particles food (95% CI)	Preferred texture
Hardness dimension		
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
Particle dimension		
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.

Appendix Table 1. Segmentation of hardness food pairs with distribution, Wald statistics, p-values, and R^2. Food pairs are sorted according to the size of the difference between clusters.

Food pair	Cluster 1 (74%)		Cluster 2 (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.

Appendix Table 2. Segmentation of particle food pairs with distribution, Wald statistics, p-values, and R^2. Food pairs are sorted according to the size of the difference between clusters.

Food pair	Cluster 1 (60%) – 'No particles'		Cluster 2 (40%) – 'With or without particles'		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.

Declaration of interests

☐The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☒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.

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

Ethical Statements

The study protocol was submitted to the Danish National Committee on Biomedical Research Ethics for review. It was concluded that formal approval of the study was not required (reference no.: 19071689) on 16-10-2019.

Children's participation in the study was voluntary. They were able to withdraw from the study at any time without giving a reason. The parents were thoroughly informed about the research through information provided to the teachers. The parents gave written consent to their children's participation and the use of data for research, by giving their signature on the following statement:

"I hereby give consent for my child, child's name, to participate in the project on children's texture preferences, and for the data collected in this context to be used for scientific publications. All data will be anonymised and data for individual children will not be identifiable."

The invited children also gave verbal consent before participating in the study.