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Exposure to texture of foods for 8-month-old infants: Does the size of the pieces matter?

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Abstract

This study examined the effect of meals varying in amount, size, and hardness of food pieces on the development of the chewing capabilities of 8-month-old infants. The study also examined changes in shivering, gagging, coughing, choking, and their ability to eat from a spoon. In an in-home setting two groups were given commercially available infant meals and fruits, purees with either less, smaller and softer or more, larger and harder pieces. Both groups were given these foods for 4 weeks and were monitored several times during this period. After the 4-week exposure period infants in both groups were given the same five test foods. Structured questionnaires with questions on eating behavior and the child's development were conducted 6 times in the 4 to 12-month period and video analyses of feedings were conducted 4 times between 8 and 9 months. After the 4-week exposure period, the group that had been exposed to the foods with more, larger and harder pieces showed a significantly higher rating for chewing a piece of carrot and potato for the first time, but not for a piece of banana nor for mashed foods. Shivering, gagging, coughing, choking, and ability to eat from a spoon were not different between the two groups. These results contribute to the insight that exposure to texture is important for young children to learn how to handle texture.

Practical applications

(a) The study shows the feasibility of testing the effects of texture interventions on chewing capability and oral responses such as gagging, coughing, and choking in infants. (b) The study contributes to the insight that exposure to food texture to learn how to handle texture is important for infants and showed that exposing children to a higher amount of larger pieces improves their chewing capability for a piece of carrot and potato, at least immediately after the intervention.

KEYWORDS

chewing capability, feeding, infant, lumpy solids, mastication development, size of pieces

1 | INTRODUCTION

Complementary feeding is the gradual introduction of beverages and foods other than breast milk or infant formulas to meet the nutritional requirements of infants, which can no longer be met by breast or formula feeding alone (Schwartz, Scholtens, Lalanne, Weenen, & Nicklaus, 2011). Ultimately, complementary feeding should lead to the consumption of a variety of foods that are nutritionally complete and balanced. Complementary feeding is also important to help the child acquire optimal behavior toward eating, a competence which is necessary for an optimal transition from milk to table foods and family foods (Schwartz et al., 2011). Traditionally, recommendations on complementary feeding include that parents first spoon feed purees and then gradually introduce finger foods in the diet (Agostoni et al., 2008).

Our knowledge of what is a normal and healthy development of the oral motor skills of children and how this is influenced by what,

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when, and how they eat is limited. This makes it difficult to judge the pros and cons of different ways of introducing complementary foods, but also of understanding whether the oral development of a child is normal or not.

Oral motor skills evolve quickly over the first years of life, more or less independently from the development of the teeth (Carruth & Skinner, 2002; Gisel, 1991; Szczesniak, 1972). Although the efficiency of chewing continues to increase until at least 24 months, the most noticeable changes in oral motor skills occur between 6 and 10 months (Gisel, 1991). This is related to the fact that the anatomy and physiology of the mouth develop mainly in the first year (Engel-Hoek, Gerven, Haaften, Groot, & Hulst, 2011; Rogers & Arvedson, 2005).

Acceptance of the texture of foods follows the development of oral functions and, as a result, textures are particularly rejected when they are difficult to manipulate in the mouth (Szczesniak, 1972). Conversely, the capacity of infants to cope with textures was also found to be dependent on the textures previously offered to them (Blossfeld, Collins, Kiely, & Delahunty, 2007). Oral movement patterns, such as lateral tongue movement emerge only if the child is given the particular textures requiring these skills (Mason, Harris, & Blissett, 2005; Reilly, Skuse, Mathisen, & Wolke, 1995). Children should thus be given textured foods to increase their oral motor skills at the time they are developmentally ready, that is around 6–7 months to prevent them from developing later feeding problems (such as failing to chew, refusing solids, and vomiting) (Illingworth & Lister, 1964). Children who were introduced to lumpy foods after the age of 10 months had more feeding problems (such as fewer solids and less likely to be having family foods) at the age of 15 months than those who were introduced to lumpy foods before the age of 10 months (Northstone, Emmett, Nethersole, & ALSPAC study team, 2001). Likewise, 7-year-old-children who were introduced to lumpy foods after 10 months had more feeding problems (including "not eating sufficient amounts," "refusal to eat the right amount," and "being choosy with food"). There is no evidence that introducing lumps before 6 months is detrimental (Coulthard, Harris, & Emmett, 2009), however, the introduction of more solid pieces should be done with caution to prevent choking. Thus, as was shown for the establishment of feeding behavior in general (Cashdan, 1998) and of taste and flavor preferences (Beauchamp & Mennella, 1998), sensitive periods seem to exist for the acceptance of texture during which the impact of experience is particularly strong.

Experimental studies examining the effects of different textures are limited. Blossfeld et al. (2007) studied the acceptance of pureed and chopped carrots in 12-month-old children. Pureed carrots were consumed and enjoyed more than chopped carrots. Familiarity with different textures, especially chopped foods was the strongest predictor of consumption and enjoyment of chopped carrots. This raises the question when infants should ideally be exposed to which texture, that is, which textures are most beneficial at what age for the development of the oral motor capabilities and acceptance of textures of healthy foods.

The present study focused on infants of 8 months and feeding complementary foods with lumps. The objective of this study was to assess whether feeding infants of 8 months of age complementary foods with either less, smaller and softer or more, larger and harder pieces affects their chewing capability and frequency of shivering, gagging, coughing, and choking, when both groups were given the same test foods after the intervention.

2 | MATERIALS AND METHODS

2.1 | Study design

The study was a two-arm randomized single blinded study, including a total of 28 healthy infants that were included between September 2011 and January 2012. Subjects were randomized using a randomization list generated by SPSS 18.0. Both groups received the same test foods before and after the intervention but during the intervention of 4 weeks, group 1 was given foods with less, smaller and softer pieces and group 2 foods with more, larger, and harder pieces. The study design is summarized in Table 1.

The study was submitted to the Medical Ethics Review Committee of University Medical Center Groningen (METc) and approved. Infants were recruited at the age of 4 months. After receiving informed consent from the mother, they completed a questionnaire with questions

TABLE 1 Measurement schedule

Time code and video number	Age	Foods	Self-developed questionnaire on motor skills, health, feeding, and behavior	Measurements
video 1:	7 months	Baseline food	Yes	–
T0: video 2	8 months	Test food: Olvarit green bean puree for 6+ month	Yes	OLSF
T1: video 3	8 + 1 week	Intervention foods: (Table 2)	No	OLSF & MOE
T2: video 4	8 + 2 weeks	Intervention foods: (Table 2)	No	OLSF & MOE
T3: video 5	9 months	Test foods: freshly mashed carrot-potato, freshly mashed banana, piece of cooked carrot, piece of cooked potato, piece of banana (1 × 1 × 1 cm)	No	OLSF & MOE

OLSF = observation list spoon feeding (Engel-Hoek et al., 2014); MOE = mastication observation and evaluation instrument (Remijn et al., 2014).

TABLE 2 Products used for the intervention: main ingredients according to the labels

Food type	Group 1	Group 2
Savory meals	Green beans, carrots, and veal	Green beans, potato, and beef
	Carrots, rice, and ham	Potatoes, beef, and spinach
	Green vegetables and rabbit	Beef Stroganoff with country vegetables
	Carrots, peas, and beef	Pumpkin, peas, and turkey
	Vegetables and salmon	Sweet maize, rice, and chicken
	Vegetables and beef	Italian risotto with rice
	Pasta and creamed spinach	Fillet of sole
	Ratatouille, rice, and hake	Chicken, carrot, and tomato
Fruit purees	Apple and exotic fruits	Orange, pear, and banana
	Apple and red fruits	Banana, strawberry, and black currant
	Apple, kiwi, and pineapple	Red fruit
	Sun fruits	Kiwi, grape, and orange

on eating behavior and the child's development. The same questionnaire was repeated at the ages of 5, 6, 7, 8, and 12 months.

At the age of 7 months, infants were recorded on video during a meal (green bean puree) (video 1). This first video recording was mainly intended to make parents and children familiar with the video recording process. When the child was about 8 months (depending on the mother's judgment of whether the child was ready to start eating foods with pieces), the child was given twice daily a meal including fruit and vegetables that were selected specifically for this study (see study products and Table 2).

Within 3 days before the start of the intervention, a second video was recorded at T0 (video 2). This video was recorded to allow observation of infant feeding behavior, with a focus on the oral processing of the food, eating behavior in general and discomfort like shivering, gagging, and choking. For the feeding session for video 2, all infants were offered the same commercial green bean puree appropriate for 6 months of age. This video was used as a baseline measurement. Parents of both groups were instructed to feed their baby 1 fruit and 1 meal per day for 4 weeks from an assortment of 4 fruits and 8 savory meals. The first meal, consisting of one of the intervention products (selected by the parent), was recorded on video. One week later another video was recorded at T1 (video 3). Within 2–3 weeks after the start of the intervention, a fourth video was recorded at T2 (video 4). At the end of the intervention, all infants received the same test meal consisting of freshly prepared mashed food and pieces of food, which were prepared and supplied by the study staff (Table 3) and this feeding session was also recorded at T3 (video 5). Two observers independently scored the videos and afterwards discussed about their differences to reach consensus.

Ability to eat with a spoon was measured using a standard protocol, the Observation List Spoon Feeding (Engel-Hoek, Hulst, Gerven, Haaften, & Groot, 2014), with seven observation items for oral motor behavior and six items for abnormal behavior was used, while feeding a freshly prepared mashed carrot potato mixture. The assessment of the chewing capability of infants was facilitated with the standard protocol, the Mastication Observation and Evaluation instrument (MOE) for infants (Remijn, Speyer, Groen, Limbeek, & Nijhuis-van der Sanden, 2014). The MOE consists of eight items (tongue protrusion, lateral tongue movement, munching, jaw movement, chewing duration, loss of food or saliva, number of swallows, and fluency/coordination) with a four-point category scale for each item and the total MOE score provides a quantitative measure of oral processing capability, including

TABLE 3 Mean (*SD*) values for chewing capability scores (MOE)

			Group	
Time	Weeks after start of study	Food	1	2
T1	1 week	Intervention foods	22.0 (2.6)	22.4 (2.4)
T2	2 weeks	Intervention foods	22.9 (2.2)	23.6 (2.2)
T3	4 weeks	Cooked and mashed carrot + potato mixture	22.4 (2.2)	22.1 (2.2)
T3	4 weeks	Mashed banana	26.0 (3.2)	26.4 (2.4)
T3	4 weeks	Total mashed foods	24.2 (1.3)	24.2 (1.6)
T3	4 weeks	Piece of cooked carrot	19.7 (2.3)*	22.8 (1.4)*
T3	4 weeks	Piece of cooked potato	19.9 (2.6)*	22.5 (2.2)*
T3	4 weeks	Piece of banana	27.6 (3.3)	27.8 (4.7)
T3	4 weeks	Total of pieces	21.2 (1.9)	23.9 (1.7)

Note. Maximum score is 32.
*$p < .05$.

discrete oral movements (e.g., lateral tongue movement) and functional units of mastication (e.g., number of swallows). The MOE score is generally very close to the maximum score for typically developing children from 6 years old and up, and is sensitive to developmental changes in young children aged 6–48 months.

We used the MOE to assess the chewing capability of the infants in our study, while feeding freshly prepared mixtures of mashed carrot and potato, mashed banana, a piece of carrot, a piece of potato, and a piece of banana, based on video recordings of these feedings (video 5). Throughout the intervention period, weekly questionnaires were completed. Questionnaires were the same at each point in time and included questions on motor skills, health, feeding, and behavior.

Both groups received the same feeding recommendations in accordance with the Dutch national complementary feeding recommendations about how and when to start with fruit and vegetables. Participants received a cup and a spoon, to avoid difference as a result of differences in the specific cup or spoon used. General feeding recommendations were given, including recommendations for the position of the child during feeding and what to do when the child gags.

2.2 | Participants

The following inclusion criteria were used: infants should be healthy, full term, aged 4–6 months at inclusion, and have not yet started with semi-solid or solid foods. Therefore, the children did not differ in experience with semi-solids. Exclusion criteria were: being preterm, participating in another study, having any food allergy or other special dietary restrictions, having neurological or gastro enteral disorders or having received tube feeding for more than 1 week.

In total 31 infants were included in the study. During the study, the parents of three infants withdrew their child after randomization. One couple moved to another city, one couple found it too burdensome to comply with the protocol and one couple did not provide any reason for withdrawal. Finally, the data of 28 infants were analyzed. Group 1 (n = 14) consisted of eight boys (57%) and six girls (43%), group 2 (n = 14) consisted of ten boys (71%) and four girls (29%). There were no significant differences between groups in APGAR scores 5 min after birth, gestational age at birth, age, weight, and age of introducing bottle feeding. The mean duration of breast feeding was 3.7 months for group 1 and 6.8 months for group 2 ($p = .09$). The majority of infants in groups 1 and 2 started complementary feeding in the seventh month (group 1 10/14 and group 2 8/14), 2/14 infants in group 1 and 3/14 infants in group 2 started complementary feeding in the sixth month ($p = .44$). The other children (respectively, 2 and 3) started complementary feeding during the study.

2.3 | Products

Infants received commercially available infant meals and fruits with either small pieces or large pieces. All infant foods were available on the market in the EU for babies of about 8 months and older (except for the green beans mash for group 2 (with more, larger, and harder pieces), which was for 6+ months and which was selected to optimize the match in ingredients between groups), fulfilled all legally required safety and quality requirements and had a history of safe use. The choice of the products was based on nutritional recommendations for infants in accordance with the advice of the Netherlands Center for Youth Health (www.ncj.nl, 2014)—for example, one meal with fish per week, a variety of vegetables, types of vegetables, starch and protein sources—and were as much as possible matched for ingredients between groups. The products were matched as much as possible on ingredients. A complete list of the foods fed to the infants in the intervention is given in Table 2, the foods that were used for assessments are summarized in Table 1.

Test foods that were given to both groups at the end of the intervention included mashed banana, a mash of cooked potato and carrots (1:1, w/w), a piece of banana and pieces of freshly soft cooked potato and carrot; the mashes were obtained by mashing with a fork to a smooth texture; the size of the pieces of carrot and potato was 1 × 1 × 1 cm; banana pieces were obtained by cutting a slice of 1 cm thick in four equal parts. The test foods were given with a spoon by the parents.

2.4 | Statistical analyses

For statistical analyses SPSS 18.0 (IBM SPSS Inc, Chicago, IL) was used. The statistical analyses consisted of frequency analyses of all questionnaires and observation lists.

As this was a pilot study, a formal sample-size calculation was not performed and the total number of infants to be included was arbitrarily set at 28.

MOE scores at T1 (8 months + 1 week) and T2 (8 months + 2 weeks) were compared using repeated measures ANOVA with group as a factor and the introduction of other chewable food as mentioned by the parent as a covariate at T1. Differences in MOE scores between groups for each product were tested with unpaired *t*-tests. Differences in categorical data were analyzed with the chi-square test or Fisher's. The difference in firmness as measured by the sensory panel was analyzed by a two-sample *t*-test. For all statistical analyses, *p*-values smaller than .05 were considered significant.

3 | RESULTS

3.1 | Products

Products in group 1 were products which are available in southern Europe, products in group 2 were available in northern Europe. Preliminary tastings had suggested that the northern European products have more pieces and larger pieces than products in southern Europe, therefore the latter were selected for one group (group 2) and products from northern Europe were selected for the other group (group 1). Samples of each of the products were sieved and each of the fractions weighed to determine the differences in size distribution of the pieces. Products for group 1 had considerably less pieces than products for group 2 (9% versus 34%, $p = .003$; weight of pieces >0.4 mm as % of total product) and this difference was even more pronounced for the

larger pieces (weight of pieces >4 mm as % of total product: 0.3%, versus 6.4%, $p < .001$). The firmness of the pieces was assessed in duplicate by a sensory panel (N = 11) trained in texture profiling of baby foods and was lower for group 1 (24.5 mm on 100 mm VAS scale) than for group 2 (54.5 mm on 100 mm VAS scale; $p = .007$). This confirmed our assumptions and supported the suitability of these products for the intervention in which texture was varied through differences in the amount, sizes, and hardness of pieces.

3.2 | Eating from a spoon

The ability to eat from a spoon was measured four times using the method of van den Engel-Hoek et al. (2014) based on video recordings. Infants in the groups did not differ in their ability to eat from a spoon at baseline (Group 1 Mean 31.2; *SD* 5.0 versus Group 2: 33.0; *SD* 2.7), this did not change during the intervention nor was there a difference at the end of the intervention (Group 1: 32.6; *SD* 4.3 versus Group 2: 32.8; *SD* 2.7).

3.3 | Chewing capability

Results of the chewing capability (MOE scores) are summarized in Table 3. At the end of the intervention, infants in both groups were given the same test foods. Post hoc analysis of chewing the two foods that were prepared by mashing with a fork (banana and a mixture of carrot + potato) did not show differences between groups in chewing capability ($p = .81$) but did show a difference for the chewing of a piece of food ($p = .009$). For two out of the three pieces, there were differences in chewing capability: MOE scores for a piece of potato and a piece of carrot were higher for infants in group 2 than for infants in group 1. MOE scores for eating a banana slice did not differ between groups. MOE scores for group 1 were higher for the mashes than for the pieces ($p = .007$), for group 2 the difference between MOE scores for mashes and pieces was not significant ($p = .92$).

3.4 | Discomfort scores

Discomfort measurements were based on videos T0–T3 and included frequencies of shivering, gagging, choking and coughing (Table 4). These behaviors were observed in both groups, but there were no differences in occurrences between the two groups. Shivering, gagging, choking, and coughing occurred more often at T3 when children were given hand mashed foods and pieces, than when the manufactured foods with pieces were given at T0–T2.

TABLE 4 Occurrence of shivering, gagging, choking, and coughing

		T1	T2	T3	T3
Discomfort type	Group	Intervention foods		Mashed foods	Pieces
Shivering	1	0	0	4 (30)	4 (33)
	2	2 (14)	2	5 (38)	4 (36)
Gagging	1	0	0	3 (23)	4 (33)
	2	0	0	3 (23)	1 (9)
Choking	1	0	0	0	2 (17)
	2	0	1	3 (23)	1 (9)
Coughing	1	0	0	1 (7)	3 (25)
	2	0	2	0	2 (18)

Note. Occurrence is expressed as the total number of observations and frequency (%) over all participants per group. T1 = 1 week; T2 = 2 weeks; T3 = 4 weeks; differences between groups were not significant. $p < .05$.

4 | DISCUSSION

The objective of this study was to assess whether feeding infants complementary foods containing a higher number of larger pieces affects their chewing capability and frequency of shivering, gagging, coughing, and choking. After the 4-week exposure period, the group that had been exposed to the foods with the larger pieces showed a significantly higher rating for chewing a piece of carrot and potato but not for a piece of banana nor for mashed foods. Ability to eat from a spoon and discomfort were not different between the two groups at the end of the 4-weeks exposure. Our hypothesis that repeatedly feeding infants with meals that contain a higher amount of larger pieces results in better chewing capability in general was partially confirmed, in the sense that the intervention led to higher chewing capability (MOE scores) for two out of three solid foods tested. Although the study was only small in number of participants and intervention period the significant differences underlines the importance of the results which neat move in the direction of what we expected from earlier studies (Blossfeld et al., 2007; Coulthard et al., 2009; Northstone et al., 2001).

A possible explanation for the lack of an increase in MOE scores from T1 to T3 is that the textures of the intervention foods may have been relatively easy and did not require jaw and tongue movements other than munching and diagonal rotating movements; oral capabilities that the children may already have had at the start of the intervention. The very low frequencies of shivering, gagging, choking, and coughing when feeding the intervention foods confirms that these were relatively easy foods for most infants. This probably means that we can offer food with more, larger and harder pieces from the age of 8 months to stimulate oral motor skills without risk for choking.

The lack of a group effect on the MOE scores for the mashed test foods given after the intervention is unexpected. The discomfort scores of the mashed foods (Table 4) suggest that these are challenging textures, at least for some infants. Nevertheless, there is no difference in the MOE scores between the groups. A possible explanation is that repeatedly feeding infants pieces (in the purees) prepares them for chewing other pieces (even without puree) but not for the texture of foods prepared by mashing with a fork. As the mashed food was prepared by the researcher, it is likely that the texture was different from what the child was used to.

The lack of a group effect on the chewing of a piece of banana can possibly be explained by the very high MOE scores for eating a piece of banana (Table 3) and therefore a ceiling effect. Apparently, eating a piece of banana is relatively easy at this age.

The lack of a group effect on the occurrence of shivering, gagging, choking, and coughing for the test foods is somewhat puzzling, as the MOE scores did show differences between groups for pieces, potato, and carrot. The discomfort frequencies for the test foods at T3 vary between 0 and 38%, suggesting that at least some of the test foods were somewhat challenging for the infants. Furthermore, the MOE scores are based on a number of items, which make this a more sensitive measurement than individual occurrences of shivering, gagging, choking, and coughing.

It is clear from Table 8 that the intervention foods gave rise to very few occurrences of shivering, gagging, choking, and coughing, especially when compared to the test foods given after 4 weeks. The low incidence of discomfort in T0–T2 is unexpected, as previous literature reports higher frequencies of choking and coughing during the development of eating capabilities (American Academy of Pediatrics, 2010). It seems plausible that foods with slightly more texture, that is, more, larger, and harder lumps than were present in the intervention foods, may be easy enough for children to safely chew and swallow. This could mean that complementary foods could have more texture than they have now. Parents and other caregivers as well as industry may be too cautious about the choking risk.

The few occurrences of discomfort that were observed with the intervention foods were seen with the foods of group 2, that is, the foods with more, larger, and harder pieces. This was as expected. However, considering the very low occurrence frequencies, we cannot draw any conclusions on whether this is a true group effect or not.

This study builds on the pioneering work by Blossfeld et al. (2007), who showed that familiarity with textures was the strongest predictor of consumption and enjoyment of chopped carrots in 12-month-old infants. Our study concerns younger infants and shows effects of repeated exposure to different textures on the chewing capability of infants and the occurrence of discomfort, which are factors affecting acceptance (Coulthard et al., 2009; Northstone et al., 2001).

A strength of this study is that it used a validated chewing capability instrument, which has recently become available (MOE; Remijn et al., 2014), to test the effect of giving healthy infants foods with different textures. The group effect found in this study for solid foods suggests that this instrument is useful for this kind of research and provides further support for the validity of the tool. In addition, the combination of the MOE instrument with the discomfort occurrences turned out to be very useful in interpreting the data and understanding whether a texture is challenging for a child.

Limitations of this study are the small amount of participants and the fact that children had experience with textures of other foods before and during the intervention. This is a relevant experience which can be expected to affect their chewing capability and bring noise to the results. The intervention meals were prescribed, but what children were fed before the start of the study or in addition to the intervention foods during the study was not controlled or prescribed. Therefore, a follow-up study with more participants and controlled for additional food is recommended. A longer intervention period and food with a more complex texture can give more insights about the way infants learn to accept and chew textured food. A future study could also include measuring liking and wanting. A recent study (Hetherington et al., 2016, 2017; Nekitsing et al., 2016) suggests that distinguishing between liking and wanting is possible in infants based on facial expressions and behavior.

In conclusion, this pilot study showed that there was a small but significant effect of giving foods with more, larger and harder pieces to infants on their ability to chew pieces. Our study also showed the feasibility of testing the effect of food texture interventions on the chewing capability of infants. Considering the fact that texture has been linked to fussy eating (Northstone et al., 2001), this study contributes to the insight that exposure to texture is important to learn how to handle texture and develop healthy eating.

ETHICAL STATEMENTS

Conflict of Interest: This study was supported by Danone Nutricia Research. Danone is a supplier of nutritional products for infants and toddlers. H. Weenen and C. Vereijken are employees of Danone Nutricia Research.

Ethical Review: This study was approved by the institutional review board of the Medical Ethics Review Committee of University Medical Center Groningen (METc UMCG).

Informed Consent: Written informed consent was obtained from all participants.

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