Fostering infant food texture acceptance: A pilot intervention promoting food texture introduction between 8 and 15 months

Carole Tournier, Clara Bernad, Jérôme Madrelle, Julien Delarue, Gérard Cuvelier, Camille Schwartz, Sophie Nicklaus

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C. Tournier[1, *], C. Bernad[1], J. Madrelle[1], J. Delarue[2], G. Cuvelier[2], C. Schwartz[1], S. Nicklaus[1]

[1] Centre des Sciences du Goût et de l'Alimentation, AgroSup Dijon, CNRS, INRAE, Université Bourgogne Franche-Comté, F-21000 Dijon, France

[2] Université Paris-Saclay, INRAE, AgroParisTech, UMR SayFood, F-91300, Massy, France

Corresponding author:

INRAE, UMR CSGA, 17 rue Sully, BP 86510, 21065, Dijon Cedex, France.

E-mail address: carole.tournier@inrae.fr (C. Tournier).

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Abbreviations:

BLW: baby-led weaning

CF: complementary feeding

CG: control group

IG: intervention group

TextExp: food texture exposure score

TexAcc_lab: experimental food texture acceptance score

T1: smooth and rough puree texture level

T2: small/soft food pieces texture level

T3: large/hard food pieces and double texture (pieces in a liquid phase) texture level

Abstract:

Healthy infant feeding practices form the basis of healthy eating behaviour later in life. The effect of providing parents with recommendations on textured food introduction between 8 and 15 months on children's experience with and acceptance of textured foods was studied. Sixty parent/child dyads were randomly assigned to a control group (CG) receiving current French recommendations and an intervention group (IG) receiving a brochure with supplementary advice, tips and monthly counselling on food texture introduction. After the intervention, parents completed self-report measures about the introduction of 188 food items, including purees, soft/small pieces, hard/large pieces and double textures. Children's acceptance of eight textured foods was assessed in a laboratory setting. Parents in the IG introduced more soft/small food pieces (P=0.004) but not more complex textures (P=0.15). There was no group difference in children acceptance for any of the textured foods offered in the laboratory. Independent of their study group, children's exposure to texture was associated with birth order, self-feeding with fingers, low gagging frequency and seldom use of commercial baby foods. Higher acceptance was associated with higher exposure to food pieces but not to pureed foods (either smooth or rough) and with children's eating behavioural traits (high food enjoyment, high food responsiveness and low food fussiness). This pilot intervention demonstrated that providing information can be effective in promoting the introduction of small and soft food pieces, but the most effective way to influence the introduction of more challenging textures (hard pieces and double texture) is uncertain. Further research should focus on the identification of barriers to complex texture introduction and on how building on this knowledge for a population-based public health intervention.

1. Introduction:

Complementary feeding (CF) is a period of food discovery for infants that is punctuated by several food transitions. CF involves a gradual introduction of foods from different groups when nutritional needs cannot be fully covered by milk (breast milk or infant formula) alone. CF often starts at approximately 4 to 6 months old in Europe (Fewtrell et al., 2017). CF also involves a gradual transition in terms of food texture, traditionally starting with pureed foods at the beginning of CF, moving on to more solid foods and finger foods, and ultimately allowing children to eat at the family table. From physiological and functional perspectives, the CF period is important for the development of oral physiology and oral processing skills, especially in the first year (Le Reverend, Edelson, & Loret, 2014; Nicklaus, Demonteil, & Tournier, 2015). The acceptance of a diversity of complementary food textures increases with age – with a texture-dependent timeline – and is related to the development of chewing behaviour (Demonteil et al., 2019). As a result, infants and children frequently reject solid foods when such foods are difficult to manipulate in the mouth (Szczesniak, 1972).

It is well known that CF dietary experiences play a role in shaping later eating habits and that fostering food acceptance before the onset of food neophobia (approximately 2 y old) is a way of leveraging the development of healthier eating habits (Schwartz, Vandenberghe-Descamps, Sulmont-Rossé, Tournier, & Feron, 2018). In this context, experience with food texture is no exception to the rule (Blossfeld, Collins, Kiely, & Delahunty, 2007; Coulthard, Harris, & Emmett, 2009; da Costa, Remijn, Weenen, Vereijken, & van der Schans, 2017; Demonteil et al., 2018; Harris & Mason, 2017). Exposing infants to a variety of textured foods (i.e., foods with textures other than puree) during the CF period may help them learn how to orally process solid foods and subsequently increase their acceptance for these foods. Food texture introduction should be done when children are developmentally ready (Cichero, 2016; Delaney & Arvedson, 2008; Illingworth & Lister, 1964) but not too late after the beginning of CF. A critical period for the introduction of textured foods has been suggested (Harris & Mason, 2017). Indeed, a prospective UK study (Avon Longitudinal Study of Parents and Children cohort, ALSPAC) reported that children introduced to lumpy foods at or later than 10 months old had more feeding difficulty at 15 months old (Northstone, Emmett, Nethersole, & ALSPAC study team, 2001), were more picky at 38 months old (Emmett, Hays, & Taylor, 2018) and consumed fewer fruits and vegetables at 7 years old (Coulthard et al., 2009). However, the best predictor of the acceptance of chopped carrots (as measured at the

laboratory) in 12-month-old infants was their previous experience with textures, especially with chopped carrots (Blossfeld et al., 2007). An intervention study evaluated the effect of exposure to ready-to-eat infant foods that varied in amount, size, and hardness of food pieces on the development of the chewing capabilities of 8-month-old infants (da Costa et al., 2017). After a 4-week exposure period, infants exposed to foods with more, larger and harder pieces displayed a significantly higher chewing score (as evaluated from video records using the Mastication Observation and Evaluation instrument (MOE)) than those exposed to fewer, smaller and softer pieces. Another study investigated an alternative complementary feeding strategy promoting the introduction of textured foods from the onset of CF without any pureed food, called the Baby-Led approach to Solids (BLISS). This method is a modified version of the Baby Led Weaning (BLW) method used by many parents in the UK, New Zealand and Canada (Cameron, Taylor, & Heath, 2015), which addresses concerns about the safety (choking risk) and nutrient sufficiency (iron and energy intake) of the BLW method. A randomized controlled trial (RCT) comparing children who were encouraged to feed themselves pieces from the start of CF (6 months old) to children introduced to CF by being spoon-fed purees showed that the two groups had similar BMI z-scores at 12 and 24 months old, but the self-fed group was reported to be less fussy at 12 months old (Taylor et al., 2017). However, unfortunately, differences in chewing behaviour and food texture acceptance between these groups were not assessed specifically.

Current recommendations from ESPGHAN nutrition committee members include avoiding prolonged use of purees and making infants eat lumpy foods between 8 and 10 months old at the latest (Fewtrell et al., 2017). However, in France, there is evidence that parents tend to introduce food textures rather late in their child's diet. For instance, 47% of 8- to 11-month-old children are fed purees (n=1188, Nutribebe survey, (SFAE, 2013)), and the first soft pieces are mainly introduced after 12 months (n=2999; (Demonteil et al., 2018)). These practices may be related to a lack of information, as the question of texture has been poorly addressed in French national recommendations so far (INPES, 2005; Schwartz, Scholtens, Lalanne, Weenen, & Nicklaus, 2011). A French survey with parents of 181 children aged between 6 and 36 months old showed that 88% of parents declared that they received oral information on CF, but only 46% received information specifically related to the introduction of food textures, although introducing texture was spontaneously reported as the most common difficulty during CF (16%) (Marduel Boulanger & Vernet, 2018). The delayed introduction of foods pieces can also be due to the fear of choking, which is widely prevalent

among French mothers (Marduel Boulanger & Vernet, 2018; Schwartz et al., 2013). In addition, another survey revealed that mothers living in France introduce a more diverse range of textures when their child has more teeth, frequently feeds him/herself with fingers and consumes only homemade/family foods (Demonteil et al., 2018). These results indicate that these cues might be interpreted as the child's readiness to accept food textures and serve as an important trigger for parents to begin food texture introduction.

Based on these findings, a pilot intervention was developed to provide parents living in France with more information about the introduction of a variety of food textures (why, how and which foods) into their child's diet. We hypothesized that providing these extended recommendations (as compared to the current national recommendations at the time of the study) to mothers when their infant was between 8 and 15 months old would result in a higher exposure to textured foods and, in turn, in a higher food texture acceptance by their infant. The primary outcome of this study is the parental report of food texture introduction into their child diet and defined by texture exposure scores (globally and per texture level). The secondary outcome is the children's acceptance, assessed from the evaluation of the children's swallowing of foods varying in texture in a laboratory setting and characterized by a global acceptance score. Finally, a third objective was to explore factors (among parental practices and children's characteristics) associated to these outcomes.

2. Material and method

2.1.General study design

The study is a pilot intervention with a prospective follow-up of infants between the ages of 8 and 15 months. Infants were enrolled at 7.5 months old. At 8 months old, they participated in two lab sessions (measurements before intervention); then, their parents were randomly allocated to either an intervention group in which they received recommendations and individualized counselling on food texture introduction combined with the provision of infant textured foods (intervention group, IG) or a control group in which they received currently available information on CF (current care or control group, CG). At 15 months old (end of the intervention period), children participated again in two lab sessions. Parents were aware that the aim of the study was about the effect of CF recommendations on their child's eating behaviour but were unaware of the focus on texture. They were also blinded to the group (IG vs CG) to which they were allocated. This information was revealed to them after the end of

the study. The study was conducted between December 2016 and April 2018 at the Centre of Taste and Feeding Behaviour in Dijon. The methodology used complies with the Declaration of Helsinki and was approved by the local ethics committees (Comité de Protection des Personnes EST I- ID RCB 2016-A00839-42 and ANSM). Written informed consent was obtained from both parents prior to the start of the follow-up.

The study was registered in clinicaltrial.gov with the number: NCT04570059

Study population

2.1.1. Recruitment and inclusion/exclusion criteria

Participating parents were recruited through flyers distributed in maternity wards, paediatric offices, day care centres, an internal consumer database (PanelSens, CNIL declaration no. 1148039) and with the help of a local recruitment agency. Eligibility was checked by an initial phone interview. To be included, parents had to be older than 18 years old. Children had to be in good health (no food allergy, no tube feeding, no chronic disease, no gastroesophageal reflux requiring medication), born full-term (gestational age > 37 weeks) and heavier than 2.5 kg. Children introduced to complementary foods before 4 months or after 6 months, using the BLW method and those already involved in another study on eating behaviour were not eligible to participate.

2.1.2. Sample size

The study sample size was estimated from previous studies. Data collected on food texture exposure in children aged 4–36 months old in France (n=3770) were used to estimate meaningful differences in food texture exposure. A power analysis conducted on children aged 13-15 months old showed that to detect an 50% increase in the number of hard and/or large pieces and double textures introduced in the children's diet (increase of 12 foods of this texture category), 27 children were needed (alpha of 0.05 and a power of 0.95). We therefore aimed at including 30 children per group, to compensate for potential attrition.

2.1.3. Randomization

The participants were randomized into one of the two study groups using numbers from a random order table.

2.1.4. Participant characterization at baseline

Upon inclusion at 7.5 months old, participants were given a baseline questionnaire assessing sociodemographic information (parental age, parental educational attainment, employment, number of children) and specific information on the infant (birth order, birth weight and height from the child health notebook, type of daycare). Parents reported information about breastfeeding, age at the start of CF, texture of the first complementary foods and whether the child was already offered textured foods in the fruits & vegetables and meat/fish categories (minced or in pieces). Those questions were included in a larger questionnaire evaluating child diet variety that was previously used in a French population (Bournez et al., 2018) to avoid focusing parents' attention towards texture. The items in this questionnaire not related to texture are not considered further in this paper.

A set of validated questionnaires was then used to characterize maternal food neophobia (Pliner & Hobden, 1992), maternal anxiety (State and Trait Anxiety Inventory; STAI (Spielberger, 1993)), infants' appetite traits (Baby Eating Behaviour Questionnaire; BEBQ (Llewellyn, van Jaarsveld, Johnson, Carnell, & Wardle, 2011)) and infants' sensory profiles (Infant/Toddler Sensory Profile caregiver questionnaire; ITSP (Dunn & Daniels, 2002)).

At 8 months old, infant weight was measured using an electronic scale (Soehnle Professional), and length was measured using a 100-cm board meter (Seca). These measurements were performed twice during the experimental sessions in the laboratory by trained staff. The intra-mean was used. Weight-for-length z-scores were determined using the World Health Organization child growth standards (WHO, 2006).

2.2.Intervention content

The intervention lasted 7 months, between the ages of 8 and 15 months old. The content of the information/material provided to parents during this period is detailed in Table 1.

Table 1 Information and material provided to participants

Resources	**Intervention group (IG)**	**Control group (CG)**
Booklet title	'How to introduce food pieces in my child's diet to help him to chew well?'	'How to introduce complementary foods?'
Booklet page number	31	7
Booklet content	Current French CF recommendations (INPES, 2005)	
	Table for recording of weight, height, teeth eruption	
	Development of mastication: physiological aspects and impact of	-

	exposure to food texture	
	Sign of readiness for pieces introduction	-
	How to adapt texture to child feeding skills?	-
	Differentiating gagging from choking	-
	Safety, managing choking and foods to avoid for safety reasons	-
Other resources	Notebook for tracking introduction of new textures over monthly phone interviews Monthly newsletters containing recipes Leaflet with example of foods with different textures	-
Gift boxes (given at 8 and 12 months old)	Commercial finger foods (Suppl. Mat1) Apple cutter Long-sleeved bib	Baby gifts (toys, books…) Long-sleeved bib
Phone interviews	7 (1 per month) Individualized counselling on texture introduction (~ 15 min duration) Feedback on the experimental lab session	2 (at 9 and 13 months old). Feedback on the experimental lab session

2.2.1. Intervention group

Participants allocated to the intervention group (IG) received the standard French recommendations on CF introduction at the time of the study (INPES, 2005). Moreover, they were provided with advice and regular counselling for promoting the introduction of textured foods. A research dietician provided individualized advice and support at the 8-month visit at the lab and then every month by phone. Different resources were offered to parents for this purpose (Table 1). Advice was grouped in a booklet (Suppl. Mat) developed from a benchmark on available information at the time of the study conception (2016) on texture introduction from governmental agencies, national guidelines of other countries, scientific literature (Blossfeld et al., 2007; Cichero, 2016; Coulthard et al., 2009; Daniels et al., 2015; Daniels et al., 2014; Delaney & Arvedson, 2008; Gaspard, 2001; Gisel, 1991; Illingworth & Lister, 1964; Le Reverend et al., 2014; Limme, 2010; Nicklaus et al., 2015; Northstone et al., 2001; Schwartz et al., 2013; Schwartz et al., 2011; Stolovitz & Gisel, 1991; Szczesniak, 1972 WHO, 2003) and other medical care documents (See Suppl Mat. for the full list of gathered information). The content of the booklet was decided by the research study team composed of 3 experts in children's eating behaviour, 1 dietetician, 1 expert in oral physiology and

chewing skills, with inputs from 1 speech therapist, 1 pediatrician and 1 psychologist. Before the start of the study, booklet content was discussed in a focus group involving 3 mothers of infants (8, 10 and 11 months old) to assess whether the content was understood and whether the feeding advice was feasible for parents (data not shown). The aims was also to check whether some information were missing or not necessary. Mothers very well appreciated the content, they acknowledged that they learnt information and very welcome details on gagging and safety advice. They commented mainly on the illustrations, which were rework afterward by a professional designer. The only negative comments was that advice did not contain reference related to which texture could be offered as a function of age. This was however on purpose, as we wanted mothers to adapt their practices to their child's chewing skills and therefore the booklet was not further modified.

Briefly, advice in the booklet encouraged parents of children 8 months old and older to:

- Avoid prolonged use of smooth purees;
- Offer at least one textured food at each meal;
- Start introducing texture even if the child has no teeth;
- Possibly (but not necessarily) use rough purees for the transition between purees and pieces;
- Propose food with increasing hardness in the following order: foods that can be squeezed with the tongue on the palate, can be crushed between fingers and finally crushed with teeth;
- Offer hard finger foods (e.g., bread end crust and baby biscuit) even if the child is not able to swallow them yet, but remove bread before it becomes too soft because of saliva to avoid choking;
- Adapt the texture to the child's response (reaction and chewing movements): once the child is able to eat one texture, offer a more difficult-to-chew one;
- Propose each food texture several times, even if not accepted the first time;
- Encourage the child to eat slowly and to chew the food well;
- Adapt finger food size to child hand motor skills;
- Propose a wide variety of food textures: dry, crunchy, chewy, grainy, smooth, creamy, spongy, juicy, melting…;
- Let the child participate in meals at the family table and eat food with his/her hands, and do not start cleaning the table before the meal is finished;
- Follow safety advice (sitting the child in a high chair, positioning of the spoon if a spoon is used, never leave the child alone, never put food in the child's mouth, check that the mouth is empty).

Along with the advice booklet, resources also included a leaflet with examples of various foods (meat, fruit and vegetables) presented in different textures and a gift box containing

various commercial textured and finger foods provided when children were 8 and 12 months old (Suppl. Mat 1). To help parents track their progression in texture introduction during the 7-month intervention phase, a tracking notebook was also provided. This notebook could be used by parents as feedback support for monthly phone counselling with the research dietician.

2.2.2. Control group

Participants randomized to the control group (CG) also received current French recommendations on CF introduction by the time of the study (INPES, 2005) in a booklet designed for the study and 2 gift boxes containing presents for the child (Table 1), amounting to a similar financial value as the box provided to the intervention group. They were called twice during the 7-month intervention period (at 9 and 13 months old), during which general information about the child was collected. These calls were aimed at keeping parental interest in the study and preventing them from withdrawing because of motivation decay.

2.3.Outcome measurements

2.3.1. Primary outcome: Food texture exposure

After the intervention period (i.e., at 15 months old), food texture introduction was assessed using a questionnaire developed to characterize the pattern of food texture exposure in French children aged 4-36 months (Demonteil et al., 2018). This questionnaire is composed of 188 items representing 61 foods commonly used in France in different texture combinations (puree, pieces, raw, cooked, etc.). For example, for 'carrot', the following texture combinations were proposed: smooth carrot puree, rough carrot puree, cooked carrot in small pieces, cooked carrot in large pieces, raw grated carrot, raw carrot in small pieces and raw carrot in large pieces. Each food-texture combination present in the questionnaire was classified into one of three texture levels: 'purees' (soft and rough; T1 texture level), 'small/soft pieces' (T2 texture level) and 'hard/big pieces and double texture' (T3 texture level) (see (Demonteil et al., 2018) for the full item list and classification levels). For each item, parents (mainly mothers, n=52 out of 60) mentioned whether they had already offered it to their child. The number of introduced items was evaluated for each texture level (T1, T2 and T3), and a global child texture exposure score (TexExp) was calculated from the sum of

all introduced items, as described in (Demonteil et al., 2018). This score is the primary outcome of this intervention and represents the variety of food textures a child was exposed to over the course of the intervention period.

2.3.2. Secondary outcome: children's food texture acceptance

2.3.2.1.Experimental setup

Children's food texture acceptance, defined as the child's ability to eat and swallow foods of different textures, was assessed experimentally pre- and post-intervention at 8 and 15 months old, respectively, in a laboratory setting. Measurements pre-intervention were aimed at verifying that acceptance was similar between groups because children's oral processing may evolve drastically at this age (Nicklaus et al., 2015). At each age, children participated in two experimental sessions in which they were offered several foods varying in texture (Table 2). Sessions were organized either for lunch or for an afternoon meal in a room designed specifically for child testing. An interval between the last meal/snack and the session was set at approximately 2 h. For each age, for a given child, the two sessions were planned during the same week whenever possible. The average delay between the two sessions was 6.6 (SD=4.6) days overall.

During the session, the child sat in a high chair and was fastened with a seat belt. The investigator was seated directly in front of the child, in a lower position, and the parent was seated next to the investigator. Two cameras were positioned to obtain a face and a profile view of the child's head. Four different foods were offered to the child (Table 2), with the same presentation order for all children. Three trials of each food were run. Each food was first shown to the child in a transparent bowl for 10 s and then offered to him/her. Smooth and rough purees and pieces (carrot, chicken and pasta) were offered with a standard spoon (Kapitex®), and baby biscuits, cheese, cucumber and raw apple were offered as finger foods (Table 2). For each trial, offering stopped after three consecutive refusals were emitted by the child (Demonteil et al., 2019). Three trained experimenters performed the test sessions. They familiarized themselves on experimental setup and assessment of behaviours (see below) by conducting a few experimental sessions of the study together.

Table 2: Offered foods during the experimental laboratory sessions conducted before (at 8 months) and after (at 15 months) the intervention period

Age (mo)	Food items	Texture	Sources/brand	Serving temperature	Session	Order	Specification
8	Carrot	Smooth and thick puree (5% water)	Ad hoc food *	Heated	S1	1	3 spoons
8	Chicken ham	Minced	Fleury Michon	Room	S1	2	3 spoons
8	Apple/strawberry/banana puree	Rough puree with lumps	Babybio	Room	S1	3	3 spoons
8	Baby biscuit (10 months old)	Whole biscuit	Carrefour baby	Room	S1	4	Finger food -1 minute duration
8	Carrot	Rough puree (fork mashed)	Ad hoc food*	Heated	S2	1	3 spoons
8	'petit suisse' white cheese	Smooth and sticky	Paturage, 9.2% fat	From fridge	S2	3	3 spoons
8	Banana	Rough puree (fork mashed)	Local supermarket	Room	S2	4	3 spoons
8 15	Carrot	Soft cooked pieces (6x6x6 mm)	Ad hoc food*	Heated	S2 S1	2 1	3 spoons
15	Carrot	Smooth liquid puree (15% water) with 29% of hard pieces (6x6X6 mm)	Ad hoc food*,a	Heated	S1	2	3 spoons
15	Chicken breast	Steamed pieces (1 cm x 1 cm x 0.5 cm)	Local supermarket	Room	S1	3	3 spoons of 1 piece
15	Hard cheese (Comté)	Stick (5 mm thick)	President Le Montarlier	Room	S1	4	Finger food – 3 mouthfuls
15	Cucumber	Slice (5 mm thick)	Local supermarket	Room	S2	1	Finger food – 3 mouthfuls
15	Carrot	Hard (blanched) pieces (6x6x6 mm)	Ad hoc food*,a	Heated	S2	2	3 spoons
15	Pasta	Farfalline cooked in water for 10 min	Barilla	Heated	S2	3	3 spoons of 3 pasta each
15	Apple (Pink Lady)	Slice (5 mm thick)	Local supermarket	Room	S2	4	Finger food – 3 mouthfuls

* Manufactured from baby food raw material in the UMR SayFood (AgroParisTech, Massy) pilot plant;
[a] Average hardness of 50g of pieces evaluated (TA.HD Plus texture Analyser - Stable Micro Systems, Godalming, UK - equiped with a Kramer cell. Speed test : 0,5mm/s, Distance : 55mm) for soft pieces (270 N) and hard pieces (1650 N).

The foods evaluated at the age of 8 months were semisolid foods (soft and rough purees; white cheese), soft cooked carrot pieces and a baby biscuit (Table 2). These foods could melt in the mouth and could be eaten by sucking. The foods evaluated post-intervention at 15 months old were chosen to explore a wide range of textures: smooth and hard pieces (carrot, chicken, pasta), double texture (carrot pieces in puree) and finger foods of different hardness (raw cucumber, raw apple, Comté® cheese).

2.3.2.2. Assessment of food acceptance during lab session

For each trial, the experimenter coded various children's behaviours using a previously developed behavioural grid (Demonteil et al., 2019). For each trial, the food was considered accepted if the child 'swallowed the food'. Other mutually exclusive acceptance-related behaviours were coded: 'refuses the food' (food did not enter the mouth), 'spits the food out' ('immediately after putting in mouth' or 'after manipulation in mouth'). The presence of these behaviours was coded as 1, and the absence was coded as 0.

The experimenter also coded other behaviours ('looks at the food', 'manipulates the food with fingers' and 'puts the food in the mouth with fingers/spoon', 'sucking', 'chewing', 'gagging', 'coughing/risk of choking', 'has difficulties with the foods'), and parents evaluated the infant's liking of the food on a linear scale. In the present study, for a sake of clarity, only acceptance-related behaviours (refuse, spits out, swallow) are presented.

To evaluate characteristics associated with food acceptance, we defined a global acceptance score (TexAcc_lab) representing the total number of food trials swallowed by the child during the two experimental sessions at 15 months old. To do so, data (coded as 0: not swallowed; 1: swallowed) collected over the three trials of a food were first averaged. Then, the means of all individual foods were summed, with the sum representing an acceptance score for each child. By definition, this score varies from 0 (the child did not swallow any trial of any food item) to 8 (the child swallowed all trials of all the offered food items).

2.3.2.3.Assessment of children's saliva flow rate and children's chewing performance during lab sessions

Salivation and mastication were hypothesised to play a role in individual's ability to eat foods as both mechanisms are known to play a role in food oral processing and bolus formation (Chen, 2009). Children's salivary flow rate and chewing efficiency were determined after a 5 min break following food acceptance measurement. The salivary flow rate was measured using a cotton swab method (Salivette®, Sarsedt) for a 45-sec duration. Saliva collection was performed by the parent maintaining the swab for 45 seconds in child's mouth. The weight of the swab was determined before and after collection and flow rate (g.min-1) was determined. Chewing efficiency was assessed from children's ability to comminute a model gel inserted in a mesh feeder during a standardized duration as described in Tournier et al. (2019). The number of formed particles collected after oral processing was used as a marker of this ability. Salivary flow rate and chewing efficiency were assessed at each experimental session (2 replicates). Intrasubject mean variables were used.

2.3.2.4.Lure odour task

The experimental session ended up with a 'lure' odour task aiming at avoiding CG parents' attention focusing too much on texture. Children were offered two baby bottles closed with gauze (one was empty and one contained vanilla flavour) to smell during a standardized duration (Wagner et al., 2013). This task does not serve the purpose of the study and is therefore not discussed further in this paper.

2.3.3. Other participant characteristics

After the intervention, other children and parental feeding practice characteristics were assessed because of their hypothesized role in individual food texture exposure and acceptance outcomes. Parents were asked whether they searched for advice on how to introduce food pieces in their infant's diet during the course of the study. Other pieces of information concerning parental feeding practices were collected: meal taken with the family (yes/no) and food preparation type (ready to eat baby foods, homemade foods, commercial non-baby foods; on a 5-point scale: 'never', 'rarely', 'sometimes', 'often' and 'always').

Parental motivations when buying foods for children were evaluated using a questionnaire assessing six dimensions: Convenience, Weight-control, Natural, Health-concern, Preference and Price (Rigal, Chabanet, Issanchou, & Monnery-Patris, 2012). These motivations were assessed using a series of 17 questions starting with 'I pay attention that the food I buy for my

child is…' and parents answer on a 5-point scale ranging from 'very wrong for me' to 'very true for me'. To assess whether participants were considering the texture when buying food for their child, we added 2 items to this questionnaire: 'I pay attention that the foods I buy for my child are 'easy to swallow' and 'I pay attention that the foods I buy for my child are easy to chew'.

Parents evaluated and reported their children's feeding skills/behaviours (holding a spoon in the mouth alone, eating with fingers, self-feeding with a fork, gagging) on a 4-point scale ('never', 'rarely', 'sometimes' or 'often'); parents also reported the number of teeth in their child's mouth.

Children's appetite traits were parent-reported at 12 months old through the 'food responsiveness', 'enjoyment of food', 'satiety responsiveness', 'food fussiness', 'emotional over-eating', and 'external food cue responsiveness' dimensions from the French version of the Child Eating Behaviour Questionnaire adapted for Toddlers (CEBQ-T; (Brugaillères, Chabanet, Issanchou, & Schwartz, 2019; Herle, Fildes, van Jaarsveld, Rijsdijk, & Llewellyn, 2016)), which is a modified version of the validated CEBQ (Wardle, Guthrie, Sanderson, & Rapoport, 2001).

2.4. Data analysis

Statistical analyses were performed using SAS 9.3 software (SAS Institute Inc., Cary, NC, USA).

2.4.1. Effect of intervention on outcomes 1 and 2

Texture exposure scores (N of items introduced for each texture level (T1, T2 and T3) and in total (TexExp score)) are presented as the means (±SD), and differences between study groups (control vs. intervention) were tested using one-sided (intervention group > control group) Student's t-tests, with a Bonferroni adjustement (alpha level of 0.016 (0.05/3) per test on T1, T2 and T3 subscores).

Texture acceptance (experimental evaluation of children swallowing the food (binary data)) is presented as a frequency (%). The effect of the study group and products on acceptance was assessed using a generalized linear mixed model (group, participant within group, food and group×food interaction as fixed factors). The group effect was then assessed for each food independently using chi-squared tests, with Bonferroni adjustement (alpha level of 0.006 (0.05/8)) per food.

Differences between study groups (control vs. intervention) for the global acceptance score (TextAcc_lab) were tested using one-sided (intervention group > control group) Student's t-test.

2.4.2. Description of other participant characteristics

For other participant characteristic variables, group comparisons were made using two-sided Student's t-tests for continuous variables (means ±SDs) and chi-squared tests for categorical characteristics (percentages). Questionnaire dimensions were considered only if the corresponding Cronbach's alpha was >0.70. Data concerning the use of food preparation methods (ready to eat baby foods, homemade foods, commercial non-baby foods) were dichotomized (combining 'never'/'rarely' and combining 'sometimes'/'often'/'always') as well as those concerning feeding skills (combining 'never'/'rarely' and combining 'sometimes'/'often').

2.4.3. Exploratory analysis of the associations between the study outcomes and the other participant characteristics

In addition to the intervention effect, we explored whether exposure and acceptance outcomes were associated with the other measured participant characteristics. We calculated the associations between the global texture exposure score outcome (TexExp) and the following characteristics variables: age of CF introduction, birth order, breastfeeding, 'search for information on texture introduction', 'food preparation type', 'children feeding skills' and 'food fussiness' using generalized linear mixed models (study group + characteristic variable) for each variable. Associations between the TexAcc_lab outcome and the other children characteristics variables (oral physiology parameters, feeding skills and CEBQ-T dimensions) were assessed using generalized linear mixed models (study group + variable) for each variable independently. For all statistical analyses, significance was set to $p<0.05$.

3. Results

3.1. Participant characteristics

Figure 1 about here

Fig. 1: Study design and flow chart

In total, 69 parent-child dyads contacted us to participate, and 64 of them were enrolled in the study (Fig. 1). During the intervention, 4 of them dropped out because they were not available or did not want to participate any more. In total, 60 dyads completed the intervention, leaving a final dataset of 30 children in each group.

Table 3: Sociodemographic characteristics and feeding practices of participants at baseline

	Study groups [(a)]		P value
Characteristics [(b)]	**Control, CG (n=30)**	**Intervention, IG (n=30)**	
Parental characteristics			
Mother's age (years) at child's birth (mean(SD))	31.8 (4.9)	31.9 (4.0)	0.94
Father's age (years) at child's birth (mean(SD))	34.0 (6.2)	34.1 (5.7)	0.96
Married, living together (%)	29 (97)	30 (100)	/
Mother education level attainment (%)			0.39
High school diploma at most	7 (23)	7 (23)	
2-year university degree	12 (40)	14 (47)	
Master's or doctoral degree	11 (37)	9 (30)	
Father education level attainment (%)			0.29
High school diploma at most	16 (53)	10 (33)	
2-year university degree	9 (30)	12 (40)	
Master's or doctoral degree	5 (17)	8 (27)	
Maternal level of anxiety (STAI) (mean(SD))	37.6 (7.4)	37.4 (1.5)	0.91
Maternal food neophobia (FNS) (mean(SD))	23.1 (2.1)	24.4 (2.3)	0.67
Infant characteristics			
Birth weight (kg) (mean(SD))	3.6 (0.5)	3.3 (0.4)	0.01
Birth height (cm) (mean(SD))	50.4 (2.1)	49.6 (2.0)	0.12
Weight-for-length Z-score at birth (mean(SD))	0.51 (0.9)	0.10 (1.2)	0.15
Weight-for-length Z-score at 8 months (mean(SD))	0.17 (0.7)	0.04 (1.0)	0.56
Sex (% female)	13 (43)	12 (40)	0.79
Birth order (%)			0.42
1	13 (43)	10 (33)	
2 and higher	17 (57)	20 (67)	
Baby Eating Behaviour dimension at 7.5 mo (BEBQ) (mean(SD))			
Food responsiveness (6 items, α=0.77)	1.83 (0.7)	1.85 (0.7)	0.88
Enjoyment of Food (4 items, α =0.75)	4.58 (0.5)	4.37 (0.6)	0.15
General Appetite (1 item)	3.57 (1.1)	3.50 (0.9)	0.79
Infant and Toddler Sensory Profile (ITSP) variables (8 mo)			
Sensation seeking (14 items, α=0.73)	25.6 (7.8)	24.1 (6.7)	0.45
Sensory sensitivity (11 items, α=0.70)	43.3(5.4)	43.3 (5.1)	0.99
Feeding practices			
Any breastfeeding (n(%))	20 (67)	23 (77)	0.39
Breastfeeding at inclusion (n(%))	8 (27)	8 (27)	/
Age of CF introduction (mean(SD))	4.8 (0.6)	4.9 (0.6)	0.40
Way of CF introduction: *Spoon-feeding with purees* (n	30 (100)	30 (100)	1.00

(%))			
Introduction of small F&V pieces at 7.5 mo [c]	5 (17)	3 (10)	0.45
Introduction of meat and fish pieces at 7.5 mo [c]	0 (0)	0 (0)	/
Type of daycare at inclusion (several possibilities (n(%)))			
Baby sitter	13 (43)	14 (47)	0.80
Daycare	8 (27)	11 (37)	0.40
Family members (including parents)	12 (40)	9 (30)	0.42
Others	2 (7)	0 (0)	/

(a) Percentage data have been rounded and may not total 100; (b) Data were missing for 4 participants for BEBQ 'general appetite'; for 3 participants 'food responsiveness' and for 1 participant for the ITSP dimensions; (c) Texture introduction before intervention: pieces offered 'sometimes/often'.
α: Cronbach's α; STAI: State and Trait Anxiety Inventory; FNS: Food Neophobia Scale; BEBQ, Baby Eating Behaviour Questionnaire; ITSP: Infant/Toddler Sensory Profile

Mothers and fathers participating in the study were an average of 32 and 34 years old, respectively, when the child was born (Table 3). First-time parents accounted for 43% of the parents in the CG and 33% of the parents in the IG. Children in the CG were slightly heavier at birth than those in the IG, but the weight-for-length z-score (at birth or at 8 months old) did not differ across groups. Study groups did not differ in terms of children's appetitive traits and sensory profile (for all dimensions) before the intervention either.

All children involved in the study were introduced to CF with purees fed with a spoon. Within each group, few children were introduced to food pieces before the intervention. A total of 17% of children in the CG and 10% in the IG were regularly offered small fruit and vegetable pieces. None were offered pieces of meat and fish. Study groups did not differ with regard to the texture of complementary foods offered before intervention (Table 3). Childcare use was also similar between the CG and IG ($p>0.05$). Study groups were thus comparable before the start of the intervention.

3.2. Primary outcome: Food texture exposure

The 7-month intervention impacted the introduction of food textures to the infant's diet (Table 4). When taking all food texture items together, the global exposure score to texture (TexExp) was significantly higher (approximately 14 additional items) in the IG than in the CG ($p<0.05$) (Table 4). When looking at texture levels, we observed that parents from the intervention group (IG) offered significantly more 'small and soft food pieces' to their child than parents from the control group ($p<0.016$; Table 4). This represents 5 additional items for the parents in the IG. However, exposure to 'harder pieces and double texture' was not different between groups, despite a trend in the same direction, with 6 additional items in the

IG; moreover, the minimum number of T3 textures introduced was twice as high in the IG (15, Table 2) than in the CG (6; Table 4). These results suggest that the intervention had a positive effect on children's exposure to a variety of small/soft pieces but less of an effect on more difficult-to-chew foods (such as large and hard pieces that require chewing and double texture which requires tongue manipulation). Within each group, inter-individual differences for each type of exposure score were observed (Table 4).

The proportion of parents reporting that they searched for additional information on food texture introduction during the study was high in both groups (73 and 87% in the CG and IG, respectively) and did not differ between groups ($p>0.05$, Table 5). The type of food preparation used did not differ between the CG and IG, with children being mainly fed homemade foods (>90%) and commercial baby food products (∼70%). The proportion of children fed commercial non-ready-to-eat baby foods was 35% in the CG and 43% in the IG. In both groups, parents were moderately paying attention to the texture (ease of chewing/swallowing) of the foods they bought for their child (Table 5).

Table 4: Comparison of food texture exposure and children's texture acceptance outcomes in the control and intervention groups

Study outcomes	Control group (n=30)	Intervention group (n=30)	P value*
Primary outcome: Food texture exposure (mean(SD); [min; max])			
TexExp: Global exposure score [a] (Total number of items introduced over 188)	96.1 (32.2) [38-170]	109.9 (29.6) [61-175]	**0.04**
Smooth and rough purees (T1, number introduced over 38)	28.8 (5.1) [19-37]	31.6 (5.7) [11-38]	0.025
Soft solid food pieces (T2, number introduced over 41)	22.8 (7.5) [8-37]	27.6 (6.1) [15-40]	**0.004**
Large cooked and/or hard pieces and double texture (T3, number introduced over 109)	44.5 (23.5) [6-98]	50.7 (23.1) [15-102]	0.15
Secondary outcome: Experimental food texture acceptance			
Global acceptance score: TextAcc_lab (mean(SD); [min; max])	5.1 (2.5) [0; 8]	5.4 (1.8) [1.7; 8]	0.35

[a] Total exposure score is the total amount of food texture introduced (T1 +T2 +T3; Demonteil et al.; 2018). * Undajusted p-Values. For T1, T2 and T3 scores, the *p-value* presented in bold is significant after Bonferroni adjustment ($\alpha<0.016$).

Table 5: Comparison of parent feeding practices, child oral characteristics and feeding skills and child's appetite traits (CEBQ-T) characteristics in the control and intervention groups

Variables [a]	Control group (n=30)	Intervention group (n=30)	P value
Search for advise on food pieces introduction (n(%))	22 (73)	26(87)	0.20
Other feeding practices characteristics			
Meal taken with the family (n(%))	21 (70)	21 (70)	1.00
Food preparation types (n(%))[b]			
Ready-to-eat baby foods	20 (69)	21 (70)	0.93
Home-made foods	27 (90)	28 (93)	/
Commercial non-baby foods	10 (35)	13 (43)	0.49
Parental motivations when buying food for their child (mean(SD))[c]			
Convenience (3 items, α=0.71)	3.33 (0.7)	3.27 (0.7)	0.66
Weight-control (3 items, α=0.85)	3.51 (0.7)	3.12 (0.8)	0.06
'Easy to chew/swallow foods' (2 items b, α=0.8) [d]	3.72 (0.8)	3.55 (0.8)	0.40
Children oral characteristics			
Number of teeth	8.4 (3.2)	8.4 (3.5)	0.97
Salivary flow rate (mL/min) [e]	0.81 (0.44) (n=17)	0.79 (0.31) (n=20)	0.86
Masticatory performance (nb particles) [e]	166.3 (101.7) (n=16)	162.0 (97.4) (n=11)	0.51
Children feeding skills (n (%)) [f]			
Hold the spoon in the mouth alone	19(63)	25(83)	0.08
Eating with fingers	27(90)	27(90)	1.00
Self-feeding with a fork	14(47)	16(53)	0.61
Gagging	8(27)	6(20)	0.54
Child Eating Behaviour (CEBQ_T variables at 12 months; mean(SD)) [g]			
Food responsiveness (4 items, α=0.83)	2.33 (0.97)	2.37 (1.05)	0.89
Enjoyment of food (4 items, α=0.76)	4.09 (0.59)	3.97 (0.67)	0.44
Satiety responsiveness (5 items, α=0.85)	2.54 (0.70)	2.63 (0.89)	0.68
Food Fussiness (5 items, α=0.88)	1.66 (0.68)	1.75 (0.76)	0.66
Emotional over-eating (3 items, α=0.92)	1.57 (0.76)	1.35(0.55)	0.22
Ext. food cue responsiveness (3 items, α=0.74)	3.87 (0.72)	3.64 (0.86)	0.29

Data were missing for 1 participant for the 'other feeding characteristics' variables and for 2 participants for the CEBQ-T variables; [a] Outcomes and variables were measured at 15 months old unless specified otherwise. Percentage data have been rounded and may not total 100.

α: Cronbach's α; [b] reported frequencies of grouped answer for: 'sometimes/often/always';/: low effective in 'rarely/never' answers do not allow application of Chi-square test. [c] PMQ: Questionnaire relating to parental motivations when buying food for children. [d] Dimension added specifically for this study (evaluated from the 2 items: 'I pay attention that the foods I buy for my child are 'easy to swallow' and 'easy to chew'); [e] n is the number of children for whom flow rate and chewing efficiency were collected (children complying to the collecting protocol); [f] frequency of children presenting the skills 'sometimes/often'; [g] CEBQ-T: Child Eating Behavior Questionnaire for Toddlers.

3.3. Secondary outcome: children's food texture acceptance

Before the intervention, there were no significant differences between groups in terms of acceptance for the 8 different foods offered in the laboratory (all Ps> 0.05; Suppl. Fig. 1).

After the intervention, at the age of 15 months (Fig. 2), children's acceptance (i.e., swallowing probability) was largely dependent on the food ($F(7,1366)=25.4$, $p<0.0001$). Group differences were studied for each food independently. Difference between the CG and IG were not significant for any of the eight studied foods. These acceptance scores at the food level were summarized into a global texture acceptance score (TextAcc_lab, Table 2), which did not differ significantly between groups (5.4 in the IG vs 5.1 in the CG, $p>0.05$; Table 2).

Fig 2 about here

Fig. 2: Food acceptance at 15 months old after the intervention in the control group (CG) and in the intervention group (IG). Acceptance is the probability of swallowing (black bars). Rejecting: children refuse to put the food in the mouth (white bars); spat out: the food was placed in the child's mouth but spat out immediately or after oral processing (hatched bars). There was no significant group difference for any foods studied after Bonferroni adjustement (α<0.006).

3.4.Exploratory analysis of the associations between study outcomes and other participant characteristics

3.4.1. Predictors of texture exposure score (primary outcome)

Independent of the group to which they were randomized, children's exposure to texture at the age of 15 months depended on parity. First-born children had a significantly lower exposure score (B=-17.6, 95% CI [-33.6, -1.6], p=0.03) than non-first-born children. TexExp was related neither to age of CF introduction nor to breastfeeding experience (p>0.05).

TexExp was also associated with other maternal feeding practices and children's feeding skills at 15 months old. Children sometimes/often/always fed with commercial baby foods had a lower texture exposure score than children never/rarely fed with these foods (B=-26.9, IC95% [-43.1, -10.7], p=0.0016). TextExp was higher in children sometimes/often eating with fingers than in those never/rarely doing so (B=30.5, IC95% [4.9, 56.2], p=0.02) and lower in children presenting frequent gagging than in those never/rarely experiencing gagging (B=20.8, IC95% [2.49,39.1], p=0.02). TextExp was not related to whether mothers searched for information on the introduction of pieces during the course of the study or whether they

were motivated to buy foods that are easy to chew/swallow for their child or to the child's level of food fussiness (CEBQ_T) (all Ps>0.05).

3.4.2. Predictors of experimental food texture acceptance (secondary outcome)

The texture acceptance score (TexAcc_lab) was related to the texture exposure score (TexExp; B=0.024, IC95% [0.006, 0.04], p=0.041). When broken down by texture level, TexAcc_lab was positively associated with the number of 'soft and small pieces' (TexExp_T2; B=0.13, IC95% [0.05, 0.20], p=0.002) and of 'hard/big pieces and double texture' (TexExp_T3; B=0.03, IC95% [0.006, 0.05], p=0.013) but not with 'smooth and rough purees' (TexExp_T1; p=0.8). Thus, independently of their study group, the more children were exposed to textured (i.e., non-pureed) foods, the more they accepted a variety of food textures during lab sessions. Moreover, TexAcc_exp was related to children's appetite traits at 12 months old: children who had higher scores for food responsiveness (B=0.82, IC95% [0.28, 1.36], p=0.004) and enjoyment of food (B=1.02, IC95% [0.12, 1.91), p=0.027) and a lower score for food fussiness (B=-1.38, IC95% [-2.11, -0.64], p=0.0004) had a higher texture acceptance score. TextAcc_lab was not significantly related to any of the oral physiology parameters or any of the feeding skills listed in Table 2 (all Ps>0.05).

4. Discussion

This intervention study evaluated the effects of providing advice and regular counselling for promoting the introduction of textured foods on parental feeding practices and children's food texture acceptance. We observed that parents in the intervention group introduced more texture variety of soft/small food pieces than parents in the control group. However, groups did not differ with regard to the introduction of hard/large pieces and double texture. There were no between-group differences in children acceptance for eight foods of different textures as assessed in a laboratory setting. Several factors among parental feeding practices and children's characteristics were associated with these intervention outcomes.

The information provided to parents influenced the introduction of soft/small pieces that can be eaten using tongue-palate compression but not the introduction of the most challenging textures (i.e., hard/large pieces requiring chewing or double texture requiring the manipulation of the chewy pieces and of the liquid phase by the tongue). One reason for this absence of effect regarding the introduction of the most challenging textures may be that the present children were already well advanced in their transition towards family foods. In line

with this, within each study group, 70% of the children were taking their meals with the family at 15 months old, and most of them (90% in the CG and 93% in the IG) were fed homemade foods. When comparing the present results to those previously collected on a larger sample of French children aged 13-15 months old (Demonteil et al., 2018), the number of introduced puree items was comparable (28 (CG) and 31 (IG) in our study vs. 29 in (Demonteil et al., 2018)), that of soft/small pieces was slightly higher (23 (CG) and 28 (IG) vs. 18 in (Demonteil et al., 2018)), and that of the more complex textures was almost twice as high in both groups of our study (45 (CG) and 51 (IG) vs. 25 in (Demonteil et al., 2018)). Parental age and educational attainment level were rather comparable between both studies; the main difference was birth order (38% of children were first-born in the present study vs. 77% in (Demonteil et al., 2018)). However, we observed in our sample that being a first-born child was significantly associated with a lower texture exposure score. Multiparous mothers may base their feeding practices on their past experience and thus may have been less sensitive to the advice they received in this intervention. Running the same study with only first-time mothers would be of interest here.

In addition, in both groups, parents' feeding practices with regard to texture introduction may have been influenced by the baseline laboratory measurements conducted at 8 months old. Indeed, during these laboratory assessments prior to intervention, children were offered a variety of foods in front of their parents, which may have drawn the attention of parents from the control group on the importance of texture. In addition, seeing their child coping well with the provided foods may have comforted parents and encouraged them to introduce more textured foods at home. It would have been interesting to include a second control group not taking part in the pre-intervention laboratory assessment to investigate this hypothesis. This hypothesis deserves further investigation since showing successful actual feeding episodes with children (through videos, for instance) could also be a tool complementary to providing advice with paper brochure and oral counselling to leverage parental feeding practices. Finally, it is likely that parents in both groups (and in particular in the control group) received external information. The present parents involved were indeed mostly well educated, followed the recommended age in the national guidelines to start CF and participated in the study of child feeding on a voluntary basis. They were likely interested in child nutrition and the introduction of texture as this was rarely addressed in the available national guidelines at the time of the study. However, our questionnaires revealed that most of the parents (73% in the CG and 87% in the IG) searched for information on this topic during the course of the study. Regardless of our will, texture introduction has become a topic of

high interest during the course of the study for various media in France. For example, an article suggesting the importance of letting children discover textured food was published in the local newspaper halfway through our study (Le Bien Public; June 2017). The internet and literature have been reported to be an important source of information on CF for parents after health professionals (Demonteil et al., 2018; Marduel Boulanger & Vernet, 2018). The quality of information available in paper and electronic formats is, however, judged by parents as being limited (Marduel Boulanger & Vernet, 2018). In these circumstances, there is clearly a need to provide both parents and health-care professionals in France with evidence-based recommendations on the introduction of texture during CF.

Intragroup variability of the mean exposure score was striking. In the IG group, the exposure score to the most challenging textures (hard pieces and double texture) varied between 15 and 102 food items. Such a low minimum score suggests that our intervention had a marginal impact on the feeding practices of some mothers. One hypothesis could be considered to explain this result. We observed a significantly lower exposure score for children with high gagging frequency, as also previously observed by Demonteil et al. (2018). Other studies reported that the fear of choking is often mentioned by French mothers with regard to the introduction of food textures in their child's diet (Marduel Boulanger & Vernet, 2018; Schwartz et al., 2013). Thus, we suppose that our advice was not efficient enough to reassure some concerned mothers, despite the provision of information on how to differentiate gagging from choking and safety advice. A further study of the barriers to texture introduction within mothers highly concerned regarding texture introduction would be needed to understand how to alleviate piece introduction-related stress and to increase the effectiveness of this kind of advice. Other factors can be considered to explain lower or higher exposure to food texture. Regarding the former, some mothers frequently feed their child with commercial ready-to-eat baby-foods, and yet the texture of these foods is rather homogeneous (Nicklaus et al., 2015). In contrast, exposure was higher in children regularly eating with their fingers. This association (observed by Demonteil et al. (2018)) is probably associated with a higher offering of finger foods.

Concerning the acceptance outcome, consequently to small differences in food texture exposure, acceptance of foods with various textures was very similar between groups. Acceptance (i.e., swallowing) frequency varied between 30 and 80% among the children. Swallowing frequencies for harder finger foods (apple and cucumber slices) were associated with a higher proportion of children putting the food in their mouth but spitting it out

afterwards, showing that they have not yet acquired the necessary chewing ability to break this food down and form a bolus for swallowing. When looking at the predictors of acceptance across groups, exposure to food textures stands out. The more parents introduced different solid foods ('small/soft pieces' and 'hard/big pieces and double textures'), the more their children ate foods of various textures in the laboratory. This relationship was not significant for pureed foods. These results highlight the necessity of exposing children to a large variety of food textures to foster their acceptance of textured foods at the age of 15 months. These results are also in line with those from another experimental study on chopped carrot acceptance in 12-month-old children (Blossfeld et al., 2007). Our study supports the ESPGHAN committee nutrition expert position to avoid the prolonged use of purees and to introduce texture foods from 8 months on (Fewtrell et al., 2017). In addition, texture acceptance is also associated with children's eating behavioural traits. The more children were 'food responsive' and 'enjoyed food' and the lower they were reported to be 'food fussy', the higher their texture acceptance score. These results are in agreement with a previous experimental study reporting a positive association between 'food enjoyment' and intake of freeze-dried bananas and crackers in 12- to 18-month-old children (Remijn et al., 2019) and a study reporting a positive association between 'food responsiveness' and liking of chopped carrots and a negative association between 'food fussiness' and intake of chopped carrots in 12-month-old children (Blossfeld et al., 2007). In our study, the lower texture acceptance observed in fussy children was not due to a lack of texture exposure. Indeed, as the CEBQ-T variables were not significantly associated with the exposure score, we conclude that in our study, mothers of fussy eaters have similar feeding practices towards texture introduction as mothers of less fussy eaters. Similarly, other studies reported that an exposure strategy for changing food acceptance was less effective when applied to fussy children (Caton et al., 2014; Holley, Haycraft, & Farrow, 2018)). More research is needed to better understand fussy children's resistance to complementary food introduction, particularly regarding food texture.

Surprisingly, food texture acceptance was not associated with oral physiology characteristics and feeding skills. Children's dentition did not explain differences in acceptance. However, the effect of teeth on texture acceptance is not systematically supported in experimental studies. Children's dentition was associated with a higher intake of chopped carrots at 12 months old (Blossfeld et al., 2007) but not with the intake of dried bananas and crackers at 12-18 months old (Remijn et al., 2019). We recently proposed a new method to evaluate infant masticatory performance based on the study of fragmentation of a model gel

under oral processing (Tournier et al., 2019) and applied it in the current study. Unfortunately, the compliance rate was average (yet equal to that previously observed in same age children (Tournier et al., 2019)), which probably does not provide sufficient power to evaluate the association with food acceptance ($p=0.1$). Saliva is also an oral parameter generally known to play a role in food oral processing and bolus formation (Chen, 2009), although it was not associated with texture acceptance in our study. Salivation is known to depend on food properties and salivary flow rate, as measured using cotton swabs in our study, may not be representative of real oral conditions. Finally, parental report of their child gagging frequency was not associated with his/her acceptance of textured foods during the experimental sessions.

This study has strengths and limitations. Concerning the intervention and its effect on parental feeding practices, the strength of this study is that we developed information on texture introduction (why, how and what), a topic that was not addressed in the national French guidelines. As described above, one limitation concerns the study population. Because of the high proportion of multiparous mothers who already have experience with food texture introduction, showing an effect of the intervention was probably more challenging than it would have been with only first-time mothers. More generally, this study is a pilot and deserves further work including the evaluation of developed advice with parents representing a wider range of sociodemographic characteristics. Moreover, we assessed texture exposure in terms of the variety of textures introduced at the age of 15 months. However, it would have been interesting to track the texture introduction pattern over the course of the intervention to see whether study groups differed in exposure dynamics. However, this may have led parents in the CG to become more aware of our focus on texture. Another limitation is that the baseline experimental sessions may have influenced parental feeding practices. However, this could be a very interesting strategy to influence practices of parents, in addition to oral or paper brochures. Regarding the strengths of our study, the laboratory setting for evaluating texture acceptance allowed a standardization of the evaluation procedure among all children. The number of foods of different textural properties studied was larger compared to most published studies. However, the distinction between role texture and flavour/taste may be considered a limitation, as most of the tested foods also varied in sensory characteristics other than texture. We proposed various carrot-based products, but the use of other foods allowed us to explore a much wider range of textures for core foods of the diet, such as pasta, cheese, raw fruit, and meat.

5. Conclusion

This pilot intervention study showed that providing information and monthly counselling to parents about the introduction of food textures to their child's diet resulted in an increase in parents' introduction of small/soft pieces but not on the introduction of more complex textures. Consequently, food texture acceptance was similar between the intervention and control groups Independent of the group to which they were allocated, first-born children were less exposed to food texture than children with siblings. Children experienced a larger variety of textures when they were ate with their fingers, presented less frequent gagging and were less often fed with commercial ready-to-eat baby foods. A larger exposure to food textures was associated with a better acceptance of the foods probed during experimental sessions in both the IG and the CG. Acceptance was also higher in children who were reported as enjoying food, being food responsive and being less fussy. Although this pilot study demonstrated that providing information can be effective in promoting the introduction of small and soft food pieces, the most effective way to encourage the introduction of more challenging textures (hard pieces and double texture) is not clear. Thus, future work should focus on the further identification of the barriers to piece introduction among French mothers and on how building on the knowledge of this pilot study for a future population-based public health intervention.

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Author's Contributions

This study was designed by CT, SN and CS. CT, CB and JM were responsible for the conception of the intervention. CB was responsible for the recruitment of the participants and data collection. JD and GC produced and characterized the ad-hoc carrot foods offered to children during the experimental sessions. CT and SN performed the analyses. CT, CB, CS and SN prepared the draft manuscript with inputs from JM, JD and GC. All of the authors are responsible for the study findings. All of the authors approved the final manuscript.

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References

Blossfeld, I., Collins, A., Kiely, M., & Delahunty, C. (2007). Texture preferences of 12-month-old infants and the role of early experiences. *Food Quality and Preference, 18*(2), 396-404.

Bournez, M., Ksiazek, E., Wagner, S., Kersuzan, C., Tichit, C., Gojard, S., . . . Nicklaus, S. (2018). Factors associated with initiation of complementary feeding in the French ELFE study. . *Maternal and Child Nutrition, 14*(2), e12536. doi: doi: 10.1111/mcn.12536.

Brugaillères, P., Chabanet, C., Issanchou, S., & Schwartz, C. (2019). Caloric compensation ability around the age of 1 year: Interplay with the caregiver-infant mealtime interaction and infant appetitive traits. *Appetite, 142*, 104382. doi: https://doi.org/10.1016/j.appet.2019.104382

Cameron, S. L., Taylor, R. W., & Heath, A. L. M. (2015). Development and pilot testing of Baby-Led Introduction to SolidS - a version of Baby-Led Weaning modified to address concerns about iron deficiency, growth faltering and choking. *BMC Pediatrics, 15*. doi: 10.1186/s12887-015-0422-8

Caton, S. J., Blundell, P., Ahern, S. M., Nekitsing, C., Olsen, A., Møller, P., . . . Hetherington, M. M. (2014). Learning to Eat Vegetables in Early Life: The Role of Timing, Age and Individual Eating Traits. *Plos One, 9*(5), e97609. doi: doi:10.1371/journal.pone.0097609

Chen, J. (2009). Food oral processing--A review. *Food Hydrocolloids, 23*(1), 1-25.

Cichero, J. A. Y. (2016). Introducing solid foods using baby-led weaning vs. spoon-feeding: A focus on oral development, nutrient intake and quality of research to bring balance to the debate. *Nutrition Bulletin, 41*(1), 72-77. doi: 10.1111/nbu.12191

Coulthard, H., Harris, G., & Emmett, P. (2009). Delayed introduction of lumpy foods to children during the complementary feeding period affects child's food acceptance and feeding at 7 years of age. *Maternal & Child Nutrition, 5*(1), 75-85.

da Costa, S. P., Remijn, L., Weenen, H., Vereijken, C., & van der Schans, C. (2017). Exposure to texture of foods for 8-month-old infants: Does the size of the pieces matter? *Journal of Texture Studies, 48*(6), 534-540. doi: 10.1111/jtxs.12271

Daniels, L., Heath, A. L. M., Williams, S. M., Cameron, S. L., Fleming, E. A., Taylor, B. J., . . . Taylor, R. W. (2015). Baby-Led Introduction to SolidS (BLISS) study: a randomised controlled trial of a baby-led approach to complementary feeding. *BMC Pediatrics, 15*. doi: 10.1186/s12887-015-0491-8

Daniels, L. A., Mallan, K. M., Battistutta, D., Nicholson, J. M., Meedeniya, J. E., Bayer, J. K., & Magarey, A. (2014). Child Eating Behavior Outcomes of an Early Feeding Intervention to Reduce Risk Indicators for Child Obesity: The NOURISH RCT. *Obesity, 22*(5), E104-E111. doi: 10.1002/oby.20693

Delaney, A. L., & Arvedson, J. C. (2008). Development of swallowing and feeding: Prenatal through first year of life. *Developmental Disabilities Research Reviews, 14*(2), 105-117. doi: 10.1002/ddrr.16

Demonteil, L., Ksiazek, E., Marduel, A., Dusoulier, M., Weenen, H., Tournier, C., & Nicklaus, S. (2018). Patterns and predictors of food texture introduction in French children aged 4-36 months. *British Journal of Nutrition, 120*(9), 1065-1077. doi: 10.1017/S0007114518002386

Demonteil, L., Tournier, C., Marduel, A., Dusoulier, M., Weenen, H., & Nicklaus, S. (2019). Longitudinal study on acceptance of food textures between 6 and 18 months. *Food Quality and Preference, 71*, 54-65. doi: 10.1016/j.foodqual.2018.05.010

Dunn, W., & Daniels, D. B. (2002). Infant/Toddler Sensory Profile : Caregiver questionnaire (7-36 months). *The Psychological Corporation*

Emmett, P. M., Hays, N. P., & Taylor, C. M. (2018). Antecedents of picky eating behaviour in young children. *Appetite, 130*, 163-173. doi: 10.1016/j.appet.2018.07.032

Fewtrell, M., Bronsky, J., Campoy, C., Domellöf, M., Embleton, N., Fidler Mis, N., . . . Molgaard, C. (2017). Complementary Feeding: A Position Paper by the European Society for Paediatric Gastroenterology, Hepatology, and Nutrition (ESPGHAN) Committee on Nutrition. *Journal of Pediatric Gastroenterology and Nutrition, 64*(1), 119-132. doi: 10.1097/mpg.0000000000001454

Gaspard, M. (2001). How children and teenagers acquire and utilize masticatory function (Part one). *Revue d'Orthopédie Dento-Faciale, 35*(3), 349-403.

Gisel, E. G. (1991). Effect of food texture on the development of chewing of children between six months and two years of age. *Developmental Medicine and Child Neurology, 33*, 69-79.

Harris, G., & Mason, S. (2017). Are There Sensitive Periods for Food Acceptance in Infancy? *Current Nutrition Reports, 6*(2), 190-196. doi: 10.1007/s13668-017-0203-0

Herle, M., Fildes, A., van Jaarsveld, C., Rijsdijk, F., & Llewellyn, C. H. (2016). Parental Reports of Infant and Child Eating Behaviors are not Affected by Their Beliefs About Their Twins' Zygosity. *Behavior Genetics, 46*(6), 763-771. doi: 10.1007/s10519-016-9798-y

Holley, C. E., Haycraft, E., & Farrow, C. (2018). Predicting children's fussiness with vegetables: The role of feeding practices. *Maternal & Child Nutrition, 14*(1). doi: 10.1111/mcn.12442

Illingworth, R. S., & Lister, J. (1964). The critical or sensitive period, with special refernce to certain feeding problems in infants and children. *The Journal of Pediatrics, 65*(Dec), 839-848.

INPES. (2005). *PNNS - La santé vient en mangeant - Le guide parents 0-3 ans*.

Le Reverend, B. J., Edelson, L. R., & Loret, C. (2014). Anatomical, functional, physiological and behavioural aspects of the development of mastication in early childhood. *British Journal of Nutrition, 111*(3), 403-414. doi: 10.1017/s0007114513002699

Limme, M. (2010). The need of efficient chewing function in young children as prevention of dental malposition and malocclusion. *Archives de Pédiatrie, 17, Supplement 5*(0), S213-S219. doi: http://dx.doi.org/10.1016/S0929-693X(10)70930-1

Llewellyn, C. H., van Jaarsveld, C. H. M., Johnson, L., Carnell, S., & Wardle, J. (2011). Development and factor structure of the Baby Eating Behaviour Questionnaire in the Gemini birth cohort. *Appetite, 57*(2), 388-396. doi: https://doi.org/10.1016/j.appet.2011.05.324

Marduel Boulanger, A., & Vernet, M. (2018). Introduction of new food textures during complementary feeding: Observations in France. *Archives de Pediatrie, 25*, 6-12. doi: 10.1016/j.arcped.2017.10.025

Nicklaus, S., Demonteil, L., & Tournier, C. (2015). Modifying the texture of foods for infants and young children In J. Chen & A. Rosenthal (Eds.), *Modifying food texture Volume 2: Sensory analysis, consumer requirements and preferences*: Woodhead Publishing.

Northstone, K., Emmett, P., Nethersole, F., & ALSPAC study team. (2001). The effect of age of introduction to lumpy solids on foods eaten and reported feeding difficulties at 6 and 15 months. *Journal of Human Nutrition and Dietetics, 14*(1), 43-54.

Pliner, P., & Hobden, K. (1992). Development of a scale to measure the trait of food neophobia in humans. *Appetite, 19*(2), 105-120. doi: https://doi.org/10.1016/0195-6663(92)90014-W

Remijn, L., da Costa, S., Bodde, C., Gerding, R., Weenen, H., Vereijken, C., & van der Schans, C. (2019). Hand motor skills affect the intake of finger foods in toddlers (12–18 months). *Food Quality and Preference, 74*, 142-146. doi: 10.1016/j.foodqual.2019.01.019

Rigal, N., Chabanet, C., Issanchou, S., & Monnery-Patris, S. (2012). Links between maternal feeding practices and children's eating difficulties. Validation of French tools. *Appetite, 58*(2), 629-637. doi: https://doi.org/10.1016/j.appet.2011.12.016

Schwartz, C., Madrelle, J., Vereijken, C., Weenen, H., Nicklaus, S., & Hetherington, M. M. (2013). Complementary feeding and "donner les bases du gout" (providing the foundation of taste). A qualitative approach to understand weaning practices, attitudes and experiences by French mothers. *Appetite, 71*, 321-331. doi: 10.1016/j.appet.2013.08.022

Schwartz, C., Scholtens, P., Lalanne, A., Weenen, H., & Nicklaus, S. (2011). Development of healthy eating habits early in life: review of recent evidence and selected guidelines. *Appetite, 57*(3), 796-807.

Schwartz, C., Vandenberghe-Descamps, M., Sulmont-Rossé, C., Tournier, C., & Feron, G. (2018). Behavioral and physiological determinants of food choice and consumption at sensitive periods of the life span, a focus on infants and elderly. *Innovative Food Science & Emerging Technologies, 46*, 91-106. doi: 10.1016/j.ifset.2017.09.008

SFAE. (2013). Enquête Nutri-bébé. *https://www.secteurfrancaisdesalimentsdelenfance.com/revele-volet-comportement-nutri-bebe-2013/*

Spielberger, C. D. (1993). Inventaire d'anxiété état-trait. In L. E. d. C. d. P. Appliquée (Ed.). Paris.

Stolovitz, P., & Gisel, E. G. (1991). Circumoral movements in response to three different food textures in children 6 months to 2 years of age. *Dysphagia, 6*, 17-25.

Szczesniak, A. S. (1972). Consumer awareness of and attitudes to food texture. II. *Children and teenagers*. *Journal of Texture Studies, 3*, 206-217.

Taylor, R. W., Williams, S. M., Fangupo, L. J., Wheeler, B. J., Taylor, B. J., Daniels, L., . . . Heath, A. M. (2017). Effect of a Baby-Led Approach to Complementary Feeding on Infant Growth and Overweight: A Randomized Clinical Trial. *JAMA Pediatrics, 171*(9), 838-846. doi: 10.1001/jamapediatrics.2017.1284

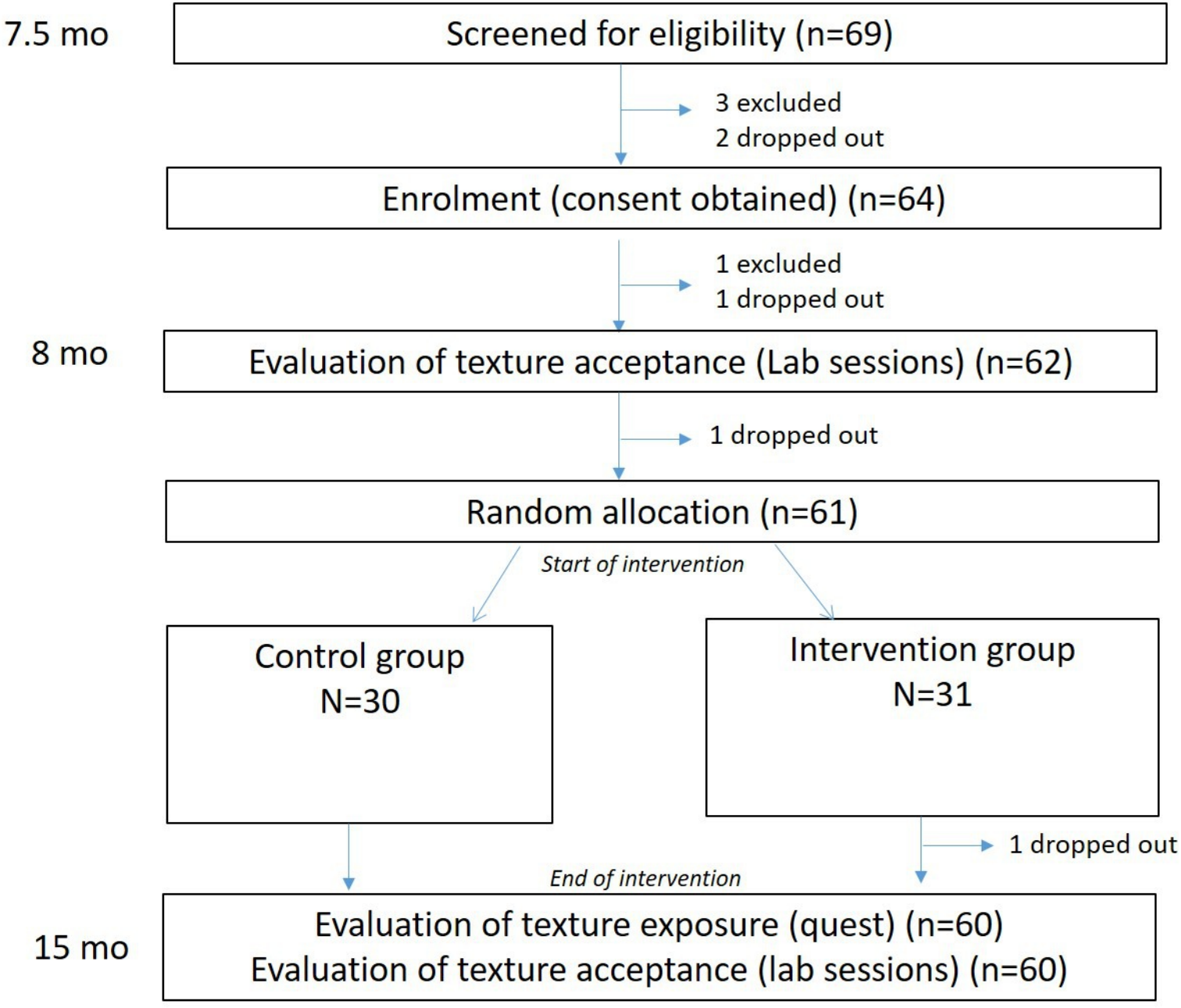
Tournier, C., Demonteil, L., Canon, F., Marduel, A., Feron, G., & Nicklaus, S. (2019). A new masticatory performance assessment method for infants: A feasibility study. *Journal of Texture Studies, 1*(11), 1-11. doi: 10.1111/jtxs.12388

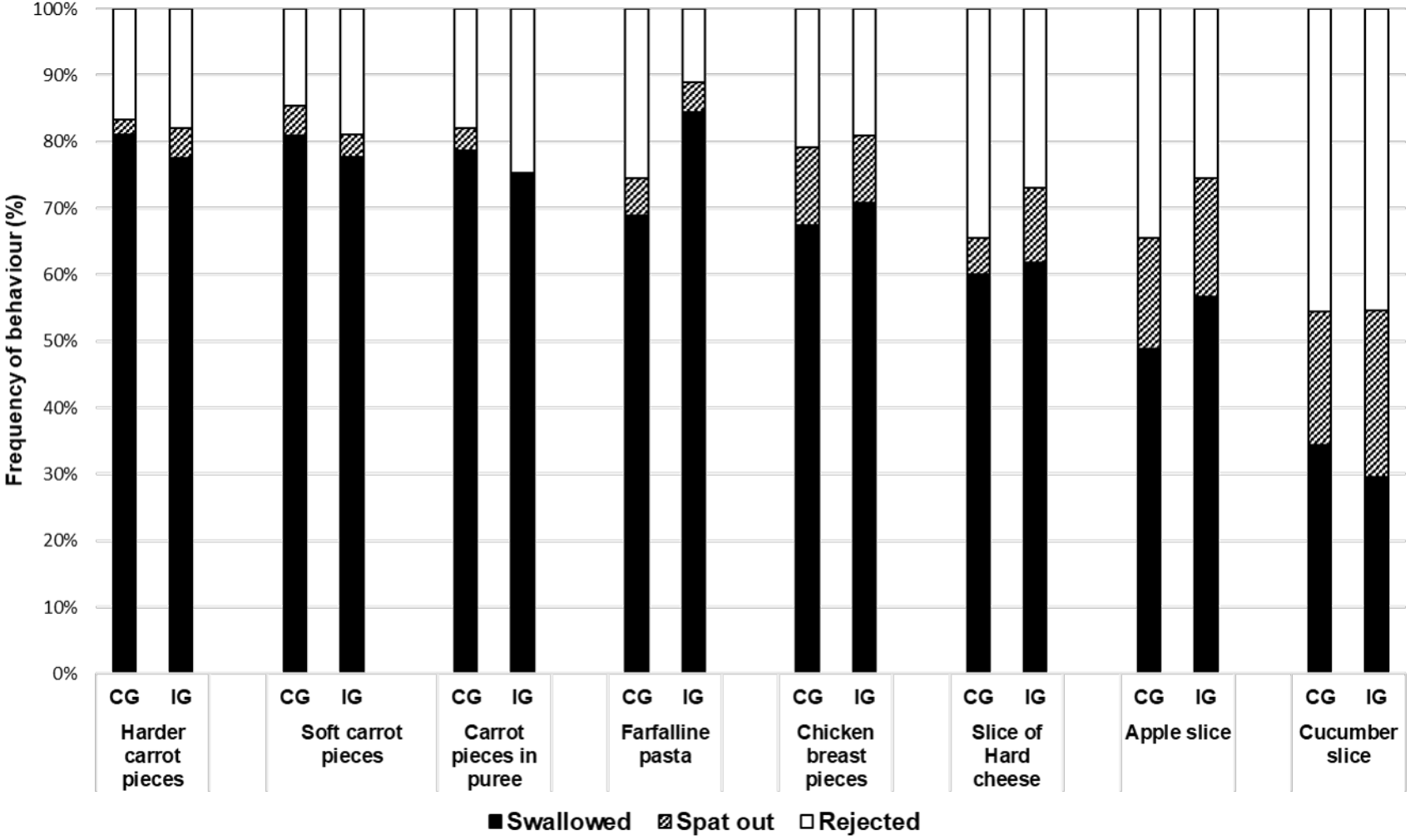
Wagner, S., Issanchou, S., Chabanet, C., Marlier, L., Schaal, B., & Monnery-Patris, S. (2013). Infants' hedonic responsiveness to food odours: a longitudinal study during and after weaning (8, 12 and 22 months). *Flavour 2*(19). doi: doi: 10.1186/2044-7248-2-19

Wardle, J., Guthrie, C. A., Sanderson, S., & Rapoport, L. (2001). Development of the children's eating behaviour questionnaire. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 42*(7), 963-970. doi: 10.1111/1469-7610.00792

WHO (2003). Complementary feeding : report of the global consultation, and summary of guiding principles for complementary feeding of the breastfed child. In W. H. O. http://www.who.int/iris/handle/10665/42739 (Ed.).

WHO. (2006). WHO Child Growth Standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and development *WHO Multicentre Growth Reference Study Group*


7.5 mo
Screened for eligibility (n=69)
3 excluded
2 dropped out
Enrolment (consent obtained) (n=64)
1 excluded
1 dropped out
8 mo
Evaluation of texture acceptance (Lab sessions) (n=62)
1 dropped out
Random allocation (n=61)
Start of intervention
Control group
N=30
Intervention group
N=31
1 dropped out
End of intervention
15 mo
Evaluation of texture exposure (quest) (n=60)
Evaluation of texture acceptance (lab sessions) (n=60)


100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Frequency of behaviour (%)
CG
IG
Harder carrot pieces
Soft carrot pieces
Carrot pieces in puree
Farfalline pasta
Chicken breast pieces
Slice of Hard cheese
Apple slice
Cucumber slice
Swallowed
Spat out
Rejected