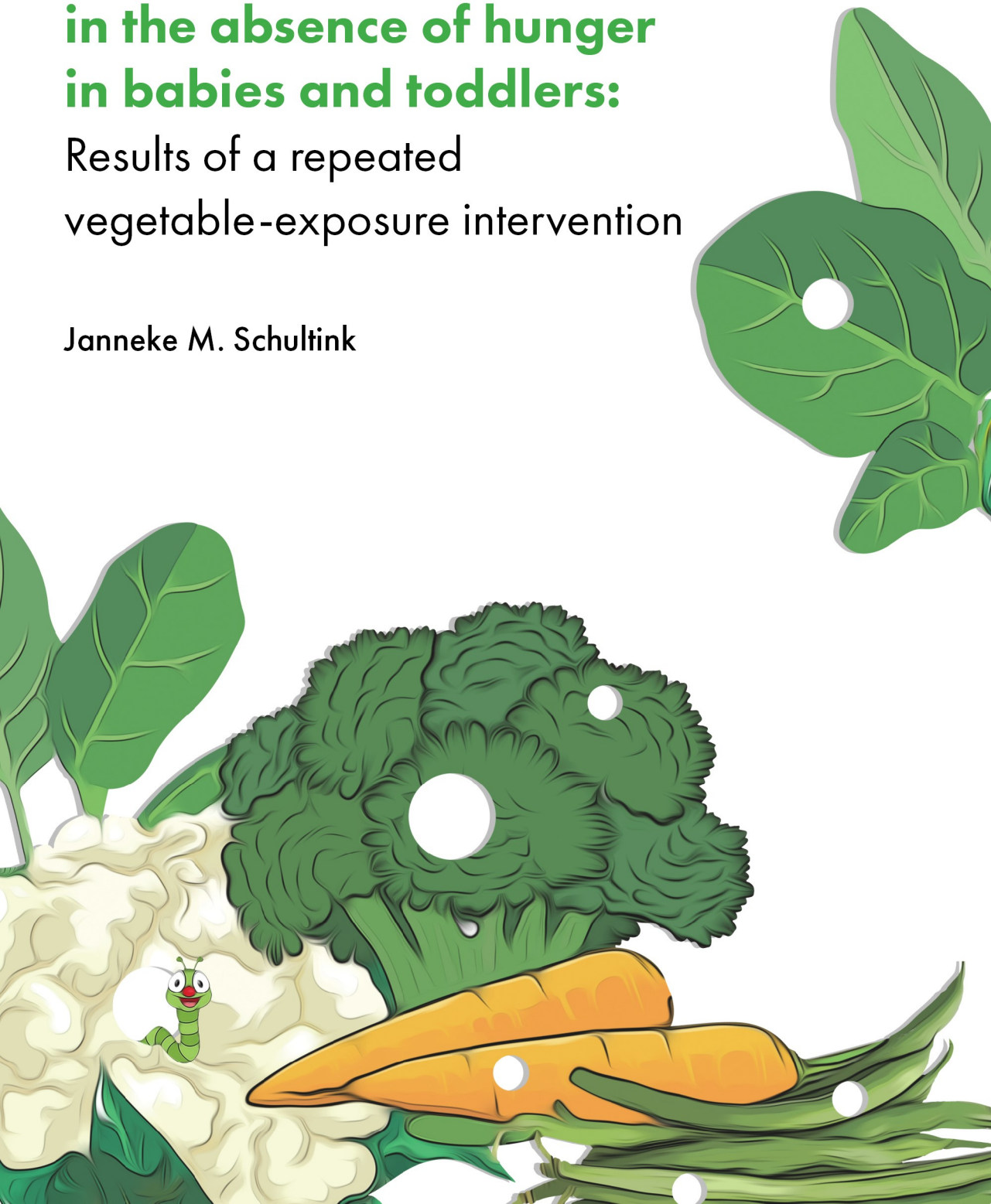
Vegetable intake and eating in the absence of hunger in babies and toddlers:

Results of a repeated vegetable-exposure intervention

Janneke M. Schultink



Propositions

1. Volunteering in a health focussed trial improves vegetable intake.
   (this thesis)

2. The eating environment stimulates toddlers to (over)eat indulging foods.
   (this thesis)

3. A doctoral thesis is complete without propositions.

4. BSc graduates of universities of applied sciences are better PhD-candidates for applied research than those of science oriented universities.

5. In light of the obesity epidemic, riding an e-bike should be prohibited by law for healthy school-aged children.

6. Day-care facilities and schools are essential in closing the health gap.

Propositions belonging to the thesis, entitled:

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Janneke M. Schultink
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Thesis

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Chapter 1

General introduction

In light of the rise in obesity and related diseases worldwide, promoting healthy dietary habits and food preferences is essential. Early prevention is considered important as overweight in childhood is predictive of overweight in adulthood. Dietary habits and food preferences are shaped in the first two years of life, and influence (healthy) food choices later in life [1-4]. Poor eating habits such as low fruit and vegetable intake, high energy dense and processed food intake, and overall low diet quality increase the risk of developing overweight. In the Netherlands, children's vegetable intake is below the recommendations [5]. Low consumption of vegetables and high consumption of energy-dense foods have already been observed in children aged 1-3 years [5-9]. Moreover, studies show that pre- and primary schoolers often struggle to regulate their energy intake and show a tendency to eat past the point of satiation [10, 11-15]. Eating past the point of satiation, and thereby failing to self-regulate energy intake, is a risk factor for developing overweight [15]. Utilizing the crucial first two years in a child's life can be a meaningful preventative approach to stimulate healthy dietary habits (i.e. self-regulation) and food preferences (i.e. vegetable intake and liking) from an early age, which can extend into adulthood [16-18].

The importance of sufficient vegetable consumption is eminent. Yet, it remains challenging to actually improve children's vegetable intake as they tend not to prefer vegetables. As preferences determine intake, gaining insight into the factors involved in shaping vegetable preferences may be used to stimulate vegetable intake. In addition, it is commonly accepted that babies are born with a natural ability to self-regulate their energy intake and that this ability reduces with age when external factors (e.g. availability of palatable foods, portion size) become increasingly more important in shaping choice and intake [19-21]. However, not much is known about self-regulation of energy intake in toddlerhood and how parents can play a role in preserving this ability.

This thesis focuses on vegetable intake and liking from the first bites of complementary food (age 4-6 months) up until the age of 2 years. In addition, self-regulation of energy intake is studied in the same study population at the ages of 18 and 24 months. Previous intervention studies, incorporating repeated exposure to vegetables, showed promising results regarding effects of early feeding interventions on vegetable intake [22-30]. However, the beneficial effects on vegetable intake do not seem to last when children grow older [26,31,32]. This is in line with the finding that children are open to trying a variety of different tastes in their first year of life, but tend to become more selective about their diet when they get older.

In this introductory chapter, I provide a background to children's vegetable intake and health, how food preferences are formed, different strategies to improve intake and liking of vegetables, the role of parental feeding practices on food acceptance and eating behavior (i.e. self-regulation of energy intake), and describe other determinants (e.g. food neophobia) of children's vegetable intake. Finally, the aim and outline of the present thesis are presented.

Vegetable intake and health

In the past years, the intake of vegetables in Dutch children, aged 1-3 years, has increased from an average of 41 grams per day in 2008 to 57 grams per day in 2016 [33,34]. However, in the Netherlands, an estimated 40-80% of preschoolers do not meet daily recommended intake of 50-100 grams per day for vegetables [7].

The importance of diets high in vegetable intake is recognized worldwide, as there is an abundance of evidence suggesting health benefits of consuming sufficient amounts of vegetables [35-38]. Vegetables are a great source of nutrients, have low energy density (when prepared without fat or sugar) and are a good source of dietary fiber [39]. Diets low in vegetables tend to include more foods of low nutritive quality that are high in sugar, saturated fat and salt content. This hampers meeting dietary recommendations and increases the risk of developing diet-related chronic diseases, such as cardiovascular disease, diabetes, some types of cancer and obesity [35-38]. Thus, increasing vegetable consumption improves diet quality and may decrease total energy intake, especially when vegetables are promoted to replace foods with higher energy density [39]. Additionally, soluble dietary fibers present in vegetables may delay gastric emptying and increase satiety [40]. Consequently a diet high in vegetables may contribute to maintaining a healthy body weight. This is important as the prevalence of obesity worldwide has doubled over the last four decades [41]. In the Netherlands, about 8% of the Dutch boys and 13% of the Dutch girls aged 3 years are considered being overweight [42]. Because overweight in childhood is predictive of overweight in adulthood, promoting healthy eating habits such as sufficient vegetable consumption from an early age onwards is crucial [16-18].

Development of food preferences in children

Food preference is seen as one of the most important predictors for food choice and intake [43-45]. Therefore it is important to understand how food preferences are formed in childhood in order to design strategies to improve health in both childhood and adulthood. The shaping of food preferences already starts during pregnancy and early milk feeding, when the flavors of a mother's diet transmit to the amniotic fluid and breastmilk, respectively. These very early flavor experiences serve as a foundation for the development of food preferences [46]. Children are born with a preference for sweet taste and a tendency to avoid bitter and sour tastes. A preference for salty taste develops around the age of 4 months [44,47]. Additionally, they have a predisposition to reject novel foods (neophobia) and come to like and prefer foods that are familiar to them [44]. In short, food preferences and selection are guided by both innate preference and the learning experience with different flavors and foods over time. Various learning mechanisms have been studied extensively, among which learned food safety, repeated exposure, flavor-nutrient learning, flavor-flavor learning, imitation and (social) reward [48-51].

The theory of *learned safety* suggests that neophobia (the fear of ingesting an unfamiliar or novel food) arises when an unfamiliar food is given and that a positive experience after eating is necessary (i.e. not becoming ill) to learn the food is safe for consumption [48]. Therefore, learned safety counteracts the predisposition to reject unfamiliar foods. By tasting small amounts of foods that are new, children learn that the offered food is safe to eat and acceptance of that particular food increases.

The learning mechanism *repeated exposure* works though the mechanism of learned safety. It is effective in increasing acceptance and intake of a new food or flavor. Repeatedly offering children an unfamiliar food, increases familiarity, liking and in turn intake [52,53].

In *flavor-nutrient learning* (FNL) positive associations are formed with a new food due to pairing them with energy dense ingredients (e.g. fat or carbohydrates). Children show a preference for foods that are high in energy (especially foods high in fat) [54,55]. FNL is based on the association between flavor and the effect of eating a food: it leads to satiation. In practice this generally involves pairing a new food with an energy dense and neutral flavored ingredient, attempting to increase liking through experienced satiety after eating the food.

In *flavor-flavor learning* (FFL) a new food is paired with an already known and liked taste (e.g. sweetness) or food (e.g. applesauce, mayonnaise) to facilitate liking and intake of the new or initially disliked food. This approach eventually leads to acceptance of the new food in absence of the added taste.

Imitation and social interaction within the family or between peers are known to be involved in food preference forming in children [51,56,57]. Children are naturally inclined to imitate others. This tendency is influenced by the quality of the emotional bond the child has with the role model. Therefore, parents are highly important role models when it comes to shaping eating behaviors and food preferences in their children [56]. For instance by having a family meal, a child will be more inclined to taste, and quicker to accept unfamiliar foods simply because they want to imitate [58].

Finally, *reward* can impact willingness to consume (unfamiliar) foods. Giving a tangible reward (e.g. stickers) or verbal praise appear to be effective in promoting intake of foods in children [59-61]. A possible downside to this strategy is that this external motivation to eat undermines internal willingness and liking. When intake is used as an outcome measure in studies investigating acceptance of foods, the effects of rewards are usually positive. However, when liking is the outcome, results are mixed [61]. The type of reward used can also impact the association (positive or negative) a child develops towards a food. For instance using tangible reward or verbal praise have been positively related to the intake of fruits and vegetables in children aged 2.5 to 7 years [61,62]. However, using food as reward (e.g. the promise of a dessert for eating vegetables) leads to a negative association with the unfamiliar or unliked food and increases liking and wanting of the unhealthy reward food [20,63].

In summary, various learning mechanisms can be involved in shaping food preferences. Infancy and toddlerhood are a sensitive and important period for shaping food preferences as well as dietary habits [1-4]. Experiences during this time set the stage for later food choices and are important for establishing food habits in later life [64]. Besides taste, other (sensory) food properties such as color, texture and appearance are important determinants of food acceptance among children.

Strategies to improve vegetable intake and liking in children

As previously stated, liking a food is an important predictor for intake [43-45]. This is especially true for children, as they eat what they like [43]. In general, children tend to dislike vegetables at first. This might be explained by vegetables having low intrinsic rewarding value, due to low energy- and macronutrient density, low flavor intensity, and their sensory properties, such as a bitter taste and particular mouthfeel [65-68]. A step to increase vegetable intake in children is to identify strategies to increase vegetable acceptance and liking. The learning

mechanisms described in the previous paragraph have been studied extensively as strategies to increase intake and liking of vegetables in infants and toddlers. In short, repeated exposure to vegetables has proven to be the most powerful method to enhance vegetable intake in infants and toddlers [16,25,69,70]. FNL and FFL have been investigated repeatedly, however recent studies did not find an added effect of FNL or FFL on vegetable intake to repeated exposure [71-77]. In addition, parental influence in the form of modeling (to target imitation) is an important strategy to stimulate vegetable intake [78]. Finally, rewarding with praise may stimulate vegetable consumption in young children (< 7 years) [78].

It has been suggested that the introduction of vegetables before fruits at the start of complementary feeding contributes to increased vegetable liking. The theory behind this is that this critical time for shaping food preferences, when infants are open to new trying new flavors, can be used to introduce the more 'difficult' or bitter tasting vegetables. Repeatedly offering a variety of vegetables at the start of complementary feeding will increase acceptance, liking and intake of vegetables. While infants' innate preference for sweet tastes will not interfere with the acceptance and liking of fruits if these are introduced later in the complementary feeding journey [27]. Whether starting complementary feeding with vegetables exclusively indeed results in increased vegetable liking and intake has not been studied often [79]. The trial by Barends et al.[30,31] tested this hypothesis and found that infants exposed to a variety of vegetables exclusively for the first three weeks of complementary feeding (including a target vegetable to which they were repeatedly exposed) had a significantly higher vegetable intake, than a control group that started exclusively with fruits. The children in the vegetable condition nearly doubled their intake of the target vegetable, whereas children in the fruit condition showed an increased intake of fruits, but not vegetables. This suggests starting complementary feeding by repeatedly exposing infants to a variety of vegetables is an effective way to increase vegetable liking and intake. However, as mentioned previously, these positive effects do not seem to last as children grow older [26,31,32]. Indeed, in the study by Barends et al. the effect was present at the age of 12 months but no longer at the age of 23 months, where the reported daily vegetable intake was similar for both groups. The authors speculate that the disappearance of the effect at 23 months was due to the onset of food neophobia. It was also suggested that the effect of a three-weeks intervention during weaning might not be enough to stimulate long-term vegetable acceptance and intake and it was recommended that parents should keep promoting a variety of vegetables during infancy and toddlerhood [31]. The current thesis builds on this hypothesis and studies the effectiveness of a more prolonged and intensified repeated vegetable-exposure intervention throughout the first year of complementary feeding to promote vegetable intake and liking in toddlers.

Parental feeding practices

In infancy and toddlerhood, parents and caregivers are primarily responsible for the diet of their children. The way parents offer food may strongly influence a child's acceptance of this food. Additionally, this may influence their ability to self-regulate their energy intake (i.e. the ability to act on one's feelings of hunger and satiety; [21,80]). A recent systematic review and meta-analysis examined the relationship between parental feeding practices (e.g. restrictive

guidance, modeling, control of availability, pressure to eat) and child food consumption of fruits, vegetables and sugar sweetened beverages [78]. The main findings indicate that availability and accessibility of food items along with parental modeling and reward with verbal praise were positively associated with child fruit and vegetable intake. Availability of food simply means that a particular food (i.e. vegetables) is available at home. Accessibility refers to whether these foods are prepared and maintained in a way that children are able or encouraged to eat them [81]. Modeling can be implemented as parental intake of a particular food item or the frequency that parents eat healthily and show the advantage and satisfaction of doing so in front of their children. Rewarding with verbal praise entails complementing a child for tasting a food. This practice appears to be more effective in promoting healthy eating in younger children (< 7 years) than in older children. Pressure to eat was negatively associated with fruit and vegetable intake. There are various ways of pressuring to eat, e.g. subtly moving food toward a child, verbally instructing a child to consume or try food or holding food up to a child's face. Even giving subtle prompts, may have a counterproductive effect [82]. However, in order to facilitate exposure to a new food or stimulate eating when children enter the more difficult phase of toddlerhood where they decrease their intake, parents are likely to use some sort of pressure to stimulate their children to eat. Additionally, pressuring children to eat decreases their ability to self-regulate energy intake and disrupts the ability to consume appropriate amounts of energy [83]

In contrast to pressuring children to eat, responsive feeding is often suggested to be the optimal way to feed infants and toddlers [84-87]. Responsive feeding is defined as a feeding style in which parents correctly interpret a child's hunger and satiety signals and respond promptly and appropriately [86-88]. This way of feeding is suggested to promote and reinforce young children's ability to self-regulate their energy intake, by not overriding their satiety cues [86]. Promoting responsive feeding has been shown to be associated with a reduced risk of overweight and rapid weight gain during the first years of life [86,89,90]. Although reacting to hunger and satiety signals may promote child self-regulation of energy intake, it is likely not sufficient to promote healthy food preferences including vegetable acceptance in the first years of life. From the age of 1.5 years, toddlers may experience the so-called "picky eating phase": a phase of selectively eating of both familiar and unfamiliar foods. This phase is present in about half of the children at some point between the age of 1.5 and 6 years and often co-occurs with fussy behavior at mealtimes [91–93]. As children become more autonomous and selective about the food they want to eat, parents will want to manage that they eat appropriate quantities and also specific (healthy) foods. In order to promote healthy food preferences, parents will need to stimulate their child to eat vegetables in a non-pressuring way that is sensitive to the child's desire for autonomy and (eating) behavior. It might take more to promote vegetable intake than just adequate responses to hunger and satiety, for instance sensitive disciplining techniques to challenging child behavior at mealtimes (e.g. when a child throws food on the floor) and sensitive responses to distracted behavior (e.g. when a child is more interested in what is happening around them than in the food). Therefore, in this thesis, the term *sensitive feeding* is used instead of responsive feeding. Sensitive feeding includes both the concept of responsive feeding and sensitive discipline techniques as well as autonomy support. Examples of sensitive disciplining strategies parents may use are: explicitly complimenting positive behavior, appropriate pacing to allow sufficient time to adapt to the

situation, granting appropriate amounts of autonomy and showing understanding for the child's point of view [94]. Using these sensitive discipline techniques has been shown to promote children's willingness and internal motivation to adhere to parental rules [95]. The current thesis further studies self-regulation of energy intake in toddlers and the possible effect of a sensitive feeding intervention on children's self-regulation skills.

Self-regulation of energy intake (eating in the absence of hunger)

Eating in the absence of hunger (EAH) refers to the failure to self-regulate energy intake, and the susceptibility to eat palatable, often energy-dense foods despite experiencing satiety [96], making it a behavioral risk factor for developing overweight [10,14,97,98]. Previous work in preschoolers and primary school age children has shown that EAH evolves with age and is consistent within individuals over time [10, 11–15]. Also, EAH has been observed in children as young as 21 months [12,99] suggesting it already occurs at a very young age. However, the age at which self-regulation of short-term energy intake diminishes and EAH emerges may be even younger than this. Also, it remains unclear how individual eating behaviors play a role in the emergence and dynamics of EAH over time. Extending our knowledge on the determinants of EAH is important for early recognition of risk behaviors contributing to overeating in children, and for the timing of early targeted interventions to prevent overeating. Furthermore, such insights in risk behavior could be translated into practical guidelines for parents and caregivers.

Other relevant factors associated with vegetable intake and liking

Both innate child characteristics and factors in a child's environment or nutritional history have been shown to affect vegetable acceptance. In this thesis, we address the important child factor food neophobia, which is common in toddlers [100–102]. Food neophobia is characterized as the unwillingness to eat and/or reject novel food [103]. Food neophobia is negatively associated with food intake, where children who display this trait more strongly try and like fewer foods. Food neophobia can occur toward all foods, however, research suggest that neophobic responses can be particularly strong for vegetables. Previous research has consistently reported lower vegetable intake in children who exhibit food neophobic and/or picky eating behaviors [91,104–106].

Children learn to eat through the direct experience of eating and the exposure to sensory properties of different foods, but also by observing others. Given that toddlers are constantly cared for by parents and or caregivers it is not surprising that maternal vegetable intake is associated with child vegetable intake as parents both model eating behaviors and select what the child is offered [63,104,107–110]. Additionally, caregivers are responsible for the availability and accessibility of vegetables in the home, which are other key determinants for children's vegetable intake [111,112]. Finally, other maternal- and child factors that have been associated with child vegetable intake are age, gender, breastfeeding and education level of the parents [45,105,113]. As these individual differences potentially affect children's vegetable intake we take into account the influence of these demographic variables.

Assessment of energy and vegetable intake

Accurate assessment of dietary intake in young children presents challenges. Due to their limited cognitive and literacy skills it is impossible for them to report their intake [114]. Therefore parents or caregivers are required to obtain information on dietary intake for this age group [114,115]. Visual observations, photographic food records, (weighed) food records and multiple 24-hour dietary recalls are dietary assessment methods often used for assessing intake in pre-school children [116,117]. These methods each have their own strengths and limitations. Possible limitations are recall bias, errors in estimating portion size, over- and underreporting of intake and high administrative burden [118].

For the assessment of energy and vegetable intakes in adults dietary assessment methods such as 24-hour dietary recalls, Food Frequency Questionnaires (FFQ) and diet histories can be used [119]. These methods are frequently used to assess habitual intake [120]. FFQ's are easily administered and therefore often used in epidemiological studies. When using FFQ's, foods are combined into food groups. The downside of this grouping and more general questions about habitual food intake that details about for instance food preparation and use of specific foods is lost. 24-hour recalls are more time consuming than FFQ's but have the advantage that details about the type of food consumed (e.g. full-, half, - skimmed milk), preparation of foods and timing can be assessed [120].

Within the current PhD project we utilized various dietary assessment methods to gain insight in dietary intake: 1) a weighted record to assess vegetable and fruit intake during the first weeks of complementary feeding; 2) 24-hour dietary recalls to assess the total diet at the ages of 18 and 24 months and; 3) an interview combined with a weighted record and photographs to assess energy intake of an evening meal at the ages of 18 and 24 months; 4) an FFQ to assess maternal habitual intake.

Baby's First Bites

Since parents largely determine *what* and *how* children eat in the first years of life, early interventions focusing on parental feeding strategies during the transitional period of complementary feeding seem a promising way to foster healthy eating habits from the very beginning. To promote vegetable consumption (the "*What*" of complementary feeding), repeatedly exposing infants to a variety of vegetables is found to be an effective method [16,25,69]. To foster self-regulation of energy intake and thereby reduce the risk of developing overweight [121,122], promoting parental sensitive feeding behavior (the "*How*" of complementary feeding) is thought to be important [121,122]. Whether a combination of repeatedly exposing infants to vegetables and encouraging sensitive feeding may lead to a better vegetable intake and liking and self-regulation of energy intake than each of the approaches separately has not been previously tested. Evaluating the effects of what, how and their combined effect within the same study creates the possibility to find out more about the efficacy of different types of advice. This was done in the BFB RCT that was conducted within the current PhD trajectory. The interventions started when children were offered their first bites of complementary foods (age 4-6 months; baseline) and lasted throughout the first year of

complementary feeding, until the age of 16 months. Outcome measures were assessed at child ages 12, 18, 24 and 36 months (Figure 1) (the results at *36 months are not reported in this thesis*).

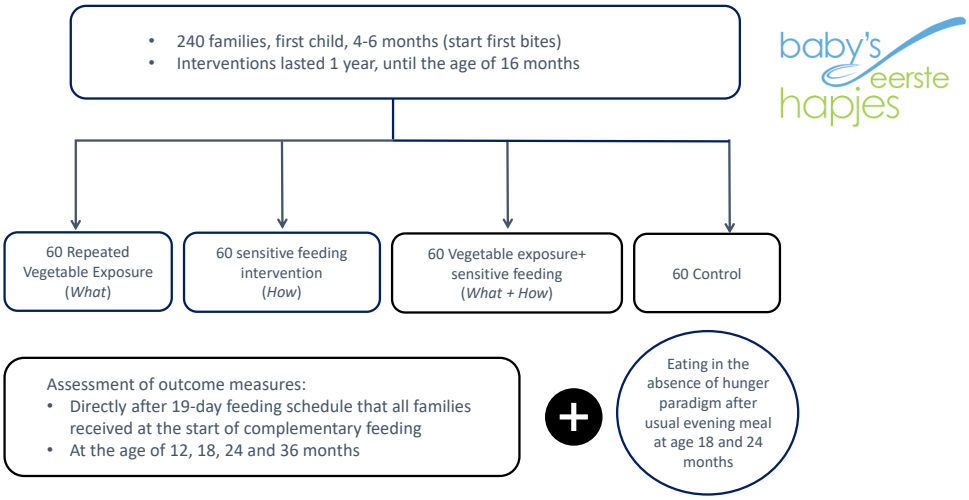

FIGURE 1 | General overview of the study design of Baby's First Bites.

Thesis aims and outline

Although studies have reported on early feeding interventions promoting vegetable intake in infants and toddlers, the beneficial effects do not seem to last when children grow older. It has been argued that the effects of interventions lasting several weeks are not enough to stimulate long-term vegetable intake and liking and that a prolonged and intensified intervention may be necessary to obtain more robust effects. For the BFB RCT, such a prolonged and intensified repeated vegetable-exposure intervention was designed. The procedure was based on the method as described by Barends and colleagues [30] and consisted of three components: a 19-day feeding schedule (child age 4-6 months), provision of 100 jars of age appropriate commercially available vegetables purées (spinach, green beans, cauliflower and broccoli until the age of 12 months), and five semi-personalized consultations by telephone with the parents (until the age of 16 months). For development of the consultation sessions, we conducted a needs assessment and applied the Intervention Mapping (IM) process [123-125] to develop this protocol. To support the method of repeated exposure, the main goal of the intervention was to motivate mothers both during and after the feeding schedule to offer their child vegetables daily. From an analysis of determinants that may influence children's vegetable consumption we selected several determinants to target in the intervention (e.g. knowledge, modelling, availability of vegetables). The telephone consultations were structured according to the general principles of Motivational Interviewing (MI) [126] and the Stages of Change Model [127] was used to monitor the behavior of offering vegetables on a daily basis.

In addition to what children are offered during complementary feeding, the way food is offered may also strongly influence a child's acceptance of the offered food and have an

influence on their ability to self-regulate their energy intake. The association between parental feeding strategy and risk of overweight and rapid weight gain has been observed in previous research. However, eating in the absence of hunger, which is a known risk factor for developing overweight, has not previously been experimentally tested in toddlers as young as 18 months. Extending our knowledge on the ethiology and determinants of EAH is important for recognition of risk behaviors contributing to overeating in children, and for the timing of early targeted interventions to prevent overeating. This also applies to practical advice given to parents and caregivers. Within the BFB RCT, we performed a sub-study among 18 month old children to assess eating in the absence of hunger. This sub-study was repeated in a subset of the sample at age 24 months.

The focus of the present thesis is children's vegetable intake and liking and self-regulation of energy intake. The following objectives were formulated:

- To assess the effect of the repeated vegetable-exposure intervention on children's vegetable intake and vegetable liking from the first bites of complementary food until the age of 24 months (chapters 3 and 4).
- To explore the association of modifying factors such as child sex, food neophobia and maternal vegetable intake and toddler's vegetable intake (chapter 4).
- To assess whether toddlers aged 18 months eat in the absence of hunger, the stability of this behavior at age 24 months and eating behaviors related to EAH (chapter 5).
- To assess the effect of the interventions carried out within BFB on child self-regulation of energy intake and child BMI-z (chapter 3).

Chapter 2 describes in detail the rationale and the design of the BFB study including the repeated vegetable-exposure and sensitive-feeding interventions.

Chapter 3 evaluates the effects of the vegetable-exposure and sensitive-feeding intervention in terms of child health outcomes and maternal feeding behavior at child ages 18 and 24 months. With respect to child outcomes, we hypothesized that 1) all interventions (vegetable-exposure, sensitive-feeding, combined intervention) are more effective in improving vegetable intake than the control condition; 2) the sensitive-feeding and combined intervention are more effective in supporting self-regulation of energy intake and in reducing anthropometric indicators of obesity risk than the vegetable-exposure or control condition; and 3) the combined intervention is more effective than the other two interventions alone in promoting vegetable intake. With respect to maternal outcomes, we hypothesized that 4) the sensitive-feeding and combined intervention are more effective in promoting positive maternal feeding behavior than the vegetable-exposure or control conditions.

Chapter 4 describes the vegetable-exposure intervention in more detail and evaluates the effects of the intervention on infant's vegetable intake, liking and variety of vegetables consumed during the first weeks of complementary feeding and at the age of 12 months. Additionally, it examines child and maternal factors that may be related to vegetable intake. The vegetable-exposure intervention was based on the procedure carried out by Barends et al [30], except with several added components, as recommended, to prolong and intensify the intervention and facilitate long-term effects. We hypothesized that 1) the repeated

vegetable-exposure intervention increases infant's vegetable intake and liking directly after the 19-day feeding schedule and at the age of 12 months; 2) the repeated vegetable-exposure intervention increases infant's variety in different types of vegetable consumed at the age of 12 months; 3) infant's vegetable intake is positively associated with maternal vegetable intake and infant fruit intake and negatively associated with infant BMI-z and food neophobia. C**hapter 5** describes an eating in the absence of hunger (EAH) experiment that was designed and conducted within the BFB RCT. We assessed to what extent 18-month-old children eat in the absence of hunger, the stability of this behavior at 24 months and the association of child eating behaviors with EAH. It was hypothesized that 1) children who ingested more energy during the evening meal, and were perceived as being more satiated, would ingest less energy from the finger foods presented during the EAH procedure; 2) certain child eating behaviors, such as greater enjoyment of food, greater food responsiveness, and lower satiety responsiveness would result in a relatively higher energy intake of finger foods; 3) EAH at 18 months would predict EAH at 24 months.

Finally, **chapter 6** presents a general discussion of the studies in this thesis and describes methodological considerations and practical implications of the findings.

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Chapter 2

Baby's First Bites: A randomized controlled trial to assess the effects of vegetable-exposure and sensitive feeding on vegetable acceptance, eating behavior and weight gain in infants and toddlers

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Abstract

Background: The start of complementary feeding in infancy plays an essential role in promoting healthy eating habits. Evidence shows that it is important *what* infants are offered during this first introduction of solid foods: e.g. starting exclusively with vegetables is more successful for vegetable acceptance than starting with fruits. *How* infants are introduced to solid foods also matters: if parents are sensitive and responsive to infant cues during feeding, this may promote self-regulation of energy intake and a healthy weight. However, the effectiveness of the *what* and the *how* of complementary feeding has never been experimentally tested in the same study. In the current project the *what* and *how* (and their combination) are tested in one study to determine their relative importance for fostering vegetable acceptance and self-regulation of energy intake in infants.

Methods: A four-arm randomized controlled trial (Baby's First Bites (BFB)) was designed for 240 first-time Dutch mothers and their infants, 60 per arm. In this trial, we compare the effectiveness of (a) a vegetable-exposure intervention focusing on the *what* in complementary feeding; (b) a sensitive feeding intervention focusing on the *how* in complementary feeding, (c) a combined intervention focusing on the *what and how* in complementary feeding; (d) an attention-control group. All mothers participate in five sessions spread over the first year of eating solid foods (child age 4-16 months). Primary outcomes are vegetable consumption, vegetable liking and self-regulation of energy intake. Secondary outcomes are child eating behaviors, child anthropometrics and maternal feeding behavior. Outcomes are assessed before, during and directly after the interventions (child age 18 months), and when children are 24 and 36 months old.

Discussion: The outcomes are expected to assess the impact of the interventions and provide new insights into the mechanisms underlying the development of vegetable acceptance, self-regulation and healthy eating patterns in infants and toddlers, as well as the prevention of overweight. The results may be used to improve current dietary advice given to parents of their young children on complementary feeding.

Keywords: complementary feeding, vegetables, vegetable exposure, responsive feeding, self-regulation of energy intake, infant, toddler

Background

In light of today's global obesity epidemic and related diseases, promoting healthy eating habits is essential(1). Children as young as 1-3 years of age already eat too much energy-dense food and too little fruit and vegetables(2-6). In the Netherlands, based on surveys between 2006 and 2014, estimates for the percentage of preschoolers failing to meet daily recommendations for vegetable intake vary from 40% up to an alarming 80%(2, 3). Moreover, a recent experimental study showed that almost 40% of 4 year-olds fail to effectively regulate their own energy intake, showing a tendency to eat even though they are not hungry(7). Poor eating habits, such as consuming too little vegetables and eating in the absence of hunger increase the risk of developing overweight and obesity, and related diseases such as type II diabetes(8-12), cardiovascular disease(13), and certain cancers(14). Both children's food preferences and their ability to self-regulate their energy intake are influenced by their direct environment already in the first two years of life(15-20). Therefore, promoting a healthy diet and healthy eating habits and behavior from infancy is essential. At this young age, parents bear primary responsibility for the diet of their children. The present article describes the study protocol and sample of a randomized controlled trial under the acronym *Baby's First Bites (BFB),* aimed at (a) promoting vegetable intake and liking, and (b) promoting child self-regulation of energy intake, by advising parents *what* and *how* to feed their infants from the very start of complementary feeding. The primary goals of promoting vegetable acceptance and self-regulation of energy intake serve the purpose of reducing the risk of developing overweight in early childhood – our secondary outcome. Three interventions will be compared to an attention-control condition: (1) a *repeated exposure* intervention motivating parents to repeatedly expose their children to the taste of a variety of vegetables during the first year of complementary feeding; (2) a *parenting* intervention promoting sensitive parental feeding; and (3) a *combined* intervention promoting both repeated exposure to vegetables and sensitive feeding.

Repeated exposure to a variety of vegetables from the start of complementary feeding

When parents start complementary feeding, they can choose from a variety of foods to introduce to their children, including (baby) cereals, grains, fruits or vegetables(21, 22). Already in the 1970s it was theorized that to improve the acceptance of vegetables, these should be introduced before fruits or other sweet tastes during complementary feeding because infants' inherent preference for sweet tastes will interfere with vegetable acceptance(23). The effects of starting complementary feeding exclusively with vegetables on promoting vegetable acceptance has, however, not been studied often(24). Two other methods of increasing vegetable intake and liking *have* been studied extensively. First, repeated exposure to the taste of vegetables has been shown effective in increasing its intake and liking in infants and preschoolers(24-32), especially for bitter tastes(33). Second, being exposed to a variety of vegetables increases vegetable acceptance in infants(23, 29, 34, 35). However, whether it is indeed most effective to start with vegetables *only* was not tested until the trial by Barends et al. in 2013(22). This study showed that infants exposed to a variety of vegetables during the first three weeks of complementary feeding – including a target vegetable to which they were

repeatedly exposed – nearly doubled their intake of the target vegetable, whereas children who only received fruits showed increased intake of fruits but not of vegetables(26). Shortly after this trial, another intervention study found similar results: encouraging parents from the United Kingdom to start complementary feeding with a variety of vegetables significantly increased vegetable intake compared to a control group in which parents were allowed to start complementary feeding with whatever food they wanted(36).

Thus, there is preliminary evidence that starting complementary feeding by repeatedly exposing infants to a variety of vegetables is an effective way to increase vegetable intake and liking in the first year of a child's life. However, the beneficial effects on vegetable acceptance do not seem to last when children grow older(27, 30, 37). This is in line with the finding that children are open to trying a variety of different tastes in their first year of life, but tend to become more selective about their diet when they become older (especially in the 'food neophobic phase')(24, 38, 39). Indeed, in the Barends et al. trial, starting complementary feeding with vegetables did *not* predict vegetable intake at age two, whereas how selective children were about what they wanted to eat did(27). Continuing the active promotion of eating vegetables in the first and second year of the child's life after exposing them to a variety of vegetables at the start of complementary feeding may counteract the negative effects of the food neophobic phase and effectively boost vegetable intake throughout childhood. However, most intervention studies have been conducted with infants in the early phases of complementary feeding or preschoolers older than 2 years; few studies focus on promoting vegetable acceptance in the difficult period between 12-24 months when children go through the major transition of eating the same meals as their family and enter the food neophobic phase(40, 41). Therefore, we studied the effectiveness of a more prolonged vegetable-exposure intervention throughout the whole first year of complementary feeding, well into the more 'difficult' second year of the child's life to promote vegetable intake in toddlers.

Sensitive feeding

Apart from *what* parents should offer their children during complementary feeding, *how* they offer this food may also strongly influence a child's acceptance of the offered food, as well as their ability to self-regulate their energy intake. Experimental studies show that pressuring a child to eat decreases children's ability to self-regulate their energy intake and thereby to consume appropriate amounts of calories(42). Similarly, pressuring a child to eat vegetables has a counterproductive effect and will make a child eat and like these vegetables less(43). Even giving subtle prompts to eat, like moving food towards a child, may have a counterproductive effect(44). However, if children start to decrease their vegetable intake when they enter the second year of life, parents are likely to use some sort of pressure to make their child eat. Indeed, an Australian study showed that more than half of the parents of 1-3 year-olds sometimes insist on their child eating a food, and 35% reported to pressure their child often or all the time(45). As such, it is not surprising that many parents struggle with the question how to feed their infants effectively. Indeed, 25 to 40% report feeding problems with their infants and toddlers, including picky eating and strong food preferences(46, 47).

In contrast to pressuring children to eat, *responsive feeding* is often suggested to be the optimal way to feed infants and toddlers(48-51). Responsive feeding is generally defined as a

style of feeding in which parents correctly perceive the hunger and satiety signals of the child, and respond promptly and appropriately(50, 52). This feeding style is suggested to promote and reinforce young children's ability to self-regulate their energy intake, because the parent who feeds responsively will not override a child's satiety cues(50). Indeed, promoting responsive feeding was shown to be associated with a reduced risk of overweight and of rapid weight gain during the first years of life(50, 53, 54). However, although attending to hunger and satiety signals may promote child self-regulation of energy intake, it may not be sufficient to promote healthy food preferences including vegetable acceptance during the first years of the child's life. As children from the age of 1.5 years become more and more autonomous and selective about their food preferences, parents have to manage that their child eats appropriate quantities, but also the specific (healthy) foods that are served. To promote healthy food preferences, parents will need to stimulate their child to eat vegetables in a non-pressuring way that is sensitive to the child's autonomy-related needs and behaviors. This requires more than just responsiveness to hunger and satiety cues, but also sensitive discipline strategies to challenging child behavior (e.g. when a child throws their food on the ground) and sensitive responses to distracted behavior (e.g. when a child is more interested in what is happening around them than in its plate of food). Sensitive discipline strategies that parents may use entail positive encouragement (e.g. explicitly complimenting the child for positive behavior), appropriate pacing to allow the child sufficient time to adapt to the situation, granting the child appropriate amounts of autonomy (e.g. allowing the child to eat autonomously when the child is able to and shows it wants to) and showing understanding for the child's point of view(55). Using these sensitive discipline strategies has been shown to promote infant's committed compliance, i.e. internally motivated and self-regulated adherence to parental rules(56). In the current study we introduce the concept *sensitive* feeding to capture this broader set of sensitive parenting skills relevant to promoting children's committed compliance to parental attempts to feed them healthy foods. Sensitive feeding thus includes the traditional concept of responsive feeding(50, 52), but with the addition of sensitive discipline as well as autonomy support, also in response to non-food related child behaviors during feeding. We hypothesize that parents showing sensitive feeding will be more successful in increasing their children's vegetable acceptance.

In recent years a number of randomized controlled trials to promote responsive feeding have been performed, some of which incorporated the discipline component described above(57-62) whereas others merely focused on teaching parents how to effectively respond to the hunger and satiety cues of their child(53, 54). However, none of these interventions focused on promoting responsive or sensitive feeding alone. Instead, they incorporated a much broader range of topics such as dietary advice, advice on general feeding practices, guidelines for physical activity, or even more broad advice on how to manage the sleeping and crying behavior of the child. As such, it is impossible to isolate the specific effect of responsive feeding on the diet and eating behavior of the child, and whether this is in fact an element that should be targeted to promote healthy eating patterns. Moreover, all previous trials evaluated changes in parenting behavior via self-report questionnaires, whereas expert observations of parent-child interaction is considered the gold standard to measure parenting behavior(63). An important disadvantage of self-reports of parenting behavior specifically is that it is questionable whether these data represent the actual parenting behavior parents

show, or rather attitudes about what they think they are or should be doing. Indeed, the correlation between self-reported and observed parenting behavior is often low, both in the field of parental feeding(64-66) and in other fields(67). Therefore, we will test the effectiveness of an intervention focusing solely on the enhancement of sensitive feeding, by evaluating its outcomes using repeated observations of family meals at home in addition to self-reports.

Repeated exposure and sensitive feeding

Whether a combination of repeatedly exposing infants to vegetables and encouraging sensitive feeding may lead to a better vegetable intake and liking than each of the interventions alone, has never been tested before. However, there is evidence that presentation of beneficial food choices (succeeding at the *what*) in a non-responsive manner (failing at the *how*), and the presentation of unhealthy food choices (failing at the *what*) in a responsive manner (succeeding at the *how*) may lead to overweight and eating problems in children(43, 68). For instance, an experimental study by Galloway and colleagues showed that pressuring a child to eat, even if this pressure is mild in nature, decreases the beneficial effects of repeated exposure to the taste of vegetables(43). This suggests that an intervention aimed at both elements may be particularly powerful.

Aims and hypotheses

In summary, the *Baby's First Bites (BFB)* study aims to test whether promoting the *what* and/or promoting the *how* of complementary feeding will result in increased vegetable consumption and liking and a better self-regulation of energy intake in infants and toddlers up until the age of 36 months. To this end, we will perform a superiority randomized controlled trial with parallel groups, comparing a) an intervention focusing on vegetable exposure (=what), b) an intervention focusing on sensitive feeding (=how), c) an intervention focusing on vegetable exposure and sensitive feeding (=what and how), and d) a control condition. The interventions will begin when the infant starts receiving complementary food (child age 4-6 months, as recommended by the Dutch Nutrition Center) and continue until the child is 16 months old. We hypothesize that a) all interventions are more effective in improving vegetable consumption and vegetable liking than the control condition without guidance on complementary feeding; b) the sensitive feeding and combined intervention will be more effective in supporting child self-regulation of energy intake than the vegetable exposure or control conditions; and c) the combined intervention is more effective than the other two interventions alone in promoting vegetable intake and vegetable liking. As the inclusion phase of the *BFB* study has already successfully been completed, the present article describes the characteristics of the sample of included participants as well as the design of this ongoing study.

Methods/Design

Study design

The *BFB* study is a collaboration between Leiden University, Wageningen University and Research, Danone Nutricia Research and Nutricia Early Life Nutrition. The study is a multicenter trial that is currently being performed at Leiden University and Wageningen University and Research, using a superiority randomized controlled design. The protocol has been approved by the Ethical Review Board of Education and Child Studies, Leiden University (protocol number ECPW-2015/116) and the Medical Ethical Review Board of Wageningen University and Research (METC-WU protocol number NL54422.081.15). The inclusion phase started in May 2016 and ended successfully in November 2017. Mothers and their 4-6 month-old infant were randomly allocated to receive either repeated exposure to a variety of vegetables (RVE), the parenting intervention Video-feedback Intervention to promote Positive Parenting-Feeding Infants (VIPP-FI), RVE and VIPP-FI combined, or an attention-control intervention (see figure 1 and table 1). Families receiving the RVE intervention were further randomly allocated to one of two types of vegetables the infant is repeatedly exposed to (see *Interventions* below): green beans or cauliflower. Two target vegetables were chosen as the current feeding schedule is based on the 19-day feeding schedule as described by Barends and colleagues (26, 27). Green beans and cauliflower are commonly consumed in the Netherlands. Randomization into these conditions was done using the online program TenALEA, which assured that the exact same randomization procedure was used at both study sites(69). To make the groups allocated to the different conditions as comparable as possible concerning relevant potential confounders, randomization was stratified by age of the child at the start of complementary feeding (4, 5 or 6 months), gender of the child and study location, using minimization procedures. The online randomization program TenALEA has been used previously in other clinical trials (70, 71)). Participants were allocated to a condition by one of the PhD-students or research assistants at each study location.

Intervention effects are assessed both during and after conclusion of the interventions by performing a pre-test at the first two days of complementary feeding (child age 4-6 months; t_0), two assessments during the interventions (at the end of the 19-day feeding schedule (child age 5-7 months; t_1) and when the child is 12 months old (t_{12})), a post-test at the age of 18 months (t_{18}) and two follow-ups when the child is 24 (t_{24}) and 36 months old (t_{36}). T_0 and t_1 are not scheduled at a standard, fixed child age but rather within a certain age range because we wanted to allow parents to start complementary feeding when they thought their child was ready. The other measurements *are* scheduled at set child ages because the intervention sessions following the very first start of complementary feeding are scheduled at fixed time points (see *Timing of intervention sessions* below). The timeline for participants is depicted in Table 2. Participants are allowed to stop at any point during the study if they no longer want to participate. If participants decide to withdraw from the study, discontinue an intervention or are unable to complete a specific assessment, they will be asked once whether they would still be willing to complete (parts of) the intervention, the post-test and/or follow-up assessments to come.

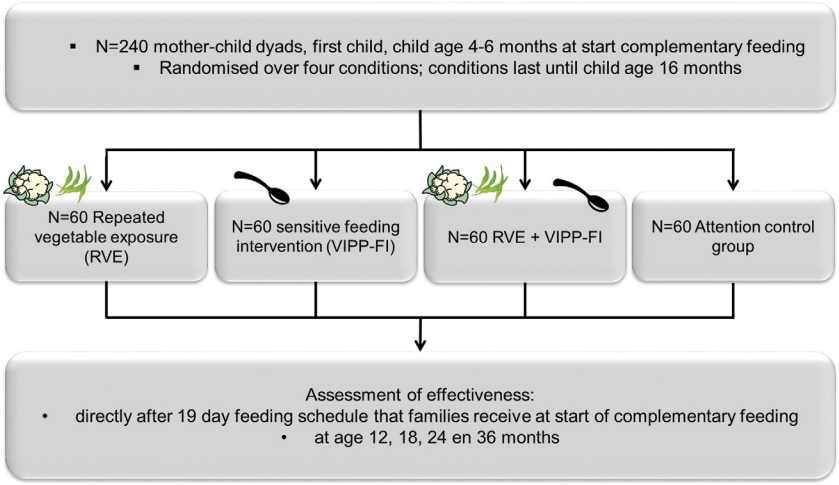

FIGURE 1 | General overview of study design.

Calculation of sample size

A power analysis was conducted to calculate the sample size necessary to detect a moderate effect size of .50, which is based on previous studies of the effects of repeated exposure to vegetables(27) and the effects of VIPP(72). Given a power of .80 and an alpha of .05 the analysis showed that a sample size of 51 participants per group would be sufficient. Taking attrition into account, we aimed to include a total of 240 mothers, 60 per group (see figure 1 and table 1).

TABLE 1 | Overview of conditions and intended N per condition.

Name	Description of condition	N
RVE	Repeated vegetable-exposure intervention: - exposure to either green beans or cauliflower as target vegetable during the first 19 days of weaning - five phone calls to motivate parents to expose children to vegetables at child age 4-6, 8, 13 and 16 months	60
VIPP-FI	VIPP-Feeding Infants: - exposure to fruits and a sweet vegetable (carrots) during the first 19 days of weaning - five home-visits using video-feedback to promote sensitive feeding at child age 4-6, 8, 13 and 16 months	60
COMBI	Combination of RVE and VIPP-FI	60
AC	Attention control group: - exposure to fruits and a sweet vegetable (carrots) during the first 19 days of weaning - five phone calls on development of child at age 4-6, 8, 13 and 16 months	60

Note. RE = repeated exposure; VIPP-FI= VIPP-Feeding infants; COMBI = repeated exposure and VIPP-Feeding infants combined; AC=attention-control condition

TABLE 2 | Timeline for participants.

	Enrolment	**Intervention-period**						**Post-test**	**Follow-up**	
Child age (in months)	2 - 4	4 – 7		8	12	13	16	18	24	36
Time point		t_0	t_1		t_{12}			t_{18}	t_{24}	t_{36}
Enrolment & allocation										
1. Invitation e-mail	x									
2. Information and informed consent	x									
3. Screening	x									
4. Allocation	x									
5. Rice-flour porridge	x									
Interventions										
RVE										
Feeding schedule		days 1-19								
Phone-call		Twice in period days 3-17		x		x	x			
Provision of vegetable purees		x		x	x					
VIPP-FI										
Feeding schedule		days 1-19								
Home-visit		Twice in period days 3-17		x		x	x			
Provision of fruit and carrot purees		x		x	x					
Combined RVE+VIPP-FI										
Feeding schedule		days 1-19								
Phone-call + home-visit		Twice in period days 3-17		x		x	x			
Provision of vegetable purees		x		x	x					
Attention-control										
Feeding schedule		days 1-19								
Phone-call		Twice in period days 3-17		x		x	x			
Provision of fruit and carrot purees		x		x	x					
Assessment of study outcomes[a]		Days 1+2	Days 18+19		x			x	x	x

Note.[a] Primary outcomes: vegetable intake and liking, child self-regulation of energy intake. Secondary outcomes: child anthropometrics, child eating behavior and maternal feeding behavior. RVE=repeated exposure to vegetables. VIPP-FI=Video-feedback Intervention to promote Positive Parenting-Feeding Infants.

Recruitment and participants

We decided to focus all interventions on mothers, because in Dutch households women most often fulfil the role of primary caregiver. Participants were recruited from the general population in four Dutch provinces (Zuid-Holland, Noord-Holland, Gelderland and Utrecht) that are closest to the two universities performing the trial, Leiden University and Wageningen University and Research. Participants were recruited by sending emails with information about the study and a link to the website of the study to mothers of 2-4 month-old infants. Addressees included parents who had signed up for the 'Nutricia for parents group' or were parents who had ordered a free gift box containing baby merchandise from 'WIJ Special Media'. All addressees had indicated that they were interested in receiving information on additional opportunities and/or activities. Names and e-mail addresses were available to only a limited number of researchers, ensuring the privacy of the addressees. Finally, we approached potential participants through handing out brochures at youth health care

centers within the vicinity of Wageningen University and Research. We cannot ascertain how many families were invited at the youth health care centers, but the total number of families invited through the two e-mail lists was 5565. A total of 409 families expressed interest in our study, 255 of which fulfilled in- and exclusion criteria (see below) and were randomly allocated to the groups (62.3%; see figure 2).

Families that showed interest in our study received a phone-call from one of our trained researchers/students, explaining the study in detail. Families still expressing interest in the study at the end of the call received a detailed information brochure as well as consent forms. Both mothers and fathers were asked to sign and return the consent forms. After receiving the signed consent forms, mothers were asked to fill out an online screening questionnaire which assessed inclusion criteria. Families had to fulfil the following inclusion criteria: a) first-time mothers; b) healthy term infants (37-42 weeks of gestation); c) planning to start complementary feeding at child age of 4-6 months (families that already started complementary feeding were excluded) and d) sufficient knowledge of the Dutch language to receive advice on complementary feeding in Dutch and to be able to fill out Dutch questionnaires. Mothers with major psychiatric diagnoses (e.g., depression, schizophrenia or borderline personality disorder) were excluded, as these may affect parenting(73). Following the study protocol of Barends and colleagues(26), families were also excluded when the first-borns were twins or in the case of medical problems in the infants that influence the ability to eat, such as food allergies, swallowing or digestion problems. Finally, for standardization purposes, mothers who were not willing to commit to the outcome of the randomization procedure were excluded, e.g. the child was assigned to a VIPP-FI group, but the mother was objecting to being video-taped. A flowchart of the inclusion phase can be found in figure 2.

In total, 255 first-time mothers and their babies were randomly allocated to the various conditions. Directly after randomization, prior to starting the intervention-phase, 12 mother-infant dyads dropped out (for reasons, see figure 2). A total of 243 families successfully started the intervention-phase. Mean age of the mothers was 30.4 years (*sd* = 4.7, range 18-44). Concerning educational level, 41.6% of mothers had a lower education (finished high school or vocational school), 38.7% finished higher education (higher vocational school) and 19.8% finished university. The trial was thus successful in including a large group with lower education, which is generally considered a risk factor for having less healthy eating habits (74) and less beneficial parental feeding styles(75). About 18% of mothers worked fulltime, and 63 worked part-time, and 19% did not have paid work Gender of the child was roughly equally distributed (47.3% boys); mean age of the children at the start of the intervention-phase was 4.68 months (*sd* = .42, range 3.98-6.38 months); median age was 4.57 months.

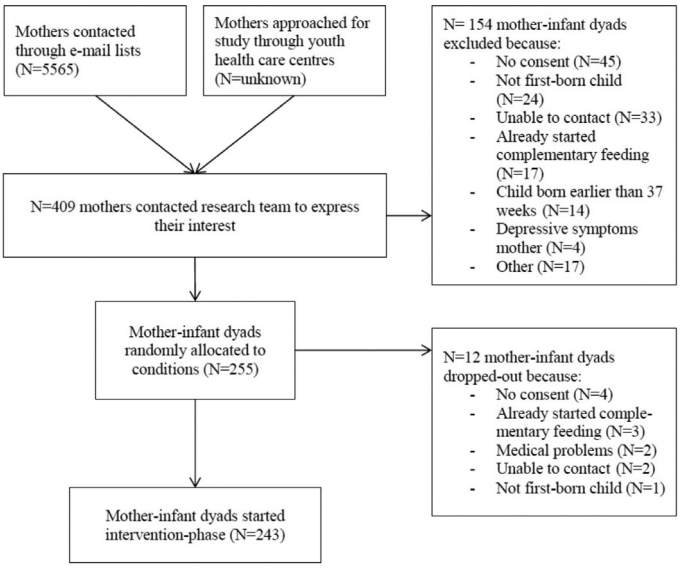

FIGURE 2 | Flowchart of the inclusion phase.

Interventions

The specific content and timing of the RVE and VIPP-FI interventions are specified in Table 1. To control for possible placebo-effects due to receiving attention from researchers/interveners, the number of contacts with researchers/interveners and time in between contacts are the same for all conditions. The interventions in all groups as well as the attention control condition is performed by trained researchers or Master's students in the fields of nutrition or child and family studies. Participants in all conditions are allowed to seek any type of concomitant advice on infant feeding during the trial; to control for potential co-intervention bias we ask participants after the interventions are completed whether they sought advice concerning feeding elsewhere, and if so, where and how often.

All groups/conditions

Feeding schedule and provision of foods in all groups

Prior to the start of each intervention, all mothers are instructed to give their infant rice-flour porridge with a spoon for at least five days, to accustom the infant to eating food from a spoon(26). Each intervention starts with providing infants their first bites of complementary foods according to a specific 19-day feeding schedule (see Table 3). The infants in the repeated exposure and combined conditions receive a variety of commercially available jars of vegetable purees, whereas the infants in the VIPP-FI and attention-control condition receive similar jars containing both fruits and a sweet vegetable puree (carrots). During the first two days and the

last two days of the feeding schedule, the target and control vegetables (cauliflower and green beans) are provided to infants in all conditions. During these days, families are visited at home by the research team and the feed is videotaped; researchers measure at home how much the child has eaten (see *Measures*). During the other days of the feeding schedule, the mother feeds her child at home without the presence of the researchers. To facilitate compliance to the feeding schedule, mothers receive a printed overview of the feeding schedule indicating which puree to feed their child on each of the 19 days. In addition, each jar of food is labelled with a sticker indicating the day of the feeding schedule.

After this feeding schedule has been completed, all families are provided with a total of 100 jars of age-appropriate fruits and/or meals with vegetables, depending on the condition they are in, up until the child is approximately 12 months of age (distributed on five different occasions; 20 jars per occasion). Parents are free to decide whether they want to feed their baby using homemade foods or the jars provided to them. The provision of these foods serves as a means to facilitate prolonged exposure to vegetables in the repeated vegetable-exposure conditions by making sure age-appropriate meals containing vegetables are available to the families. Whether or not families use these jars and how much the child eats of these jars is reported by the mother.

TABLE 3 | Feeding schedules used within each intervention group and the control group.

	Day																		
Condition	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
RE and COMBI	TV	CV	TV	V1	TV	V2	TV	V1	TV	V2	TV	V1	TV	V2	TV	V1	TV	CV	TV
VIPP-FI and AC	CF	GB	F1	F2	F3	V3	F1	F2	F3	V3	F1	F2	F3	V3	F1	F2	F3	GB	CF

Note. RE = repeated exposure; COMBI = repeated exposure and VIPP-Feeding infants combined; VIPP-FI= VIPP-Feeding infants; AC=attention-control; TV=target vegetable (either green beans or cauliflower); CV=control vegetable (either green beans or cauliflower); V1=spinach; V2=broccoli; CF=cauliflower; GB=green beans; F1=apple; F2=pear; F3=banana; V3=carrot.

Timing of intervention sessions

The five sessions of each intervention and the phone calls in the control condition are timed to take place when the infant goes through major transitions in eating (see Table 2). It was decided to give advice specifically during these major transitions to optimize the potential effectiveness of the interventions. The first two sessions are scheduled when the infant has just started eating complementary foods (approximately one and two weeks after the start). The third session is scheduled when the child reaches the age of 8 months and parents should start introducing their child to more lumpy foods to facilitate their infants' acceptance of different food textures(76). The fourth session is scheduled when the child is approximately 13 months and is allowed to eat the same foods as the rest of the family. Finally, the fifth session is scheduled when the child is 16 months of age to prepare parents for the potentially difficult 'food neophobic phase' that infants tend to reach in their second year(39, 77).

Repeated exposure to a variation of vegetables (RVE)

The repeated vegetable-exposure (RVE) intervention focuses on *what* to feed infants. The RVE intervention starts with vegetables only according to a 19-day feeding schedule as described by Barends and colleagues(26, 27), and further promotes vegetable exposure in the first year of complementary feeding until 16 months of age using a protocol developed specifically for the current study. We conducted a needs assessment and applied the Intervention Mapping (IM) process(78-80) to develop this protocol.

In short, to promote vegetable exposure in the first year of eating complementary foods the method of repeated exposure to vegetables is used because it has been found to be the most effective way to increase vegetable intake and liking in infants(40, 81). To support this method, we motivate mothers both during and after the feeding schedule to offer their child vegetables daily. From an analysis of risk factors and determinants that may influence children's vegetable consumption we selected the determinants *knowledge, attitude, self-efficacy, skills, modelling, availability of vegetables, beliefs of the parent, positive reinforcement,* and *costs* to target in the intervention.

The main goal of the RVE intervention is for mothers to increase the child's acceptance and liking of vegetables by a) starting the first 19 days of complementary feeding with vegetables only and b) offer vegetables to their child daily after this first period. The risk factors and determinants described above are targeted with the feeding schedule and the five telephone calls. Each phone call focuses on a different theme (Table 4) and discusses basic information material and optional additional information material that is sent to mothers by post. Mothers are asked to read the basic information before the scheduled telephone call with the researcher. Conversations are structured according to the general principles of Motivational Interviewing (MI)(82). Interveners are instructed to act as a coach and guide mothers through the feeding schedule and – during later sessions – the family meal. The telephone protocol contains guidelines with questions mothers might ask and possible responses.

The Stages of Change Model (83) is used to achieve behavior change. The model identifies five stages that people move through when modifying behavior; 1) pre-contemplation; 2) contemplation; 3) preparation; 4) action; 5) maintenance. During the first two sessions (during the 19 day feeding schedule) it is assumed that mothers are motivated to offer their child a vegetable puree daily (preparation/action phase). For session three to five, the stage of change is monitored based on the conversation with the mother. When the mother appears not to be motivated to offer vegetables or encounters barriers in doing so, the protocol contains a series of possible questions and arguments to be discussed to motivate or come up with solutions for the encountered barriers.

Interveners are explicitly not allowed to give advice on *how* to feed the infant to avoid overlap with the VIPP-FI intervention. If mothers have any specific questions about feeding issues, they are referred to their youth health care center or the website of the Dutch? Nutrition Centre where parents get standard advice available for the general public.

In summary, the standardized telephone protocol for each intervention session contains the following elements:

- General part with standardized questions about adherence of mother and child to the vegetable guidelines

- Classifying the stage of change
- Testing the extent to which goals (e.g. knowledge of the topics discussed) of the previous session were achieved by asking questions and repeating information when necessary (sessions 2, 3, 4, 5)
- Discussing the basic information material that mothers receive per post and presenting the option to tailor the conversation by addressing the optional information and questions the mother might have
- Discussing continuation and goal setting with regard to vegetable consumption (sessions 2, 3, 4, 5)

To optimize adherence of interveners to the intervention protocol, interveners familiarize themselves with all the information in the protocol and are trained on how to approach the mothers during the telephone calls. In addition, the interveners have regular meetings to discuss the RVE intervention, exchange experiences and discuss difficulties that may arise. To allow further monitoring of adherence and achievement of the intervention goals, notes are made of each interaction with the parent. In addition, important individual details and information discussed are noted.

VIPP-Feeding Infants (VIPP-FI)

The VIPP-Feeding Infants intervention focuses on *how* to feed an infant. The intervention is based on an existing parenting intervention that has repeatedly been proven effective in enhancing both parental sensitivity in general and sensitive discipline in particular: the Video-feedback Intervention to promote Positive Parenting-Sensitive Discipline (VIPP-SD)(84). For the present study, the VIPP-SD was adapted to the specific situation of feeding infants (VIPP-FI) and aims to enhance sensitive parenting during feeding. The intervention consists of five sessions that take place at home and makes use of a detailed protocol that can be requested from the first author, SV. To avoid overlap with the RVE intervention, interveners are explicitly not allowed to give any advice on what type of food to give the infant. If mothers have any specific questions about this, they are referred to their youth health care center or the Dutch Nutrition Centre.

The goal of VIPP-FI is to increase mothers' sensitive reactions to her child's hunger and satiety cues and to increase sensitive discipline and autonomy support during feeding. To reach this goal, mothers are shown videotapes of their own feeding-interaction with their infant and receive feedback on these tapes by a trained intervener. For each session a different type of meal-setting is filmed. The videos also include potentially challenging situations like introducing the child to a new taste. The mealtimes are filmed approximately one week before the session takes place, to allow the intervener to prepare the feedback they want to give mothers. The different settings that are filmed and topics that are discussed during each session are displayed in Table 4.

One of the core principles of VIPP is to always provide positive feedback to a mother(72). Every moment where a mother shows sensitive ways of responding to infant cues of hunger, satiety, or other cues are pointed out during the sessions. Instances of insensitive behavior by the mother during the video are also discussed but the intervener always provides the

mother with an alternative by referring to a more sensitive response that the mother showed during the video. In doing so, the mother becomes her own role model for showing sensitive reactions to the infant's needs. Another core principle of VIPP is that to improve maternal sensitivity, mothers need to be trained in observing and interpreting the behavior of their child (in essence, how does my child signal hunger, satiety, interest in their surroundings, etc.(72)). Therefore, during the first sessions mothers do not get direct feedback on their own behavior, as this likely distracts them from observing the behavior of their infant while watching the video. In the standard VIPP protocol mothers do not get specific feedback on their own behavior until the third session. However, in VIPP-FI we allow interveners to do this from the second half of the second session. We made this alteration as there is a relatively long time gap between the second and third session (2 to 4 months) and we wanted to give mothers as many pointers as possible to practice sensitive feeding in the months between the sessions. Examples of techniques used for providing feedback to mothers are *speaking for the child* (i.e. the intervener stops the video and talks with a mother about what the infant is trying to communicate at that point in the video) and *corrective messages* (i.e. the intervener stops the video after an example of insensitive behavior of the mother and gives an example of a more sensitive approach she could have used and showed at another point during the video).

To ensure the adherence of interveners to the intervention protocol, interveners receive five days of training in VIPP-SD and a one-day training in VIPP-FI. Moreover, they perform the VIPP-FI in one pilot-family before performing the intervention for the present trial. The progress of the intervention in this pilot-family is discussed extensively with interveners who have experience with the VIPP-FI protocol. Adherence is further optimized by scheduling regular meetings with all interveners at each study location, where the progress of each family receiving the intervention is discussed, as well as any issues that may arise while providing the interventions. Finally, the interveners from both study sites have regular meetings to make sure that adherence is similar at both sites. Similar to the procedure in the RVE intervention, notes are made of each interaction with the parent to allow further monitoring of adherence and achievement of the intervention goals. In addition, important individual details and information discussed are noted.

Vegetable exposure + VIPP-Feeding Infants (COMBI)

Participants randomly allocated to the combined intervention receive both the RVE intervention and the VIPP-FI as described above. Similar to these interventions, families receive five phone calls for the RVE intervention and five home visits for VIPP-FI, at the same moments as in the two separate interventions.

TABLE 4 | Content of each of the RVE and VIPP-FI intervention sessions.

Session	Child age	RVE			VIPP-FI	
		Theme	**Topics discussed**	**Optional information**	**Situation filmed**	**Topics discussed**
1	4-6 m	Discovering vegetables	• Why should children learn to eat vegetables? • Keep offering, also if child rejects (at least 10 times)	• Benefits of eating vegetables • Development of taste in young children	Mother feeding infant pureed vegetables/fruits	Learn to observe and interpret child feeding cues (hunger, satiation, liking)
2	4-6 m	Keep on offering vegetables	• How long should I persist? (at least 10 times) • Daily variation, steady increase of portion size	• Tips about offering vegetables to children on a daily basis and the preparation of age appropriate vegetable meals	Mother feeding infant pureed vegetables/fruits	Five tips: Timing, routine, adequate pacing, stop at the right time, enjoy
3	8 m	Being creative with vegetables	• Increase level and variety of texture • Set a good example	• Additional information about introducing more lumpy foods to children. • Tips about preparing and storing age appropriate vegetable meals • Tips to cut costs	Child eating sandwich with mother; new topping on sandwich	What to do when infants a) want more autonomy during mealtimes and b) don't want to eat
4	13 m	Vegetables are part of a balanced diet	• Eating with the whole family • Recommendations for vegetable intake	• Achieving the recommended intake for vegetables	Dinner with whole family; child is served a new vegetable	Positive ways of dealing with negative behavior during dinner
5	16 m	Keep eating vegetables	• Inform parents on possible food neophobia phase, and how to respond	• Involving children in the preparation of vegetables	Dinner with whole family; child is served something new	Inform parents on possible food neophobia phase, and how to respond to that

Note. m=months.

Attention control condition (AC)

Participants in the attention control condition receive five phone calls, scheduled at the same time that the intervention sessions in the RVE, VIPP-FI and COMBI conditions take place. The researchers/students that make the phone calls are explicitly not allowed to give any advice on the what and how of complementary feeding; instead, they are instructed to simply inquire after the development of the child, using a semi-structured interview, listen to mothers and show interest and empathy. Topics that are discussed concern the general development of the child (e.g., sleeping behavior, motor development, language development) as well as what the mother's experiences are with the complementary feeding of her child. If mothers have any specific questions about complementary feeding, they are referred to their youth health care center or the Dutch Nutrition Centre.

Measures

Primary outcome measures

Vegetable intake. For the duration of the 19-day weaning schedule the child's consumption of the purees is assessed. On days 1, 2, 18, and 19 of the feeding schedule researchers visit the families' homes and measure the amount of the vegetables the infants eat in grams (maximum of 125 grams per day, as this is the amount available per day). This is done by weighing the jar of food, bowl, spoon, bib and the cloth mother plans to clean the baby with both before and after the meal by using a standard small kitchen scale (Soehnle, Fiesta 65106). For the other days of the feeding schedule, mothers are asked to put all the leftover puree back in the jar as precisely as possible and store it in the fridge until the researchers collect the jars of food at day 18. The researchers determine the amount of puree eaten on these days by weighing the jars.

At t_{12}, t_{18}, t_{24}, and t_{36} vegetable intake is measured by asking mothers to fill out web-based 24-hour recalls on three randomly assigned, non-consecutive days using the online program, Compl-eat, developed by Wageningen University and Research. Compl-eat is based on the multiple pass method(85) to increase accuracy of dietary recalls and uses the Dutch food composition table(86) to calculate energy and nutrient intake. The program was adapted to assess the diets of infants and young children for this study (e.g., inclusion of smaller portion sizes, and special baby foods). The recall days are scheduled in advance. The parent is provided with a paper food diary to be filled out throughout the day if the child is not in the parents care, but for instance with a babysitter or at a day-care center, making it possible for the parent to enter the data in Compl-eat afterwards. In addition, the parent is asked to weigh all vegetables consumed by the child on a digital scale. Instructions on how to fill out Compl-eat are given during the home visits of t_{12}, t_{18}, t_{24}, and t_{36}; invitations to fill out the recalls are sent after the home visits.

Vegetable liking is measured every day of the feeding schedule by asking mothers to note their infants liking of the vegetables in a diary. Using the same scale as used in the trial by Barends and colleagues (2013), mothers are asked to rate their infant's liking on a 9-point

Likert scale, ranging from 1 (dislikes very much) to 9 (likes very much). At t_{12}, t_{18}, t_{24}, and t_{36}, liking of the target and control vegetables (cauliflower and green beans) is measured using the same scale, filled out by the mother.

Child **self-regulation of energy-intake** is measured using questionnaires and observation. Mothers are asked to fill out the Baby Eating Behavior Questionnaire (BEBQ(87)) at t_0 and the Child Eating Behavior Questionnaire – Toddler (CEBQ-T(88)) at all other *t*'s. The BEBQ and CEBQ-T assess several aspects of eating behavior including satiety responsiveness and food responsiveness. These scales are used as indicators of the infant's self-regulation of energy-intake.

In addition, at t_{18}, t_{24} and t_{36}, a home-based *eating in the absence of hunger (EAH)* paradigm is used. This is done according to the free-access procedure, which is considered the gold-standard for this type of measurement(89-92). During the home visit the researcher carefully assesses what and how much the child eats during dinner to determine the weight, energy and macronutrient content of the meal. In addition, the mother is asked to indicate how satiated she thinks her child is after consuming dinner. Directly after dinner an 8-minute free play session takes place after which the researcher provides a plate with savory and sweet age-appropriate snacks and the child is told that these are for him/her to eat. The mother is asked not to interfere with the child's behavior during this time. Using these data, the EAH-score, the percentage of energy intake from the snacks relative to the energy intake from the dinner, is calculated.

Secondary outcome measures

Child anthropometrics are measured at all *t*'s. Infants' body weight is measured by asking mothers to first stand on a calibrated electronic personal scale (KERN MPC/SECA robusta 813) themselves, and then again while holding their infant. The difference between these two weights produces the child's weight. As of t_{24}, children are invited to stand on the scales themselves. Weight is measured in 0.1 kilograms. Infants' length is measured by lying them down on a small mat with an indication of centimeters printed on top of it. As of t_{24} child length is measured using a stadiometer (SECA 213, Chino, USA/Garant).

Child eating behavior is measured by the mother-reported Baby Eating Behavior Questionnaire at t_0 (BEBQ(87)) and the Child Eating Behavior Questionnaire – Toddler (CEBQ-T(88)) at all other *t*'s. The BEBQ and CEBQ-T are both derived from the Child Eating Behavior Questionnaire (CEBQ), a well-validated, reliable and widely used questionnaire that assesses different aspects of child eating behavior(93, 94). We use the CEBQ-T as of t_1 as it is more appropriate for assessing children's eating behavior in relation to eating solid foods. However, since the scale 'emotional over-eating' is largely inapplicable for infants under the age of 2 years (e.g., "My child eats more when upset") this scale is only added to t_{18}, t_{24} and t_{36}.

Maternal feeding behavior is measured using both observations of family meals at home and questionnaires. When the child is 4-7 months of age (t_0 and t_1), a videotape is made of the mother feeding the child one of the pureed foods of the feeding schedule. At all other time points, a family dinner is videotaped. These videos are coded by trained researchers/students for maternal sensitive feeding using the Ainsworth scale(95). In addition, maternal

responsiveness to child satiety cues is coded using a scale based on the Responsiveness to Child Feeding Cues Scale(96), and maternal pressure to eat is coded using a scale based on a large Dutch study that observed family meals in 4-6 year-olds(66).

In addition, at each time point the Infant Feeding Style Questionnaire(97) is administered. This questionnaire has shown adequate internal consistency and validity and measures the following parental feeding styles: laissez-faire, restrictive, pressuring, responsive and indulgent. As of t_{18} the following scales from the validated Comprehensive Feeding Practices Questionnaire(98, 99) are added which are appropriate at that age: restriction, monitoring, modelling, encourage balance and variety, pressure to eat, child control, emotion regulation and food as reward. Scales from the Feeding Practices and Structures Questionnaire(100) are also added as of t_{18} (reward for eating, overt restriction) and t_{24} (reward for behavior, persuasive feeding, structured meal setting, structured meal timing).

Other measures

The following potential covariates will be assessed: demographic variables such as maternal and paternal education and job status, family income, cultural background (t_0); type of milk feeding (breast/formula: t_0-t_{18}); maternal depression (t_0-t_{36}: Center for Epidemiologic Studies Depression Scale(101)); maternal vegetable intake (t_{12} and t_{36}: Food frequency questionnaire(102)); maternal anthropometrics (t_0-t_{36}); use and amount of purée consumed of the 100 distributed vegetable- and fruit jars in the 5 months after the feeding schedule (t_{12}); maternal self-efficacy related to feeding their child (t_0-t_{36}: Parental Feeding Self-Efficacy Questionnaire(103)); maternal emotions during feeding the child (t_0-t_{36}: measure designed for this study); structure of family meals (t_0-t_{36}: Meals in our Household(104)); maternal perception of feeding (t_0-t_{36}: Five Minute Speech Sample(105)); child temperament (t_0-t_{12}: Infant Behavior Questionnaire-Revised(106); t_{18}-t_{36}: Early Childhood Behavior Questionnaire(107)); general parenting styles (t_0-t_{36}: observed maternal intrusiveness during mealtimes and observed maternal sensitivity and intrusiveness during free-play situations(95); t_{18}-t_{36}: Comprehensive General Parenting Questionnaire(108)).

Blinding

Researchers coding video data are blinded for intervention-allocation. It is impossible to blind participants for intervention-allocation, because they will be informed prior to randomization about what types of advice they can receive in the study and it will be clear after randomization what type of advice they are receiving.

Participant reimbursement and efforts to prevent drop-out

As a compensation for the time and effort participants invest in our study, families receive several compensations. Apart from the pureed vegetables or fruits during the feeding schedule and the 100 jars of baby foods until the infant is 12 months of age, families receive gift tokens of 25 euros and a gift for the child of approximately 5 euros at t_{18}, t_{24}, and t_{36}. Additionally, all videos made throughout the study are shared with the families at completion of the study, and families randomly allocated to receive VIPP-FI receive the videos used for the intervention during the last session of the intervention.

To involve participants in the study we will send families biannual newsletters about the study, mentioning interesting facts (e.g., inclusion rates, presentations at symposia, pictures of researchers/students involved in the project). Also, we aim to stimulate a pleasant relationship between researchers and participating mothers by for example sending birthday cards to the family when the child will have its birthday. In a similar effort, and to diminish any additional burden for the participating families, we will strive to provide continuity in the researchers/students that are in direct contact with a family (e.g., at home visits or telephone calls). Moreover, we will make sure during every home visit to check whether participants have any questions about the measurements and/or interventions and to provide assistance in filling out questionnaires or dietary recalls whenever needed.

Confidentiality, data management and access

All data will be stored using numbers to identify participants at the secured databases of Leiden University and Wageningen University and Research. Only one document exists that links participant numbers to personal data, and this file is only available to the main researchers performing data collection at Leiden University and Wageningen University. Data that need to be entered manually (e.g., measured weight and height during home visits, codes of video material) will be entered in the latest version of the statistical software package IBM SPSS Statistics by trained researchers/students. The quality of this data entry will be checked regularly by another (independent) trained researcher/student.

As detailed in the consortium agreement-contract of the project, only researchers and students involved in the project working at any of the academic parties (Leiden University, Wageningen University and Research) will be allowed access to the data. With the exception of the video-recordings (VIPP-FI), which contain privacy-sensitive information, research data will be open access where possible (e.g. when a peer-reviewed journal requests or offers the uploading of anonymized datasets into an open access database. In these cases, all personal information will be removed from data files and replaced by participant identification numbers. The file linking these numbers to personal information will be stored digitally in a separate password protected file that will only be accessible to the researchers). Large video-files will be shared between the two universities by making copies on external pass-word protected hard-drives and personally exchanging these hard-drives.

Analyses

The intention-to-treat principle will be applied to all analyses. Whether the interventions differentially affect primary and secondary outcomes over time will be analyzed using linear mixed models analyses, a technique that makes use of every data point for every participant, irrespective of their missing data. The three intervention groups will be compared to the control group, and the combined group will be compared to the repeated exposure and the VIPP-FI group. A significance level of $\alpha = .05$ will be used. The analyses will be corrected for relevant covariates such as family socioeconomic status, maternal consumption of vegetables, parental body mass index (BMI), child temperament, etc.

Monitoring of interventions and trial progression

Participants will be asked to fill out an evaluation form concerning the interventions following the last session. These forms will assess participants' satisfaction with the intervention as well as with the person delivering the intervention. In addition, participants will be asked to note any other comments about the interventions, allowing for spontaneously reported adverse events. As the interventions are not invasive and merely provide parents support, advice and commercially available foods with a history of safe use, no adverse events are expected and no stopping guidelines are formulated. For the same reasons, a data management committee is not needed. Principle investigators at each study site (i.e. JM, SV, KG, JV and GJ) will supervise data collection and data management. We will not perform any interim analyses as we want to avoid the risk of the results of such analyses influencing the overall results of the trial. No explicit trial conduct audit is planned; however, yearly reports on the progress of the project will be sent to the major funder of the trial (The Netherlands Organization for Scientific Research). If any major changes will occur in the study protocol (e.g., changes to outcomes or assessment periods) the ethical review boards that approved the study as well as the funder of the trial will be notified of these changes.

Dissemination policy

It is planned to publish the results of our trial in peer-reviewed journals, as well as present the results at (inter)national conferences. Also, participants will receive a report of the results of our study after completion of the study. Publication in magazines for healthcare professionals and the general public are also intended. Authorship to any publications will be granted to those who fulfil the ICMJE recommendations(109). We will not hire any professional writers.

Discussion

Baby's First Bites will be the first trial explicitly testing the separate and combined effects of promoting the *what* and *how* of complementary feeding. By comparing three prolonged, intensive interventions, we will be able to draw firm conclusions on what is most important to focus on when promoting vegetable acceptance and children's self-regulation of energy intake in early childhood; what food to offer, how to offer this food, or a combination of the two. Moreover, this will be the first trial to include an intervention specifically manipulating sensitive feeding practices without manipulating any other variables, evaluating its effects using both self-report and observational measures. This allows conclusions on whether this parenting practice will indeed promote healthier food preferences in children and will foster children's ability to self-regulate their energy intake, as is often suggested in the literature.

The planned study also provides some points of discussion to be considered. First, the channels of recruitment we have chosen pose the risk that participating families are not representative of the general population, as they are partly recruited from a database of pregnant women who showed interest in information about infant nutrition. Thus, these families may be more motivated to provide a healthy eating environment for their infant than the general public. However, it should be noted that time-consuming randomized controlled trials (RCTs) like the present study will always elicit this potential selection bias, irrespective

of the channels of recruitment chosen. Also, this drawback is negated somewhat by the fact that this study succeeded in including participants at all educational levels. Nevertheless, this potential selection bias should be taken into account when considering the implementation of the results of this study. Second, we chose to give parents the opportunity to start complementary feeding from the age of 4 months, thereby making sure that we followed parental preferences in starting complementary feeding. There is still some discussion in the literature about when to start complementary feeding. The general recommendation from the World Health Organization (WHO) is to exclusively breastfeed until the age of 6 months and introduce complementary foods from 6 months(1). For the European Region, WHO(113) recommend that all infants should be exclusively breastfed from birth to about 6 months of age, and at least for the first 4 months of life, but that some infants may need complementary foods before 6 months of age, and that these should not be introduced before 4 months. The European Food and Safety Authority (EFSA) panel(114), the European Society for Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN)(115) recommend that complementary foods including allergens are introduced between 4 and 6 months, and this has been shown to be associated with a reduced risk of food allergies(110). Starting complementary feeding between 4-6 months is also in accordance with recommendations from the Dutch Nutrition Centre(111) and the Dutch youth health care centers(112) and thus reflects official Dutch guidelines and probably the daily practice of parents in the Netherlands.

Third, we chose to deliver the combined intervention by simply following the same procedures as used in each separate intervention, and the intervention was provided by two different researchers/students (one delivering RVE, and one delivering VIPP-FI). As such, it can be debated whether this really constitutes a *combined* intervention or simply *two* interventions. Also, from the families' point of view, receiving advice from two different persons might not be ideal. An alternative approach would have been to incorporate all information of both interventions in the home visits. However, we decided against this as the VIPP-FI home visits already took up 60 to 90 minutes. Including the information of the RVE intervention in this session would result in too much information for the mother to properly process in one sitting, increasing the risk that the effects of the intervention would diminish. Fourth, considering the time-consuming nature of this study for families, there will be a considerable risk of drop-out during the study. This risk is even higher in the selected sample of first-time mothers, as it is likely that many families will expand their family during the study period, making the time they have available for participating in this study more limited. We plan to accommodate families as much as possible to make sure that they will be able to finish the study, for instance by offering assistance where necessary (e.g., filling out questionnaires together or sending personal reminders) and by being flexible in planning the home-visits.

Finally, if the proposed RCT will prove the interventions effective, the labor intensiveness of the tested interventions may pose problems for their implementation to the general public. Although this is not so much a limitation of the current study, it is a drawback for implementing its results, as it will be necessary to translate the interventions to scalable prevention programs before the interventions can be implemented for a larger group.

In conclusion, the planned trial has the potential to provide valid evidence on the question how parents may promote healthy eating habits from the very first start of eating solid foods. If proven effective, these interventions could be useful to large scale effective prevention of childhood obesity.

Competing interests

Danone Nutricia Research and Nutricia Early Life Nutrition has provided additional funding for *Baby's First Bites* (see Funding).

C. Vereijken (CV) and H. Weenen (HW) are employees of Danone Nutricia Research, N. van Winden (NW) is employee of Nutricia Early Life Nutrition, The authors declare that they have no other competing interests.

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CV and HW (employees of Danone Nutricia Research), and NW (employee of Nutricia Early Life Nutrition) took part in conceiving the study, gave input during development of the interventions, and gave input on the draft manuscript. NWO peer reviewed the study proposal before allocating the grant.

Authors' contributions

SV, JM, CG, JV, GJ, CV, HW, and NW conceived the study. JS and JV developed the vegetable-exposure intervention, with relevant input from GJ, HW and CG. SV, JM, MV and SJ developed the VIPP-FI intervention, with relevant input from CV and NW. MV, JS, SJ and VW conduct data collection. SV drafted the manuscript with critical input from all authors. All authors have read and approved the final manuscript.

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Chapter 3

The Baby's First Bites RCT: Evaluating a vegetable-exposure and a sensitive-feeding intervention in terms of child health outcomes and maternal feeding behavior during toddlerhood

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Abstract

Background: Parenting interventions during the first years of life on *what* and/or *how* to feed infants during complementary feeding (CF) may promote healthy eating habits.

Objective: An intervention promoting repeated exposure to a variety of vegetables (RVE; *what*) and an intervention promoting to respond sensitively to child signals during mealtime (VIPP-FI; *how*) were compared, separately and combined (COMBI), to an attention control condition (AC). Primary outcomes were vegetable consumption and self-regulation of energy intake; secondary outcomes were child anthropometrics and maternal feeding practices (sensitive feeding, pressure to eat).

Methods: Our four-arm randomized controlled trial included 246 first-time Dutch mothers and their infants. Interventions started when infants were 4-6 months old and ended at age 16 months. The present study evaluated effects at 18 (t18) and 24 (t24) months of age. Vegetable acceptance was assessed using three 24h dietary recalls, self-regulation of energy intake by an eating-in-the-absence-of-hunger experiment and mother-report, and maternal feeding behavior by observation and mother-report.

Results: Linear Mixed Model and ANOVA analyses revealed no follow-up group differences regarding child vegetable intake or self-regulatory behavior. The proportion of children with overweight was significantly lower in the COMBI group, compared to the VIPP-FI group at t18 (2% vs. 16%), and AC group at t24 (7 vs. 20%), although this finding needs to be interpreted cautiously due to the small number of infants with overweight and non-significant effects on the continuous BMI-z measure (*P*-values 0.29-0.82). Finally, more sensitive feeding behavior and less pressure to eat was found in the VIPP-FI and COMBI groups, compared to the RVE and AC group, mostly at t18 (significant effect sizes: $d = 0.23$-0.64).

Conclusion: Interventions were not effective in increasing vegetable intake or self-regulation of energy intake. Future research might do well to focus on risk groups such as families who already experience problems around feeding.

Keywords: complementary feeding, vegetables, self-regulation of energy intake, repeated exposure, responsive feeding, sensitive feeding, infant, toddler, child

Introduction

Adults with overweight or obesity have a higher risk of developing type II diabetes, cardiovascular disease and certain cancers [1-3]. Because overweight in childhood is predictive of overweight in adulthood, promoting healthy eating habits such as sufficient vegetable consumption [4, 5] and self-regulation of energy intake (i.e. the ability to act on one's feelings of hunger and satiety; [6, 7]) from an early age onwards is crucial [8, 9]. Since parents largely determine *what* and *how* children are fed in the first years of life, early interventions focussing on parental feeding strategies during the transitional period of complementary feeding (CF) seem a promising way to foster healthy eating habits from the very beginning. To promote vegetable consumption (the "*What*" of CF), repeatedly exposing infants to a variety of vegetables is found to be an effective method [5, 10, 11]. To foster self-regulation of energy intake and thereby reduce the risk of developing overweight [12, 13]), promoting parental responsive feeding behavior (the "*How*" of CF) is thought to be important, as responsively feeding parents adequately respond to infant hunger and satiety cues and do not pressure infants to eat beyond satiation [12, 13]. Moreover, although not previously studied, responsive feeding might have beneficial effects on vegetable intake as well. Experimental evidence shows that *non*-responsive feeding strategies such as pressuring a child to eat can have adverse effects on vegetable intake and can foster negative affective responses to foods [14]. In contrast, parents who feed in a responsive way allow their child to be in control of its food intake, thereby possibly contributing to more appreciation and intake of vegetables in the long run.

To date, two large RCTs showed that parenting interventions successfully promoted healthier child (dietary) outcomes (increased combined fruit and vegetable intake [15] and less rapid weight gain [16, 17]): the NOURISH and the INSIGHT trial [18, 19]. In the NOURISH trial, mothers received twelve interactive group sessions divided over two modules, one at the start of complementary feeding (age 4-6 months), and one at the age of 13-16 months. The content of the intervention sessions concerned repeated exposure to healthy foods, avoiding unhealthy foods, responsive feeding, modelling, and avoidance of coercion or food rewards [18]. At 14 months, less rapid weight gain and lower BMI-z scores were found in the intervention group. Moreover, mothers reported less use of some nonresponsive feeding strategies [16]. Finally, when averaging data of 3.7 and 5 years, a greater combined fruit and vegetable intake was reported for children in the intervention group. Effects on child BMI were no longer present on those time points. In the INSIGHT trial, four home visits took place at 3, 16, 28 and 40 weeks of age, where several topics on *what* (e.g. fruit and vegetables, water, and snacking), *when* (e.g. introducing solid food, introducing a cup or a spoon) and *how* (e.g. repeated exposure, hunger and fullness cues, avoiding pressure to eat, modelling, and family meals) were addressed [19]. Moreover, advice was given on physical activity and sleeping behavior. At the age of 1 year, they did not find effects on vegetable intake, but did find children in the intervention group to show less rapid weight gain [17]. Moreover, less non-responsive feeding practices were reported in the intervention group [20]. Although both trials found some positive effects on dietary outcomes, no effects were found on vegetable intake alone. Moreover, (non-)responsive feeding behavior was assessed by self-report instead of observation, and therefore prone to social desirability. Finally, these interventions included

many different elements on a broader level and included advice on the *what* and the *how* of CF simultaneously, making it impossible to determine the relative effect of these types of advice. Evaluating the effects of what, how and their combined effect within the same study allows for inferences about the efficacy of these different types of advice.

In the present study, a vegetable-exposure intervention promoting vegetable consumption (RVE; focusing on the "*what*") was compared to a parenting intervention to promote sensitive feeding behavior (VIPP-FI; focusing on the "*how*") [21]. Within an RCT design, the two interventions were administered separately as well as combined (COMBI), and were compared to an attention control condition (AC). The interventions started when children were offered their first bites of complementary foods (age 4-6 months; baseline t0) and lasted throughout the first year of CF, up until the age of 16 months. In the present paper, the effects of the interventions two months after completion when the age of the child is 18 months (t18) and at eight months follow-up when the age of the child is 24 months (t24) are evaluated. With respect to child outcomes, we hypothesized that a) all interventions (RVE, VIPP-FI, COMBI) are more effective in improving vegetable intake than the control condition; b) the sensitive-feeding and combined intervention are more effective in supporting self-regulation of energy intake and in reducing anthropometric indicators of obesity risk than the vegetable-exposure or control condition; and c) the combined intervention is more effective than the other two interventions alone in promoting vegetable intake. With respect to maternal outcomes, we hypothesized that d) the sensitive-feeding and combined intervention are more effective in promoting positive maternal feeding behavior than the vegetable-exposure or control conditions.

Subjects and Methods

Participants

The Baby's First Bites study is a multicenter trial using a superiority randomized controlled design that was conducted from two study locations (Wageningen University and Research, and Leiden University) and carried out in four provinces (Zuid-Holland, Noord-Holland, Gelderland and Utrecht) in the Netherlands. Information regarding for example recruitment of participants and randomization can be found in the study protocol, as well as in the flow chart depicted in Supplemental Figure 1 [21]. As soon as parents decided to participate, written informed consent was obtained from both parents. The protocol was approved by the Ethical Review Board of Education and Child Studies, Leiden University (protocol number ECPW-2015/116) and the Medical Ethical Review Board of Wageningen University and Research (METC-WU protocol number NL54422.081.15). The trial was registered during inclusion of participants at the Netherlands National Trial Register (identifier NTR6572) and at ClinicalTrials.gov (NCT03348176).

A total of 246 mother-child pairs started the intervention phase. Participant characteristics are shown in Table 1. Parents received a small present for their child after each home visit, as well as a €25 gift voucher for each post intervention assessment.

TABLE 1 | Baseline characteristics of mother-child pairs allocated to intervention or control conditions.

Variable[1]	Total (*n*=246)	RVE (*n*=61)	VIPP-FI (*n*=62)	COMBI (*n*=60)	AC (*n*=63)
Mother					
Education (masters degree) – *n* (%)	47 (19.1%)	15 (24.6%)	12 (19.4%)	10 (16.7%)	10 (15.9%)
Age at baseline (y)	31.0 ± 4.7	30.3 ± 4.8	31.4 ± 4.5	30.6 ± 4.8	31.7 ± 4.6
BMI (kg/m²) at baseline	27.1 ± 5.5	26.7 ± 5.2	27.1 ± 6.1	26.9 ± 5.3	27.5 ± 5.5
Child					
Sex (male) – *n* (%)	117 (47.6%)	28 (45.9%)	29 (46.8%)	28 (46.7%)	32 (50.8%)
BMI-z at baseline[2]	-0.20 ± 0.10	-0.20 ± 0.92	-0.29 ± 1.11	-0.14 ± 1.04	-0.15 ± 0.91
Age at baseline (wks)	20.1 ± 3.9	20.5 ± 2.1	20.8 ± 2.5	20.0 ± 1.5	20.2 ± 1.9
Breastfeeding duration (wks)[3] – Median (range)	19.0 (0-75)	20.0 (0-72)	14.0 (0-75)	24.0 (0-75)	14.0 (0-72)
Cared for by others at baseline - *n* (%)[4]					
<5 hours/week	69 (28.3%)	17 (28.3%)	19 (30.6%)	17 (28.8%	16 (25.4%)
5-10 hours/week	28 (11.5%)	6 (10.0%)	7 (11.3%)	6 (10.2%)	9 (14.3%)
10-20 hours/week	66 (27%)	15 (25.0%)	13 (21.0%)	17 (28.8%)	21 (33.3%)
>20 hours per week	81 (33.2%)	22 (36.7%)	23 (37.1%)	19 (32.2%)	17 (27.0%)

[1]Values are means ± SDs, unless reported otherwise. RVE = Repeated Vegetable-Exposure Intervention, VIPP-FI = Video Intervention to Promote Positive Parenting Feeding Infants intervention, COMBI = Combined condition of RVE and VIPP-FI, AC = Attention-control condition. No group differences were present for any of the variables
[2]World Health Organization Standards [33]
[3]Breastfeeding duration was assessed when children were 18 months of age
[4]Hours the child is not taken care of by the parents at baseline (age 4-6 months), e.g. daycare, grandparents

Procedure

As soon as parents consented to participate, they received a short list of signals to help them decide whether their infant (aged 4-6 months) was ready to start complementary feeding (e.g. "child can stabilize head"; "child shows interest in food"). After they indicated their child was ready, they were asked to give their infant rice-flour porridge with a spoon for at least five days to familiarize the infant with eating from a spoon. Subsequently, all participants started with a 19-day feeding schedule as described in more detail elsewhere [21], which specified one purée meal per day in addition to usual milk feeding. These feeding schedules were provided for the benefit of the RVE intervention. For standardization purposes commercially available jars of vegetable and fruit purées were provided. Home visits were performed by one of the researchers on days 1, 2, 18 and 19 to videotape the feeding interaction between mother and child, assess how much the child had eaten, and perform other measurements, such as mother and infant weight and height. On these four days all conditions received the same vegetable purées (green beans and cauliflower, in counterbalanced order). On day 3-17 of the feeding schedule, the mother fed her child the purées at home without the presence of the researchers. During the feeding schedule, we advised families not to offer other complementary food besides the prescribed purée.

Intervention sessions started concurrently with the feeding schedules. These interventions took place in five sessions over the course of a year, timed in accordance with major transitions in eating. Two sessions took place at child age 4-6 months and the other three at 8, 12 and 16

months. The focus of the RVE intervention was to motivate mothers to repeatedly expose their children to vegetables. The focus of the VIPP-FI intervention was to enhance maternal sensitive responses to her child during mealtimes. More detailed information about the development and content of the interventions can be found in the protocol paper [21] and in Supplemental Table 1. At 18 as well as 24 months another home visit took place, which contained the same elements as the pretest home visit. Finally, about a week before each home visit, mothers were asked to fill out several questionnaires online (see [21] for more detail).

Outcome measures

Child measures

Primary outcome: Vegetable intake

For the duration of the 19-day feeding schedule that all families commenced with from the first bite onwards (age 4-6 months), the child's consumption of purée was assessed daily by weighing the amount eaten from the provided jars (125g per jar) on standard small kitchen scales (Soehnle, Fiesta 65106). Vegetable intake was assessed at t18 and t24, by asking mothers to fill out web-based 24-hour dietary recalls on three randomly assigned, non-consecutive days within a 3 week period using the online program Compl-eat [25]. Compl-eat used the Dutch food composition database (NEVO) edition 2016/5.0 for the calculation of energy and nutrient intake and food grouping of vegetables. Pre-packaged foods or jars of baby food that were not yet available in the database were manually added by checking the product's package label. The dietary data were processed by trained dietitians, and in case of uncertainties participants were contacted via email or telephone to clarify their entry. More information on measuring vegetable intake is provided in the study protocol [21].

For outcome measures where a logical cut-off could be determined, it was established whether a participant was unsuccessful (1) or successful (2) at this outcome measure (success rate). With respect to vegetable intake, a cut-off of 50 grams per day (Dutch daily recommended vegetable intake for children of this age) was used to determine if a child on average consumed enough vegetables or not, in order to compare the four study groups on this binary outcome.

Primary outcome: Self-regulation of energy-intake

Experimental task. Self-regulation of energy intake was assessed by an eating in the absence of hunger (EAH) experiment at t18. The procedure for measuring EAH was based on the free-access procedure for children aged 3-5 years old in a laboratory setting as described by Fisher and Birch [26], and adapted for 18-month-old children in a home setting. The protocol for the present study and adaptations to the original procedure have recently been described elsewhere [27]. Parents were asked to prepare an evening meal for the child as usual and have dinner together as part of the daily routine. The type and amount of food the child consumed was carefully assessed by obtaining a detailed description of the meal, weighing all food and drinks and taking photographs before and after the meal. The data were processed by trained dietitians to obtain total energy content of the meal. This was followed by an eight-minute free-play session of mother and child after which the researcher provided the child with a

plate of two savory (two breadsticks and a handful of potato snack sticks) and two sweet (one slice of gingerbread, and two plain biscuits) age-appropriate palatable finger foods (total 275 kcal) for ten minutes. If the child was allergic to a food or parents disapproved of a food, an alternative was offered, which was the case for 24 children. Mothers remained in the room but were asked not to interfere with the child's behavior, so the child had the opportunity to continue playing with the toys or eat the provided foods without interference. Finger foods were weighed before and after the free access procedure and the weight was multiplied by the energy content of each individual food to determine respectively the total weight (grams) and energy (kcal) consumed by the child. To measure self-regulation, children's finger food intake in kcal, corrected for energy intake during the evening meal, was used in subsequent analyses. Because a cut-off score of finger food intake could not be determined based on theoretical or empirical grounds, no success rate was established for this measure.

Mother-report. Mothers were asked to fill out the Baby Eating Behavior Questionnaire (BEBQ; [28]) before starting the feeding schedule, and the Child Eating Behavior Questionnaire – Toddler (CEBQ-T; [29]) prior to the home visits at t18 and t24. The BEBQ and CEBQ-T assess several aspects of child eating behavior, including food responsiveness (FR) and satiety responsiveness (SR). Mothers reported on a 5-point Likert scale (from "1= never" to "5= always") how frequently they observed their child demonstrate several eating behavior characteristics on a typical day (e.g., *If (s)he was allowed, my child would overeat* (FR)*; My child cannot eat a meal if (s)he has had a snack just before* (SR)). The FR and SR scales are used as indicators of the child's self-regulation of energy-intake, where scoring lower on FR and higher on SR indicates better self-regulation skills [30]. The original CEBQ scale has been shown to have good internal consistency (Cronbach's alphas ranging from 0.72 to 0.91; [31]), adequate two-week test-retest reliability (correlation coefficients ranging from 0.52 to 0.87; [31]), and adequate construct validity [32]. In our sample, internal consistency ranged from α = 0.73 (t0) to α = 0.80 (t18/24) for Food Responsiveness, and α = 0.68 (t0) to α = 0.81 (t18/24) for Satiety Responsiveness. Because a cut-off score of FR and SR could not be determined based on theoretical or empirical grounds, no success rate was established for this measure.

Secondary outcome: Anthropometrics

Child bodyweight was measured during each follow-up assessment at home using a calibrated digital scale (SECA robusta 813), in kilograms to the nearest 0.1 kg. Up until t18 the child's height was measured on an infant measuring mat to the nearest 0.5 cm. At t24 children's height was measured with a portable stadiometer (SECA 213, Chino, USA/Garant). Body Mass Index (BMI) was calculated and transformed into age and sex-standardized z-scores (BMI-z) using reference values from the WHO child growth standards (2019) [33] and the following formula: BMI-z=$[(BMI/M)^{L}-1]/(L\times S)$ [34]. As reported in earlier studies [35, 36], change in BMI-z was calculated (t0 to t18, to to t24 and t18 to t24) as a measure of weight gain. To establish the success rate in each condition, a cut-off for BMI-z of 2 (upper limit for normal weight) was used [37].

Secondary outcome: Maternal feeding behavior

Observed feeding behavior. Maternal feeding behavior was observed during mother-child feeding interactions in the home setting. Feeding interactions of t0, t18 and t24 were videotaped and coded from the beginning of the feed (first spoon offer until the moment the mother decided to end the meal) to measure, among others, responsiveness-to-stop signals of the child, maternal sensitivity during feeding and pressure to eat. After intensive training, a reliability set of 30 videos was coded by four coders, yielding intercoder reliabilities (intraclass correlations, single rater, absolute agreement) of > 0.70 for all scales between all individual coders [38]. The coders were not familiar with the families in the videos they were allocated, nor aware of these families' group status (experimental vs control).

Responsiveness to stop signals. The Responsiveness-To-Stop-Signals scale was based on the responsiveness-to-child-fullness-cues scale as described in the Responsiveness-To-Child-Feeding-Cues Scale coding instrument [39]. Adaptations made to the original scale are described elsewhere [40]. The responsiveness of the mother was based on her response to the fullness cues expressed by the child, taking into account the frequency and intensity of child fullness cues prior to the mother's decision to stop the feed. Maternal responsiveness was scored on a 5-point scale, ranging from highly unresponsive (1) to highly responsive (5). In case this maternal behavior could not be observed, for example when the child finished all the food without showing any stop signals, or the mother restricted the child from finishing all the food, mother was given a score of 9 (not applicable). Interrater reliability was good to excellent (ICC^{t0} = 0.75 - 0.87; ICC^{t18} = 0.77 - 0.94; ICC^{t24} = 0.78 - 0.97). To establish the success rate in each condition, a cut-off of ≥4 (often or always responsive) was used.

Sensitivity. To rate maternal sensitivity towards all child behavior shown during the feed, the Ainsworth sensitivity scale was used [41]. Mothers were scored on the original 9-point scale, ranging from highly insensitive (1) to highly sensitive (9). Interrater reliability was good to excellent (ICC^{t0} = 0.73 - 0.85; ICC^{t18} = 0.79 - 0.87; ICC^{t24} = 0.78 - 0.93). To establish the success rate in each condition, a cut-off of ≥6 (high sensitivity scores indicating the absence of behaviors clearly out of tune with the child's signals) on the Ainsworth scale was used.

Pressure to eat. Our observed pressure to eat scale was adapted from the "received pressure to eat scale" as designed by Camfferman and colleagues [42]. Pressure to eat was defined as any encouragement, either physically or verbally, by the mother to make the child eat more, and was coded on a 5-point scale (1 = no pressure at all, 5 = extreme pressure). Extreme pressure to eat could be defined either in terms of quantity (pressure throughout the entire interaction) or in terms of intensity (e.g. force feeding the child). Pressure to eat was only coded at t18 and t24. Internal consistency was good (ICC^{t18} = 0.71 - 0.83; ICC^{t24} = 0.77 - 0.86). To establish the success rate in each condition, a cut-off of ≤2 (never, or rarely use of pressure to eat) was used.

Self-reported feeding behavior. The Infant Feeding Style Questionnaire (IFSQ, [43]) was used to measure responsive feeding and pressure to eat. Mothers reported on a 5-point Likert scale varying from never (1) to always (5), and were asked which answer was most applicable to their situation.

Responsive feeding. The original IFSQ Responsive-Feeding scale consists of 6 to 8 items,

depending on the age and the diet of the infant (milk only versus including solid food). However, because some items show overlap with concepts other than responsive feeding (e.g., modeling, or child behavior instead of maternal behavior), we decided to select the three items of this scale that clearly represent responsive feeding (i.e., *I let C decide how much s/he eats; I pay attention when C seems to be telling me that s/he is full or hungry; I allow C to eat when s/he is hungry*). Internal consistency of the adapted responsive feeding scale was rather low (α^{t0} = 0.48, α^{t18} = 0.47, α^{t24} = 0.46), which reflects the fact that these behaviors do not necessarily have to occur simultaneously, but all represent different manifestations of responsive feeding. To establish the success rate in each condition, a cut-off of ≥4 (often or always responsive) was used.

Pressure to eat. The original pressure to eat scale consists of 5 to 7 items, depending on the age and the diet of the infant (milk only versus including solid food). However, because for some items it was ambiguous whether parents actually meant to pressure their child to eat by performing this behavior (e.g., the item "adding rice flour to the bottle"), we decided to use only 4 items that clearly defined pressure to eat (i.e., *I try to get C to finish his/her food; If C seems full, I encourage him/her to finish his/her food anyway; I try to get C to eat even if not hungry; I insist to retry new food refused at same meal*). Internal consistency of the adapted pressure scale was highest at later time-points (α^{t0} = 0.58, α^{t18} = 0.73, α^{t24} = 0.66). To establish the success rate in each condition, a cut-off of ≤2 (never, or rarely use of pressure to eat) was used.

Covariates

At t0 a baseline structured interview was conducted. This interview consisted of questions about perinatal characteristics, family situation, and parental characteristics such as education, health, job status and income, marital situation and information about type of milk feeding (e.g., duration of breastfeeding). In addition, prior to the home visits at t0, t18 and t24, all mothers filled out online questionnaires, for assessing covariates such as child temperament, child food neophobia, maternal depression, or changes in the family's situation compared to t0 (e.g. educational level, marital status). Child temperament was assessed by the Infant Behavior Questionnaire-Revised short form at baseline t0 [44], and the Early Childhood Behavioral Questionnaire at t18 [45]. Child food neophobia was assessed by the Child Food Neophobia Scale [46, 47], and maternal depression by the Center for Epidemiologic

Studies Depression Scale [48]. Furthermore, because pressure to eat was not coded at t0 and the related construct of maternal intrusiveness was (by means of Ainsworth's Interference vs. Cooperation scale; [41]), the latter was used as a covariate. A similar baseline correction was performed for the self-report measures of maternal feeding behavior, by using the baseline data concerning type of milk feeding as a covariate. Maternal height (t0) and bodyweight were measured at all time points and used to calculate BMI in kg/m^2. Finally, children's dietary intake was assessed at t18 and t24 using the same three 24-hour dietary recalls as for assessing vegetable intake. Energy intake was calculated per recall day and an average daily energy intake was calculated per child for t18 and t24 separately. The data collected on days that a child was sick were excluded, therefore the average daily energy intake was based on one (4.4%), two (15.1%) or three (80.5%) recall days.

Statistical analysis

Detailed information about the inclusion phase and retention from initial contact with potential participants to randomization, as well as justification of the sample size are described elsewhere [21].

Linear mixed model analysis (LMM) was used to test if the interventions differentially affected outcome measures over time. Because LMM facilitates an intention-to-treat analysis, all participants with data on at least one time point (t0, t18 or t24) were included in the analyses. Therefore, imputations were not considered necessary. As no baseline group differences were detected on relevant covariates (Table 1), adjustment for covariates was not undertaken, unless considered necessary based on other grounds (e.g. baseline correction). The covariance structure was determined for each outcome measure separately, by choosing the structure with the optimal fit (i.e. lowest AIC value, [49]). Within LMM, pairwise comparisons that were relevant for our hypotheses were performed, at t18 and t24 separately. No posthoc-adjustments were undertaken, because only hypotheses-driven comparisons were performed [50, 51]. Effects of condition, time, and their interaction (comparing all groups simultaneously over time), were analyzed and reported as well, and considered exploratory analyses.

With respect to vegetable intake, a square root transformation was performed because of severe positive skewness. By means of planned pairwise comparisons in LMM, all three intervention groups were compared to the control group, and the COMBI group was compared to the VIPP-FI as well as the RVE group. Vegetable intake was related to average daily energy intake ($r(194) = 0.17$, $P = 0.02$ and $r(179) = 0.28$, $P = <0.001$) at t18 and t24, respectively. Therefore, the LMM analysis was run with and without correction for average daily energy intake to account for variations in appetite, which in turn may also influence vegetable intake. Because energy intake was not assessed at t0, baseline vegetable intake was expressed as grams per kilogram bodyweight.

To test differences in finger food intake between the conditions at t18 in order to measure self-regulation, an ANCOVA was performed. Planned pairwise analyses were performed, comparing the VIPP-FI and COMBI group to the RVE and AC group. Energy intake of the evening meal was added to the model as covariate. Regarding the FR and SR scales of the CEBQ-T, planned pairwise comparisons were performed in LMM, by comparing the VIPP-FI and COMBI group to the RVE and AC group. Data were analyzed at t18 and t24, corrected for pretest data concerning milk feeding.

Regarding child BMI-z scores, planned pairwise comparisons were performed in LMM, by comparing the VIPP-FI and COMBI group to the RVE and AC group. To test whether changes in child BMI-z scores (weight gain) differed between the intervention groups stated above (baseline to t18 and t24 and t18 to t24), ANOVA analyses were performed.

With respect to the parenting measures, planned pairwise comparisons were performed in LMM, by comparing the VIPP-FI and COMBI group to the RVE and AC group. Observed pressure to eat (corrected for maternal intrusiveness at t0), as well as the self-report measures maternal responsive feeding and maternal pressure to eat (corrected for pretest data concerning milk feeding) were only analyzed at t18 and t24. The observational measures responsiveness-to-stop-signals and maternal sensitivity did include a pretest measure equal to the measures at t18 and t24.

Finally, differences in success rates between groups were analyzed by means of Generalized Linear Models with a binary outcome, correcting for pretest data. An overall Chi-square measure was reported, as well as *P*-values resulting from subsequent pairwise comparisons between relevant conditions.

Statistical significance was set at $P < 0.05$. Cohen's *d* effect sizes were obtained and reported regarding mean differences between conditions [52]. Values of 0.20, 0.50 and 0.80 were considered a small, moderate and large effect, respectively [52]. All analyses were performed with statistical software IBM SPSS version 25.

Results

Participant characteristics

Participant flow throughout the study and baseline characteristics are depicted in Supplemental Figure 1 and Table 1, respectively. With respect to attrition, mothers who prematurely dropped out tended to have a lower educational level (2.6% of dropouts vs 22.2% of remaining participants had a university degree). Dropping out was not related to maternal BMI, maternal age, maternal vegetable intake, intervention group or household income. The only baseline difference found significant was vegetable intake at t0 ($P = 0.03$), with higher vegetable intake in the RVE condition than in the COMBI condition (Figure 1; Table 2).

Child outcomes

With respect to child vegetable intake, planned pairwise comparisons resulting from Linear Mixed Model analysis at t18 and t24 showed no significant differences between the RVE, VIPP-FI and COMBI groups compared to the AC group (*P*-values 0.11-0.86; Figure 1A; Table 2). The COMBI group was also not superior to the RVE or VIPP-FI groups, as pairwise comparisons revealed no significant differences between these groups. The main effect of time was significant, with significant increases in vegetable intake in grams from t0 to t18 ($P < 0.001$) and t0 to t24 ($P < 0.001$) for all groups, and a significant decrease from t18 to t24, $P < 0.01$ (t0: 24 ± 23 g, t18: 87 ± 53 g, t24: 77 ± 54 g). Main effects of condition and the interaction effect of time x condition, which both compare all conditions simultaneously, were not significant). With respect to success rate, at t18 and t24, the majority of all children achieved the daily recommended intake of at least 50 grams. Corrected for vegetable intake at t0 and for daily energy intake, no main effect of condition was found at t18 ($X^2 = 2.82$, $P = 0.43$) or t24 ($X^2 = 0.43$, $P = 0.93$). In addition, planned pairwise comparisons did not reveal any group differences in achieving daily recommended vegetable intake at t18 or t24 ($P = 0.61$-0.92; Table 2). Taken together, in contrast to our hypotheses, no differences between the three intervention groups compared to AC emerged in terms of vegetable consumption.

To examine the effects of the interventions on self-regulation, absolute intake of finger foods during the eating in the absence of hunger experiment was compared between conditions, corrected for energy intake of the meal consumed before the task (Table 2). At t18, a one-way ANCOVA analysis revealed no main effect of condition, indicating that children

in the VIPP-FI and COMBI groups did not show better self-regulation skills than children in the RVE and AC group (Table 2). With respect to mother-reported self-regulation skills by means of the FR and SR scales of the CEBQ-T, t18 and t24 were examined with correction for mother-reported FR and SR concerning milk feeding at baseline. Planned pairwise comparisons revealed no significant differences between the VIPP-FI and COMBI groups on the one hand, and the RVE and AC group on the other hand, at t18 as well as t24 (*P*-values FR: 0.07-0.91; *P*-values SR: 0.17-0.92; Table 2). The main effect of time was significant for FR as well as SR, with significant decreases in FR from t18 to t24 (t18: 2.6 ± 0.8, t24: 2.5 ± 0.8), and significant increases in SR from t18 to t24 (t18: 2.8 ± 0.6, t24: 3.1 ± 0.7). Main effects of condition and the interaction effect of time x condition, which both compare all conditions simultaneously, were not significant for both FR and SR (Table 2).

Regarding child BMI-z score, planned pairwise comparisons resulting from Linear Mixed Model analysis at t18 and t24 showed no significant differences between the VIPP-FI and COMBI groups compared to the RVE and AC group (*P*-values 0.29-0.82; Table 2). The main effect of time was significant, with significant increases in BMI-z from t0 to t18 ($P < 0.001$), t0 to t24 ($P < 0.001$) and t18 to t24, $P < 0.001$ (t0: -0.2 ± 1.0, t18: 0.4 ± 1.1, t24: 1.0 ± 1.0). Main effects of condition and the interaction effect of time x condition, which both compare all conditions simultaneously, were not significant (Table 2). With respect to child weight gain, there were no group differences from t0 to t18 ($P = 0.79$), t0 to t24 ($P = 0.97$) or t18 to t24 ($P = 0.69$). However, with respect to success rate at t18, corrected for BMI-z at t0, the main effect of condition revealed a trend ($X^2 = 6.86$, $P = 0.07$). When examining planned pairwise comparisons, the COMBI group had a significantly lower proportion of children with overweight (2%) than the VIPP-FI group (16%; $P = 0.02$; Table 2). At t24, the main effect of condition showed a trend as well, $X^2 = 7.60$, $P = 0.06$. Planned pairwise comparisons revealed that the COMBI group had a lower proportion of children with overweight (7%) than the AC group (20%; $P = 0.02$; Table 2).

Maternal feeding behavior

Observed. With respect to maternal responsiveness to satiety cues, planned pairwise comparisons resulting from Linear Mixed Model analysis revealed higher levels of responsiveness in the COMBI and VIPP-FI group compared to AC at 18 months ($P = 0.02$, $d = 0.55$, and $P = 0.03$, $d = 0.47$, respectively; Table 3; Figure 1B). No differences in maternal responsiveness were present between COMBI and VIPP-FI compared to the RVE condition ($P = 0.14$, $P = 0.20$, respectively), and there were no group differences at 24 months ($P = 0.49$-0.98). The main effect of time showed a marginally significant effect ($P = 0.052$), with a significant increase in responsiveness from t0 to t18, $P = 0.03$ (t0: 3.5 ± 1.1, t18: 3.8 ± 1.2, t24: 3.7 ± 1.2). Main effects of condition and the interaction effect of time x condition, which both compare all conditions simultaneously, were not significant. With respect to success rate at t18, corrected for t0, the main effect of condition was not significant, $X^2 = 5.88$, $P = 0.11$. However, planned pairwise comparisons revealed a higher proportion of the mothers in the COMBI condition that was considered *(very) Responsive* (score ≥4) than in the AC condition ($P = 0.01$). Other groups did not differ in terms of success rate at t18 ($P = 0.12$-0.40), and no significant main effect ($X^2 = 1.28$, $P = 0.73$) or significant planned pairwise comparisons were present at t24 ($P = 0.33$-0.96; Table 3).

TABLE 2 | Descriptives and analysis of child health outcomes comparing RVE, VIPP-FI, COMBI and AC at t0, t18 and t24.

Assessment[1]	**t0**			**t18**		**t24**		**Overall**[2]		
	n	**M ± SD**	**%**	**M ± SD**	**%**	**M ± SD**	**%**	***PT***	***PC***	***PTxC***
Vegetable intake, g/day	246	24 ± 23		87 ± 53	79	77 ± 54	67	<.001*	.48	.45
RVE	61	32 ± 30		90 ± 54	73	75 ± 61	63			
VIPP-FI	62	22 ± 20		95 ± 58	86	84 ± 62	67			
COMBI	60	19 ± 16		85 ± 56	77	80 ± 53	69			
AC	63	23 ± 20		79 ± 44	77	70 ± 40	68			
BMI-z[3]	246	-0.2 ± 1.0	99	0.4 ± 1.0	93	1.0 ± 1.1	85	<.001*	.89	.88
RVE	61	-0.2 ± 0.9	100	0.3 ± 1.4	94	0.9 ± 1.0	86			
VIPP-FI	62	-0.3 ± 1.1	98	0.5 ± 1.2	84*	1.0 ± 1.1	82			
COMBI	60	-0.1 ± 1.0	97	0.6 ± 1.0	98*	1.0 ± 1.1	93*			
AC	63	-0.1 ± 0.9	94	0.4 ± 0.9	94	0.9 ± 1.1	80*			
Self-regulation – FFI, kcal	205	-	-	39 ± 36	-	-	-		.91[4]	
RVE	48			41 ± 34						
VIPP-FI	51			39 ± 38						
COMBI	54			37 ± 30						
AC	52			41 ± 43						
Self-regulation – FR	213	-	-	2.6 ± 0.8	-	2.5 ± 0.8	-	<.001*	.20	.35
RVE	50			2.4 ± 0.8		2.3 ± 0.6				
VIPP-FI	53			2.7 ± 0.9		2.7 ± 1.0				
COMBI	54			2.6 ± 0.7		2.5 ± 0.6				
AC	56			2.8 ± 0.8		2.5 ± 0.7				
Self-regulation – SR	213	-	-	2.8 ± 0.6	-	3.1 ± 0.7	-	<.001*	.40	.47
RVE	50			3.0 ± 0.6		3.2 ± 0.6				
VIPP-FI	53			2.7 ± 0.7		3.0 ± 0.8				
COMBI	54			2.9 ± 0.6		3.2 ± 0.6				
AC	56			2.8 ± 0.7		3.0 ± 0.6				

[1]Baseline and follow-up measurements at child age in months (mean ± SD) at each time point: t0 (4.6 ± 0.9) t18 (18.5 ± 0.7) t24 (24.4 ± 0.5). Values are means ± SDs, or percentages (%) referring to the success rate, applicable to the following outcome measures: Vegetable intake – Daily recommended intake of ≥50gr achieved; BMI-z, normal weight between -2 and 2. Per outcome measure, for each condition, the number of participants (*n* =) is reported. Differences in means were assessed using Linear Mixed Model (LMM) analysis, differences in percentages were assessed using Chi-square tests with subsequent pairwise comparisons, which are reported in the text. Regarding pairwise comparisons following from LMM, exact *P*-values and effect sizes are reported in the text. * Significant at $P < 0.05$. RVE = Repeated Vegetable-Exposure Intervention, VIPP-FI = Video Intervention to Promote Positive Parenting Feeding Infants intervention, COMBI = Combined condition of RVE and VIPP-FI, AC = Attention-control condition. FFI= Finger Food Intake, FR = Food Responsiveness (mean score on scale 1-5), SR = Satiety Responsiveness (mean score on scale 1-5).

[2]Overall effects resulting from Linear Mixed Model analysis. *P*T = time effect, *P*C = main effect condition, *P*TxC = interaction time x condition.

[3]World Health Organization Standards

[4]One-way ANCOVA analysis, $F(3, 199) = 0.181$

Regarding maternal sensitivity, planned pairwise comparisons resulting from Linear Mixed Model analysis revealed a marginally significant effect for more sensitive behavior during the meal in the VIPP-FI group compared to AC at t18 ($P = 0.052$; Table 3). The difference between VIPP-FI and RVE was not significant, $P = 0.21$. No differences in favor of the COMBI group compared to RVE and AC were found at t18 ($P = 0.42$, $P = 0.14$, respectively), and no differences

in maternal sensitivity between any groups at t24 (P = 0.34-0.91). The main effect of time was significant, with an increase in sensitive behavior from t0 to t18 (P < 0.001) and t0 to t24 (P = 0.03), and a decrease in sensitive behavior from t18 to t24, P = 0.04 (t0: 6.2 ± 1.5, t18: 6.8 ± 1.6, t24: 6.5 ± 1.7). Main effects of condition and the interaction effect of time x condition, which both compare all conditions simultaneously, were not significant. With respect to success rate (sensitivity score ≥6), the main effect of condition was not significant at t18 (X^2 = 2.71, P = 0.44), as well as t24 (X^2 = 0.34, P = 0.95). Planned pairwise comparisons revealed no differences between VIPP-FI and COMBI on the one hand, and RVE and AC on the other hand (t18: P = 0.10-0.83; t24: P = 0.67-0.95).

TABLE 3 | Descriptives and analysis of maternal outcome measures comparing RVE, VIPP-FI, COMBI and AC at t0, t18 and t24.

Assessment[1]	**t0**			**t18**		**t24**		**Overall**[2]		
	n	**M ± SD**	**%**	**M ± SD**	**%**	**M ± SD**	**%**	***PT***	***PC***	***PT*x*C***
Responsiveness to satiety cues (Obs)	246	3.5 ± 1.1	49	3.8 ± 1.2	68	3.7 ± 1.2	62	.06	.20	.60
RVE	61	3.5 ± 1.0	42	3.7± 1.4	68	3.8 ± 1.3	64			
VIPP-FI	62	3.5 ± 1.2	53	4.0* ± 1.1	70	3.7 ± 1.2	66			
COMBI	60	3.5 ± 1.1	52	4.0* ± 1.0	77*	3.7 ± 1.3	63			
AC	63	3.4 ± 1.1	47	3.4* ± 1.2	57*	3.6 ± 1.1	56			
Sensitivity (Obs)	246	6.2 ± 1.5	40	6.8 ± 1.6	58	6.5 ± 1.7	47	.03*	.78	.34
RVE	61	6.1 ± 1.5	38	6.6 ± 1.8	57	6.3 ± 1.6	43			
VIPP-FI	62	6.1 ± 1.7	42	7.0 ± 1.7	65	6.5 ± 1.8	48			
COMBI	60	6.3 ± 1.6	47	6.9 ± 1.3	67	6.4 ± 1.7	53			
AC	63	6.2 ± 1.4	35	6.4 ± 1.7	52	6.7 ± 1.6	51			
Pressure (Obs)	220	-	-	2.1 ± 1.0	56	2.7 ± 1.0	43	<.001*	.53	27
RVE	51			2.6 ± 1.1	46*	2.8 ± 0.9	38			
VIPP-FI	55			2.1 ± 1.1	62	2.5 ± 1.1	54			
COMBI	58			2.2 ± 0.8	67*	2.9 ± 0.9	38			
AC	56			2.6 ± 1.0	47*	2.7 ± 0.9	41			
Responsive feeding (self-report)	212	-	-	4.1 ± 0.5	73	3.9 ± 0.6	61	<.001*	.22	.49
RVE	50			4.0* ± 0.6	64	4.0 ± 0.6	66			
VIPP-FI	52			4.1 ± 0.5	76	4.0 ± 0.6	59			
COMBI	54			4.3* ± 0.5	84	4.0 ± 0.5	68			
AC	56			4.0* ± 0.5	69	3.8 ± 0.6	53			
Pressure (self-report)	210	-	-	2.4 ± 0.8	45	2.2 ± 0.8	45	.26	.02*	.51
RVE	48			2.5* ± 0.9	36*	2.3* ± 0.9	46			
VIPP-FI	52			2.2* ± 0.8	53*	2.2 ± 0.8	51			
COMBI	54			2.1* ± 0.8	55*	2.1* ± 0.8	48			
AC	56			2.4* ± 0.7	35*	2.3 ± 0.8	36			

[1]Baseline and follow-up measurements at child age in months (mean ± SD) at each time point: t0 (4.6 ± 0.9) t18 (18.5 ± 0.7) t24 (24.4 ± 0.5). Values are means ± SDs, or percentages (%) referring to the success rate, applicable to the following outcome measures: Responsiveness (observation and self-report) - score ≥4; Sensitivity - score ≥6; Pressure (observation and self-report) – score ≤2.

Per outcome measure, for each condition, the number of participants (n =) is reported. Differences in means were assessed using Linear Mixed Model (LMM) analysis, differences in percentages were assessed using Chi-square tests with subsequent pairwise comparisons, which are reported in the text. Regarding pairwise comparisons following from LMM, exact P-values and effect sizes are reported in the text. * Significant at P < 0.05. AC = Attention-control condition, COMBI = Combined condition of RVE and VIPP-FI, Obs = Observed outcome measure, RVE = Repeated Vegetable-Exposure Intervention, and VIPP-FI = Video Intervention to Promote Positive Parenting Feeding Infants intervention.

[2]Overall effects resulting from Linear Mixed Model analysis. *P*T = time effect, *P*C = main effect condition, *P*TxC = interaction time x condition.

With respect to observed maternal pressure to eat, t18 and t24 were examined with correction for intrusiveness during feeding at baseline. Resulting from Linear Mixed Model analysis, planned pairwise comparisons at t18 and t24 showed no significant differences between the VIPP-FI and COMBI groups compared to the RVE and AC group over time (*P*-values 0.17-0.48; Table 3). The main effect of time was significant, indicating an increase in pressure to eat from t18 to t24 (t18: 2.4 ± 1.0, t24: 2.7 ± 1.0). Main effects of condition and the interaction effect of time x condition, which both compare all conditions simultaneously, were not significant. With respect to success rate at t18, the main effect of condition revealed a trend (X^2 = 6.68, *P* = 0.08). Planned pairwise comparisons revealed a higher proportion of the mothers in the COMBI group that hardly used pressure to eat or did not use it at all (score ≤2), compared to the RVE and AC group (*P* = 0.04 and *P* = 0.04, respectively; Table 3). The VIPP-FI group did not significantly differ from RVE or AC (*P* = 0.10, *P* = 0.11, respectively). At t24, the main effect of condition was not significant (X^2 = 3.66, *P* = 0.30), nor did any differences emerge between VIPP-FI and COMBI on the one hand, and RVE and AC on the other hand (*P* = 0.13-0.85).

Self-report. Regarding self-reported maternal responsive feeding, t18 and t24 were examined with correction for self-reported responsive feeding concerning milk feeding at baseline. Resulting from Linear Mixed Model analysis, planned pairwise comparisons at t18 revealed that more responsive feeding behavior was reported in the COMBI group compared to RVE and AC group (*P* = 0.04, *d* = 0.45 and *P* = 0.02, *d* = 0.64, respectively; Table 3; Figure 1C). No differences in favor of the VIPP-FI group were found compared to RVE or AC at t18 (*P* = 0.16 and *P* = 0.32, respectively), nor any differences at t24, between VIPP-FI and COMBI on the one hand, and RVE and AC on the other hand (*P* = 0.31-0.82). The main effect of time was significant, indicating a significant decrease in responsive feeding behavior from t18 to t24 (t18: 4.1 ± 0.5, t24: 3.9 ± 0.5). Main effects of condition and the interaction effect of time x condition, which both compare all conditions simultaneously, were not significant. With respect to success rate (sensitivity score ≥6), the main effect of condition was not significant at t18 (X^2 = 3.66, *P* = 0.30). Planned pairwise comparisons only revealed a marginally significant effect for the difference between COMBI and RVE (*P* = 0.054), with more responsive feeding behavior reported in the COMBI group. The difference between COMBI and AC at t18 was not significant (*P* = 0.33), nor differences between VIPP-FI and RVE or AC (*P* = 0.25, *P* = 0.90, respectively). At t24, the main effect of condition was not significant (X^2 = 1.55, *P* = 0.67), nor did any differences emerge between VIPP-FI and COMBI on the one hand, and RVE and AC on the other hand (*P* = 0.30-0.92).

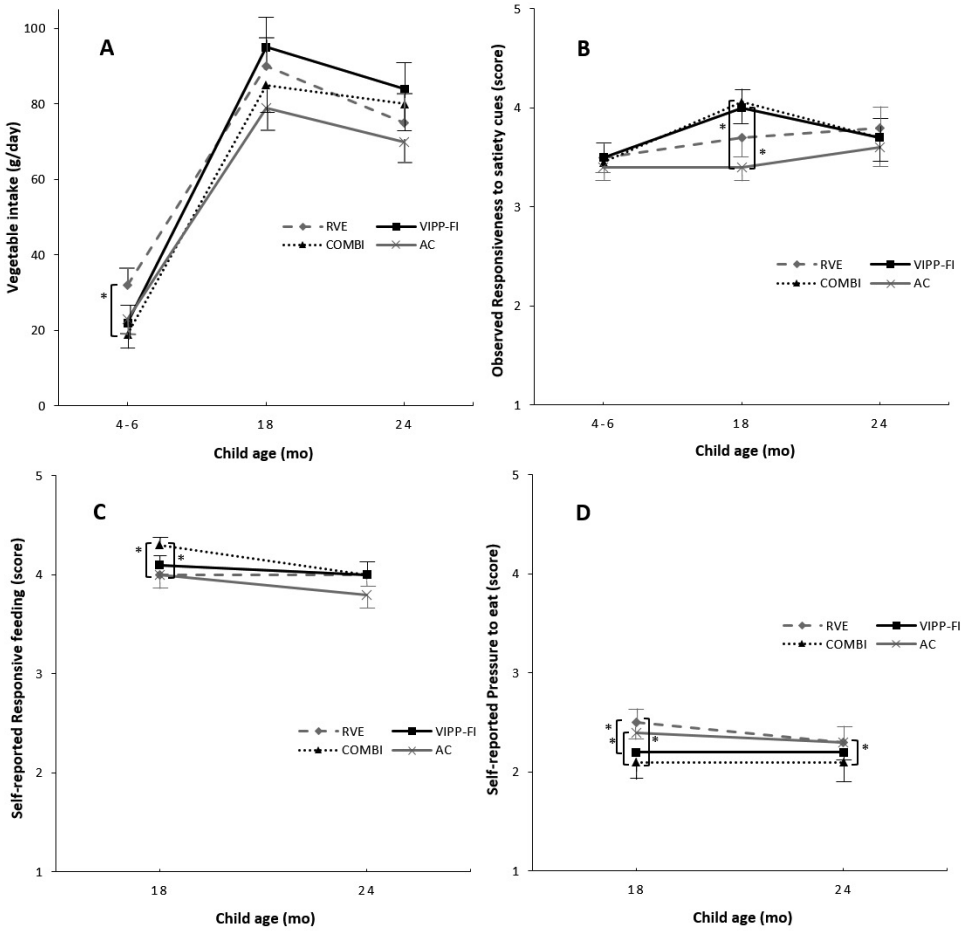

FIGURE 1 | Analysis of outcome measures comparing RVE, VIPP-FI, COMBI and AC at t0, t18 and t24 on (**A**) child vegetable intake (n = 246), (**B**) maternal responsiveness to satiety cues (n = 246), (**C**) maternal self-reported responsive feeding (n = 212), and (**D**) maternal self-reported pressure to eat (n = 210). Means shown are absolute values. Linear Mixed Model analysis was used to identify main effects of treatment and time and their interaction (P < 0.05), followed by pairwise comparisons to identify mean differences between groups. Values are means ± SEs. AC = Attention-control condition, COMBI = Combined condition of RVE and VIPP-FI, RVE = Repeated Vegetable-Exposure Intervention, and VIPP-FI = Video Intervention to Promote Positive Parenting Feeding Infants intervention. Condition (n) per group in each figure: **A** and **B** – RVE (61), VIPP-FI (62), COMBI (60), AC (63); **C** - RVE (50), VIPP-FI (52), COMBI (54), AC (56); **D** - RVE (48), VIPP-FI (52), COMBI (54), AC (56).

With respect to self-reported maternal pressure to eat, t18 and t24 were examined with correction for self-reported pressure concerning milk feeding at baseline. Resulting from Linear Mixed Model analysis, at t18, planned pairwise comparisons indicated less pressure in the VIPP-FI group compared to the RVE group (P = 0.01, d = 0.35), and less pressure in the COMBI group compared to the RVE and AC group (P = 0.01, d = 0.47, and P = 0.04, d = 0.40, respectively; Table 3; Figure 1D). A trend was found for the difference between VIPP-FI and AC at t18 (P = 0.07). At t24, less pressure was reported in the COMBI group compared to the RVE group, and a trend was found for the difference with AC (P = 0.08). No differences were found in favor of the VIPP-FI group compared to RVE and AC (P = 0.21, P = 0.33, respectively).

The main effect of time was not significant, but the main effect of condition, comparing all four conditions amongst each other, was. With respect to success rate, at t18, a significant main effect of condition was present (X^2 = 9.34, P = 0.03). Planned pairwise comparisons revealed a higher proportion of the mothers in the COMBI and VIPP-FI groups that reported to hardly use pressure to eat techniques (score ≤2), compared to both RVE (P = 0.02 and P = 0.04, respectively) and AC condition (P = 0.01 and P = 0.04, respectively; Table 3). At t24, the main effect of condition was not significant (X^2 = 3.84, P = 0.28), nor did any differences emerge between VIPP-FI and COMBI on the one hand, and RVE and AC on the other hand (P = 0.08-0.56).

Discussion

The present study reports on the post-test (18 months) and first follow-up (24 months) effects in the Baby's First Bites trial. No intervention effects were found on child vegetable intake and self-regulation of energy intake. There were fewer children with overweight in the COMBI group compared to the VIPP-FI group at 18 months and the AC group at 24 months. However, this finding needs to be interpreted cautiously due to the small number of infants with overweight and the fact that differences between those groups were absent on the continuous measure of BMI-z. Finally, although effects of the interventions were not reflected in child outcomes, the VIPP Feeding Infants intervention was effective in enhancing sensitive maternal feeding behavior at 18 months - yet this effect disappeared at 24 months.

Despite the lack of effect of the interventions on vegetable intake in our study, overall vegetable intake of children (intervention and control) was relatively high. At 18 and 24 months, the average daily vegetable intake of our sample was 87 and 77 grams, respectively, compared to an average of 52 grams a day in the Dutch toddler population (age 12-36 months) as reported in the Dutch National Food Consumption Survey [53]. The overall high vegetable intake may have been related to sample characteristics. Although participants were recruited from the general Dutch population, recruitment was partly targeted at parents who had signed up for the 'Nutricia for parents' group, thereby showing special interest in information on child nutrition. As a consequence, the topic of our study may have attracted parents with an above average interest in infant food products and healthy eating practices (including vegetable consumption). Moreover, mere participation in an RCT like the current study may have increased parental awareness of the importance of healthy eating practices for their child, which may have had a positive effect on vegetable intake in all groups.

In addition, a large interindividual variation in vegetable intake was observed within all conditions (SDs 44-69 grams), which may have further complicated detection of an effect. This heterogeneity in intake may point to the existence of subgroups within our sample, which was found in another study as well [54]. In this particular study of Caton and colleagues, different types of "eaters" were identified: "learners", who were defined as children who's intake increased over time; "plate-clearers", or children that consistently consumed a high amount; "non-eaters", that consistently consumed very little vegetables, or "others", which were children with a variable pattern [54]. It is plausible that such subgroups are present in our sample as well, and that interventions affect certain types of eaters differently. Other possible

moderators such as child picky eating or family factors such as socioeconomic status might be studied as well, in order to derive "what works for whom". In addition, future studies may need to focus on certain risk groups, such as caregivers that encounter difficulties feeding their child vegetables. Because in our sample vegetable intake was quite high in all study groups, for quite some children there was little need to improve their intake. In order to further test the effectiveness of our interventions, it would be fruitful to see if children with low intake would benefit from the intervention program.

The lack of an effect on absolute vegetable intake is in line with other RCTs studying this age group [20, 55-57]. One study only found short-term effects of repeated vegetable exposure in the first year of life and no longer at 24 months, suggesting that intervention effects might not be robust enough to have long lasting effects [23, 55]. Interestingly, another study did show a lasting effect of repeated exposure to a high vs. low variety of vegetables at the start of complementary feeding on vegetable intake and liking at age 3 and 6 years [11, 57]. The absence of an effect at age 15 months in the same study might suggest that children may still benefit from exposure to vegetables at the start of complementary feeding later in life, but other studies to confirm this theory are lacking.

Although the VIPP-FI intervention effectively improved maternal sensitive feeding behavior at 18 months, we did not find children in those conditions to have better self-regulation skills. An explanation might be that a possible positive effect of sensitive feeding on self-regulation was not yet present or not large enough, and that it might evolve later on. Another possibility is that VIPP-FI did not lead to improved self-regulatory eating behavior. Although parents are known to have a key influence on their children's eating behaviors [58-60], evidence that self-regulation of eating in toddlerhood can be influenced by improving maternal feeding practices is still lacking. Alternatively, it has been posed that heritability of appetitive traits of the child plays a role in both children's appetite regulation and their susceptibility to environments that stimulate overeating [61, 62]. In that case interventions may need to specifically target children's environment and behavioral traits rather than focus on maternal feeding alone. Finally, because our study included an evening meal, the EAH experiment was often conducted during the early evening. Because a toddler's appetite may be different during the evening than during the day, the timing of the experiment might have influenced the results. It would be interesting to repeat the experiment at a different time of day, for example around lunchtime.

With respect to anthropometrics, we did not find effects on BMI-z or rapid weight gain for any of the tested interventions, which is in contrast with other similar RCTs that found effects on rapid weight gain at 12-14 months [16, 17], and on BMI-z at 36 months; [63]. However, those intervention programs included elements on a much broader level, such as avoiding unhealthy foods, portion sizes, and daily physical activity [18, 19]. It is possible that solely focussing on the *what* and *how* is not enough to achieve effects on child weight (gain). Our findings regarding the proportion of healthy weight *do* provide some indication that the combined advice on vegetable intake and sensitive feeding positively affected child weight. However, the prevalence of children with overweight was low. Moreover, children's average daily energy intake did not differ between intervention groups. Contrary to our expectations, a higher prevalence of overweight at 18 months was present in the VIPP-FI condition, compared to the COMBI condition. Although this finding needs to be interpreted with caution as well,

it is plausible that feeding sensitively with more room for child autonomy in eating leads to greater enjoyment of food, a higher food intake and thereby a higher weight. Indeed, a study on Baby Led Weaning (BLW) found that children who were introduced to solid food with a BLW approach displayed more eating behavior characteristics associated with obesity risk [64].

Taken together, our interventions were not effective in changing child outcomes. Our follow-up measurement at 36 months will reveal whether our intervention programs affect child health outcomes after a longer period of time.

The sensitive feeding intervention VIPP-FI was effective in promoting sensitive maternal feeding behavior. Other trials incorporating similar feeding advice as part of a broader prevention program also found positive effects [16, 20], however we are the first to show effects for *observed* maternal feeding behavior. Although we did find moderate effect sizes, absolute differences between groups on maternal behavior were small. Very insensitive behavior or extreme levels of pressure to eat were not often observed or reported, resulting in relatively high levels of positive behavior in all groups. Although this may have caused a ceiling effect, VIPP-FI was still effective in improving maternal sensitive feeding behavior.

However, most effects of VIPP-FI were only found at 18 months: at 24 months all differences between conditions, except for self-reported pressure to eat, disappeared. This might be explained by the onset of the so-called 'picky eating' phase: a phase of selectiveness in eating, present in about half of the children at some point between the age of 1.5 and 6 years [26-28]. Indeed, time effects from 18 to 24 months showed an overall decrease in vegetable intake, a decrease in observed maternal sensitivity and self-reported responsive feeding, and an increase in observed pressure to eat. This suggests that mealtimes are more challenging at 24 months, making it harder for all parents, including those in the intervention groups, to keep on showing positive feeding behavior. Therefore, it might be fruitful to offer more guidance on how to deal with the picky eating phase, for example by designing more VIPP-FI sessions around toddler age.

There are several limitations that should be noted. Our sample consisted mainly of well-educated Caucasian families and was not fully representative of the Dutch population (e.g., 57% obtained at least a bachelor's degree, compared to 41% in the general Dutch population [65]). Moreover, all families had to commit to participate in a highly intensive program. These sample characteristics may have led to a well performing control condition, and a ceiling effect among intervention groups in most outcome measures. In addition, mothers who prematurely dropped out tended to have a lower educational level. Another limitation is that our study focused solely on mothers and did not take other caregivers into account.

In summary, the present study tested whether three approaches to parental guidance in complementary feeding promote health outcomes in toddlers: advising parents on *what* to feed, *how* to feed or both. Although our intervention on how to feed effectively enhanced sensitive maternal feeding behavior, we did not prove effectiveness of our interventions regarding child health outcomes. To determine if child health outcomes can be influenced in the first years of life by advising parents on the *what* and/or *how* of complementary feeding, future research should aim to include a more heterogeneous sample or perhaps specifically focus on risk groups, such as picky eaters. Finally, intervention programs may need to pay more attention to toddlerhood, when new child behavior, such as food refusal during mealtimes, may challenge positive parental feeding practices as well as healthy child outcomes.

Author contributions

The authors' contributions were as follows: SV, CG, JV, GJ, CV, HW and JM designed the overarching study Baby's first bites; JS designed the vegetable intervention protocol and EAH protocol with input from JV, GJ, VW, HW and SV, and SV and MV designed the VIPP-FI protocol, with input from JM and CV. VW conducted data collection and performed the intervention protocols. MV and JS conducted data collection, performed the intervention protocols, analyzed the data and wrote the manuscript with relevant input from all authors. All authors have read, reviewed and approved the final manuscript.

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Availability of data and materials

The anonymized dataset analyzed during the current study is available upon request. Video files are not publicly available for privacy reasons.

Competing interests

Danone Nutricia Research and Nutricia Nederland B.V. have provided additional funding for Baby's First Bites (see Funding). CV and HW are former employees of Danone Nutricia Research. The authors declare that they have no other competing interests.

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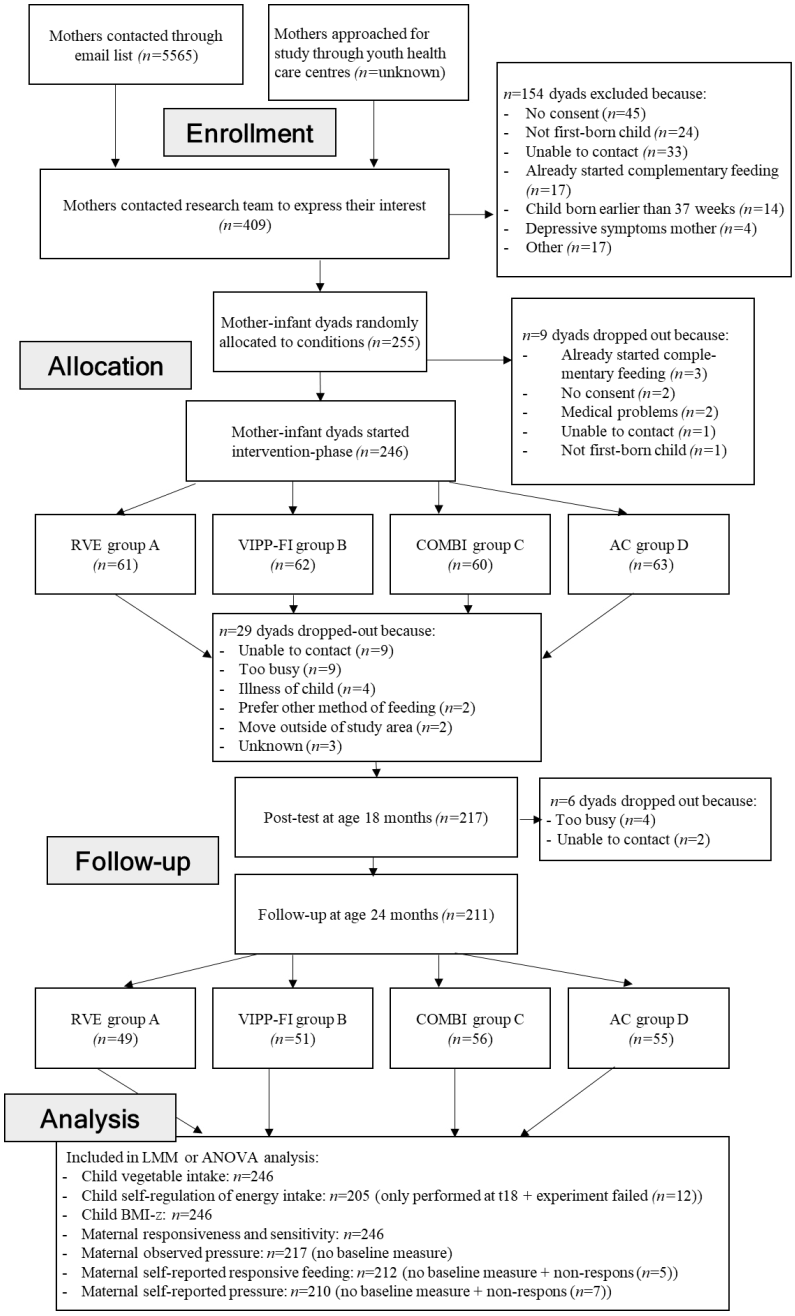
Supplemental material



SUPPLEMENTAL FIGURE 1 | Study flow chart. *Note.* RVE = Repeated Vegetable-Exposure intervention, VIPP-FI = Video-feedback Intervention to Promote Positive Parenting – Feeding Infants, COMBI = Combined condition of RVE and VIPP-FI, AC = Attention-control group.

SUPPLEMENTAL TABLE 1 | Content of each of the RVE and VIPP-FI intervention sessions.

Session	Child age (mo)	RVE			VIPP-FI	
		Theme	**Topics discussed**	**Optional information**	**Situation filmed**	**Topics discussed**
1	4-6	Discovering vegetables	• Why should children learn to eat vegetables? • Keep offering, also if child rejects (at least 10 times)	• Benefits of eating vegetables • Development of taste in young children	Mother feeding infant pureed vegetables/fruits	Learn to observe and interpret child feeding cues (hunger, satiation, liking)
2	4-6	Keep on offering vegetables	• How long should I persist? (at least 10 times) • Daily variation, steady increase of portion size	• Tips about offering vegetables to children on a daily basis and the preparation of age appropriate vegetable meals	Mother feeding infant pureed vegetables/fruits	Five tips: Timing, routine, adequate pacing, stop at the right time, enjoy
3	8	Being creative with vegetables	• Increase level and variety of texture • Set a good example	• Additional information about introducing more lumpy foods to children. • Tips about preparing and storing age appropriate vegetable meals • Tips to cut costs	Child eating sandwich with mother; new topping on sandwich	What to do when infants a) want more autonomy during mealtimes and b) don't want to eat
4	13	Vegetables are part of a balanced diet	• Eating with the whole family • Recommendations for vegetable intake	• Achieving the recommended intake for vegetables	Dinner with whole family; child is served a new vegetable	Positive ways of dealing with negative behavior during dinner
5	16	Keep eating vegetables	• Inform parents on possible food neophobia phase, and how to respond	• Involving children in the preparation of vegetables	Dinner with whole family; child is served something new	Inform parents on possible food neophobia phase, and how to respond to that

Note. mo = months. RVE = Repeated Vegetable-Exposure intervention. VIPP-FI = Video-feedback Intervention to Promote Positive Parenting – Feeding Infants.

Chapter 4

Effects of repeated vegetable exposure on infants' vegetable intake, liking and variety of vegetables consumed during the first weeks of complementary feeding and at the age of 12 months

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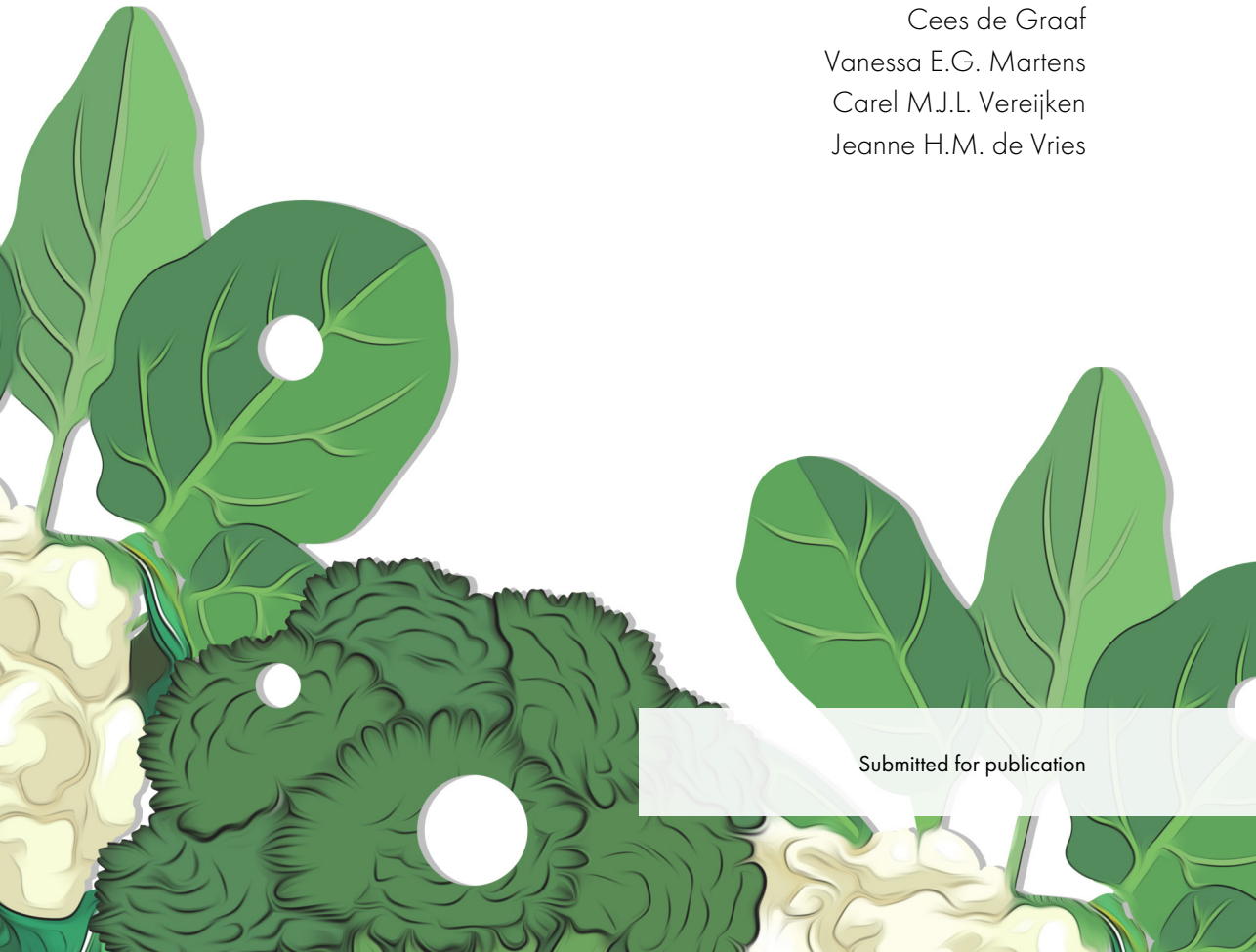

Submitted for publication

Abstract

Background: Repeated exposure to vegetables at the start of complementary feeding is an effective strategy to increase intake and liking of vegetables in infants in the short-term but the longer-term effects are questionable.

Objective: We assessed the effect of an extended repeated vegetable-exposure intervention on the amount, variety, and liking of vegetable intake at the start of complementary feeding and the age of 12 months compared to a control group.

Methods: Mother-infant pairs received exclusively vegetables or fruits for 19 consecutive days (age 4-6 months, n=246). Concurrently, four consultation sessions (until the age of 12 months) were offered to the mothers to keep stimulating repeated exposure to a variety of vegetables. Vegetable liking was assessed during the feeding schedule and at the age of 12 months in an online survey. At 12 months, vegetable intake was assessed by 24h dietary recalls (n=227), and food neophobia through the Child Food Neophobia Scale.

Results: Linear Mixed Model analysis revealed no differences in vegetable intake between the vegetable and fruit conditions, neither after the feeding schedule nor at 12 months. However, at this age, vegetable intake was on average 86±42g, which meets the recommended amount. Mother reported liking scores were higher for vegetables than for fruit over time. At the age of 12 months, a higher variety in vegetable intake was associated with higher amount of vegetable intake ($r = .019$, $P = .007$), and vegetable intake was negatively associated with food neophobia ($r = -.22$, $P = .004$).

Conclusion: The extended repeated exposure intervention increased vegetable liking, but it did not increase vegetable intake in the repeated exposure group as compared to the control group. Future research could focus on risk groups, such as children with high food neophobia or a one-sided diet, who might benefit more from this intervention.

Keywords: Vegetable, Complementary Feeding, Infants, Repeated Exposure, Variety, Liking

Background

The importance of diets high in vegetable intake is recognized worldwide, as there is an abundance of evidence suggesting health benefits of consuming sufficient amounts of vegetables [1-4].Vegetables are an important source of nutrients and non-nutritive components (e.g. dietary fiber and phytochemicals). In addition, diets low in vegetables and fruits tend to include more energy-dense foods of low nutritive quality that are high in sugar, saturated fat and salt. This hampers meeting targets set in food-based dietary guidelines and increases the risk of becoming overweight and developing related chronic diseases [1-4]. Because overweight in childhood is predictive of overweight in adulthood, promoting healthy eating habits, such as sufficient vegetable consumption from an early age onwards, is crucial [5-7].

In the past decade, the intake of vegetables in Dutch children aged 1-3 years has increased from an average of 41 grams per day in 2008 to 57 grams per day in 2016 [8,9]. However, many Dutch children still do not meet the guidelines of 50-100 grams per day. This is worrisome, because taste preferences and dietary habits develop in early childhood through exposure and continue into later life [10-14]. Especially the first two years of life present a window of opportunity to promote healthy eating habits [10,15-17]. Therefore, promoting vegetable intake during complementary feeding may be a powerful strategy to increase vegetable intake and liking. Two recent systematic reviews showed that repeated exposure to vegetables is a strategy that has been proven effective in enhancing vegetable intake and liking in infants and toddlers [5,18]. Repeatedly exposing children to the flavor of vegetables increases familiarity, liking and in turn, intake [19,20].

With regard to vegetable intake, not only quantity but also variety in types of vegetables consumed is important. This ensures adequate intake of micronutrients, dietary fibers and bioactive compounds [21]. Additionally, consuming a variety of vegetables (and fruits) has been linked to greater overall diet quality in toddlers [22], and to increasing acceptance and liking [19,20]. As a consequence, this may increase absolute daily vegetable intake. With respect to the consumption of foods in general, serving a variety of foods within the same meal increases intake of food and energy in both adults and children [23-25]. This effect has also been studied as a strategy to increase vegetable intake. There are indications that offering young children a variety of vegetables within the same meal has a positive effect on vegetable intake [26-29], but evidence is inconclusive [30]. It needs to be studied further whether higher variety in vegetable intake in the diet as a whole is associated with increased daily vegetable intake.

There are many other variables that influence vegetable intake in children. Among the most important child factors are pickiness and food neophobia which are common in toddlers [31-33]. Previous research has consistently reported lower vegetable intake in children who exhibit these behaviors [34-37]. Also, children learn to eat through the direct experience of eating, and by observing others. Given that toddlers are constantly cared for by parents and/or other caregivers, it is not surprising that maternal vegetable intake is associated with child vegetable intake as mothers both model eating foods and often select what the child is offered [35,38-41]. Finally, other aspects in a child's diet may be related to vegetable intake. For instance, studies often report on fruit *and* vegetable consumption in children in relation to health outcomes and diet quality. A higher intake and variety of fruit and vegetables was associated with overall better diet quality [22]. However, the association between fruit and

vegetable consumption is not clear. Possibly, children who have higher fruit intake are also more likely to eat larger amounts of vegetables.

A previous study by Barends et al.[42,43] found that infants exclusively exposed to a variety of vegetables at the start of complementary feeding had a significantly higher vegetable intake, than a group that started exclusively with fruits. This effect was found directly after a 19-day feeding schedule consisting of one purée meal per day. It was still present at the age of 12 months, with significantly higher daily vegetable intake reported in the group that had been exposed to the vegetable feeding schedule. However, at the age of 23 months the effect was no longer present, and the reported daily vegetable intake was similar for both groups. The authors speculate that the disappearance of the effect at 23 months was due to onset of food neophobia. It was also suggested that the effect of an intervention during weaning might not be enough to stimulate long-term vegetable preferences, and it was recommended that parents keep promoting vegetables throughout infancy and toddlerhood[43].

The current study aimed to assess the effect of repeated exposure on absolute daily vegetable intake, vegetable liking and variety in vegetable intake in infants. The secondary aim was to assess the association of infant vegetable intake with maternal vegetable intake, child BMI-z, food neophobia and fruit intake. This was done as part of a large RCT [44] that did not only focus on the type of food offered (*what;* repeated vegetable-exposure intervention (RVE) including a feeding schedule consisting of a variety of vegetables) but also on mother-child interaction during mealtimes (*how;* Video-feedback Intervention to promote Positive Parenting- Feeding Infants (VIPP-FI) including a feeding schedule consisting of fruits and a sweet vegetable). The RVE intervention was based on the procedure carried out by Barends et al [42], except with several added components, as recommended, to prolong and intensify the intervention and facilitate long-term effects.

As part of this RCT, effects of the intensified and prolonged intervention of repeated exposure to vegetables were investigated at ages 18 and 24 months (results presented elsewhere [45]). Contrary to the hypothesis, no effects were found on absolute daily vegetable intake. This raised the question whether at least at 12 months, effects of the RVE intervention were present. This was expected, given the previous findings of Barends et al., and given the fact that the present intervention was more intensive and continued for a longer period of time than the intervention by Barends et al. Therefore, for the current study, the outcome measures were assessed directly after the feeding schedule (t1) and at the age of 12 months (t12).

We hypothesized that 1) the repeated vegetable-exposure intervention increases infants' vegetable intake and liking directly after the 19-day feeding schedule and at the age of 12 months; 2) the repeated vegetable-exposure intervention increases infants' variety in different types of vegetables consumed at the age of 12 months; 3) infants' vegetable intake is positively associated with maternal vegetable intake and infant fruit intake and negatively associated with infant BMI-z and food neophobia.

Methods

Study design and participant characteristics

The current study presents data collected as part of the Baby's First Bites (BFB) study described elsewhere [44]. In summary, BFB aimed to foster healthy eating habits from the start of complementary feeding. This was done in a four-arm randomized controlled trial that focused on two approaches to influence eating habits in children (*what* and *how*). These approaches were hypothesized to have an effect on child health outcomes such as vegetable intake, BMI-z and self-regulation of energy intake. The effectiveness of the interventions was tested both separately (RVE & VIPP-FI) and combined (COMBI), compared to a control condition. The interventions were home based and started when parents indicated their child was ready to take their first bites of solid food (age 4-6 months) and lasted until the age of 16 months. Outcome measures were assessed at child ages 6, 12, 18, 24 and 36 months. For each assessment mothers received a €25 gift card and the child a small present (e.g. coloring book, reading book, bath toy).

A detailed description of the recruitment and inclusion can be found in the study protocol [44]. Mother-child pairs were randomly assigned to one of the conditions: RVE, VIPP-FI, COMBI (RVE & VIPP-FI) or the control condition. Randomization was stratified by age and sex of the child and study location. Both parents signed an informed consent form before participation in the BFB trial. The protocol was approved by the Ethical Review Board of Education and Child Studies, Leiden University (protocol number ECPW-2015/116) and the Medical Ethical Review Board of Wageningen University and Research (METC-WU protocol number NL54422.081.15). The trial was registered during inclusion of participants at the Netherlands National Trial Register (identifier NTR6572) and at ClinicalTrials.gov (NCT03348176).

The BFB-trial included 246 mother-child pairs. Nineteen (7.7%) mother-infant pairs dropped out before the home visit at 12 months. Table 1 shows the participant characteristics for each of the interventions and the control condition at baseline and t12. No group differences were detected.

Repeated vegetable-exposure intervention

The RVE intervention was based on the method as described by Barends and colleagues [42], but intensified, and consisted of three components: a 19-day feeding schedule, provision of 100 jars of age appropriate commercially available vegetables purées (spinach, green beans, cauliflower and broccoli) to be offered to the infants until the age of 12 months, and four semi-personalized consultations by telephone with the parents. The jars provided to the VIPP-FI and control condition after the feeding schedule were fruit (pear, apple, banana) and carrot pureés.

TABLE 1 | Characteristics of mother-infant pairs categorized per intervention and control condition at baseline and 12 months.

Variable[1]	Total	RVE	COMBI	VIPP-FI	Control
Baseline (*n*)	246	61	60	62	63
Infants					
Age (months)	4.6 ± 0.9	4.7 ± 0.5	4.6 ± 0.3	4.5 ± 1.6	4.6 ± 0.4
Sex (boys) – *n* (%)	117 (48)	28 ± (46)	28 ± (47)	29 ± (47)	32 ± (51)
BMI-z[2]	-0.20 ± 0.10	-0.20 ± 0.92	-0.14 ± 1.04	-0.29 ± 1.11	-0.15 ± 0.91
Duration breastfeeding (weeks) – median (range)	13.0 (0-26)	13.5 (0-25.5)	18.0 (0-26)	14.5 (0-26)	8.5 (0-24)
Mothers					
Age (years)	31.0 ± 4.7	30.3 ± 4.8	30.6 ± 4.8	31.4 ± 4.5	31.7 ± 4.6
BMI (kg/m^2)	27.1 ± 5.5	26.7 ± 5.2	26.9 ± 5.3	27.1 ± 6.1	27.5 ± 5.5
Education[3] – *n* (%)					
low & middle level	103 (42)	24 (39)	28 (47)	27 (44)	24 (38)
high level	143 (58)	37 (61)	32 (53)	35 (56)	39 (62)
12 months (*n*)	227	52	57	59	59
Infants					
Age (months)	12.4 ± 0.4	12.5 ± 0.5	12.4 ± 0.4	12.5 ± 0.4	12.3 ± 0.4
BMI-z[2]	0.35 ± 1.04	0.40 ± 1.09	0.38 ± 0.93	.038 ± 1.07	0.24 ± 1.08
Duration breastfeeding (weeks) – median (range)	16.0 (0-56)	15.5 (0-54)	32.0 (0-56)	16.0 (0-54)	12.0 (0-56)
Mothers					
BMI (kg/m^2)	26.7 ± 5.9	26.4 ± 5.3	26.7 ± 5.7	27.0 ± 6.7	26.7 ± 5.7
Education[3] – *n* (%)					
low & middle level	95 (42)	19 (37)	28 (49)	33 (56)	22 (37)
high level	132 (58)	33 (63)	29 (51)	26 (44)	37 (63)

[1]Values are means ± SDs, unless reported otherwise.
[2]World Health Organization Standards[46]
[3] Caregorized according to Centraal Bureau voor statistiek [47]
RVE = Repeated Vegetable Exposure Intervention, COMBI = Combined condition of RVE and VIPP-FI, VIPP-FI = Video Intervention to Promote Positive Parenting Feeding Infants intervention, Control = Attention-control condition. No group differences were present for any of the variables.

To accustom children to the testing procedure, mothers were asked to feed their child rice flour porridge with a spoon (both of which were supplied) for at least 5 consecutive days prior to the start of the intervention. Assessments within the BFB-trial were done during home visits and online questionnaires. During the 19-day feeding schedule (see Table 2), infants were offered commercially available vegetable purées (green beans, cauliflower, spinach and broccoli) once a day. The pre- and post-test meals were the same for all conditions (green beans and cauliflower purées). These were offered on days 1, 2 (t0), 18 and 19 (t1) in counterbalanced order (starting and ending with green beans or cauliflower, depending on the assigned schedule). During days 3 – 17, green beans or cauliflower were offered every other day, alternated with other vegetables on the remaining days to increase variety (spinach and broccoli). Researchers were present at t0 and t1 of the feeding schedule to measure the amount of vegetable purée eaten by the child by weighing the jar/plate, spoon and bib before and after the feed on a calibrated kitchen scale (Soehnle, Fiesta 65106), and to conduct additional measurements. On day 1 of the feeding schedule, mothers received a box of jars with purées labelled for the day of consumption (1-19) to be offered once a day for the duration of the

feeding schedule. In addition, they received the feeding schedule in print and a diary to note the time of the feed, any special remarks and rate the child's liking of the purée on a 9-point scale daily. The score ranged from 1= 'disliked very much' to 9= 'liked very much'. On days 3-17, mothers were asked to feed their child the designated purée and save the leftovers as best they could in the jar and to store it in the refrigerator. Researchers collected the jars with leftovers on day 19 and measured the amount of purée eaten. In order to standardize the measure of intake on days the researcher was not present, the jars were pre-weighed at the university. Mothers fed their child as they saw fit; the only instruction mothers received was to make sure their child tasted some of the purée at least three times per feed. Vegetable intake was determined in grams for the pre- and post-test of the feeding schedule by averaging the intake of to and t1.

TABLE 2 | Feeding schedules used within the intervention and control conditions.

	Day																		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
RVE and COMBI																			
Greens beans	GB	Cf	GB	Spi	GB	Bro	GB	Spi	GB	Bro	GB	Spi	GB	Bro	GB	Spi	GB	Cf	GB
Cauliflower	Cf	GB	Cf	Spi	Cf	Bro	Cf	Spi	Cf	Bro	Cf	Spi	Cf	Bro	Cf	Spi	Cf	GB	Cf
VIPP-FI and Control	Cf	GB	F1	F2	F3	Ca	F1	F2	F3	Ca	F1	F2	F3	Ca	F1	F2	F3	GB	Cf

RVE = Repeated Vegetable Exposure Intervention, COMBI = Combined condition of RVE and VIPP-FI, VIPP-FI = Video Intervention to Promote Positive Parenting Feeding Infants intervention, Control = Attention-control condition. GB= green beans, Cf= cauliflower, Spi= spinach, Bro= broccoli, Ca= carrot, F1=apple; F2=pear; F3=banana;

The first five months after the feeding schedule, parents were provided with 20 jars of age appropriate commercially available vegetable purées per month. Hereby the availability of vegetables in the home was increased in order to stimulate and facilitate parents to offer their child vegetables daily. Finally, four semi-personalized consultations over the telephone were offered, each lasting on average 20 minutes. These sessions started simultaneously with the feeding schedule and took place in the first months of complementary feeding (twice at child age 4-6 months and once at 8 months).

For development of the consultation sessions, we conducted a needs assessment and applied the Intervention Mapping (IM) process [48-50] to develop this protocol. To support the method of repeated exposure, the main goal of the intervention was to motivate mothers both during and after the feeding schedule to offer their child vegetables daily. From an analysis of determinants that may influence children's vegetable consumption we selected several determinants to target in the intervention (e.g. knowledge, modelling, self-efficacy, availability of vegetables). The risk factors and determinants were targeted with the feeding schedule and the telephone consultations. The calls focused on different topics, e.g. during the first two consultations, that took place during the feeding schedule, the topics of discussion were that infants need to learn to appreciate the flavor of vegetables, the importance of repetition, even if the infant seems to dislike the flavor, and the importance of offering a variety of vegetables. The third consultation at the age of 8 months addressed the importance of increasing texture in the offered vegetables, modelling vegetable intake as a parent, and

again, the importance of offering a variety of vegetables. The fourth session at the age of 12 months addressed eating with the whole family and recommendations for vegetable intake. In addition to these general topics, parents received optional information in case they were interested. This information was for instance about the benefits of eating vegetables and the development of taste in young children, recipe ideas for vegetable meals and tips to cut costs. All the general and additional information was sent to participants by post before the consultations. More information about the themes and content of the session is shown in Table 3. The telephone consultations were structured according to the general principles of Motivational Interviewing (MI) [51]. The Stages of Change Model [52] was used to monitor the behavior of offering vegetables on a daily basis. If mothers appeared not to be motivated

TABLE 3 | Content of the sessions of the Repeated Vegetable-exposure intervention.

Session	Child age	Theme	Topics discussed	Optional information
1	4-6 m	Discovering vegetables	• The importance of learning to eat vegetables • Keep offering, also if child seems to dislike the flavor (at least 10 times)	• Benefits of eating vegetables • Development of taste in young children
2	4-6 m	Keep on offering vegetables	• Keep offering (at least 10 times) • Daily variation in offered vegetables	• Tips about offering vegetables to children on a daily basis and the preparation of age-appropriate vegetable meals
3	8 m	Being creative with vegetables	• The importance of increasing texture of offered vegetables • Parent as a role model for vegetable intake • Daily variation in offered vegetables	• Additional information about introducing more lumpy foods to children. • Tips about preparing and storing age-appropriate vegetable meals • Tips to cut costs
4	12m	Vegetables are part of a balanced diet	• Eating with the whole family • Recommendations for vegetable intake	• Achieving the recommended intake for vegetables

m=months

to offer vegetables or encountered barriers in doing so, the protocol contained a series of possible questions and arguments to be discussed to motivate or come up with solutions for the encountered barriers. In summary, the standardized telephone protocol for each intervention session contained the following elements: 1) General part with standardized questions about adherence of mother and child to the vegetable guidelines; 2) Classifying the stage of change; 3) Testing the extent to which goals (e.g. knowledge of the topics discussed) of the previous session were achieved by asking questions and repeating information when necessary; 4) Discussing the basic information material that mothers received per post and presenting the option to tailor the conversation by addressing the optional information and questions the mother might have; 5) Discussing continuation and goal setting with regard to vegetable consumption (consultation at 8 months). More detail about the development of the RVE intervention and intervention components that took place after the age of 12 months is described elsewhere [44].

Assessment of dietary intake

At the age of 12 months, children's dietary intake was assessed by 24h dietary recalls (t12) on three randomly assigned non-consecutive days within a three week period using the program Compl-Eat [53]. For this study, the program was adapted to assess the diet of infants and young children (e.g. inclusion of smaller portion sizes and special baby foods). Days of the week were equally distributed across all participants and within the conditions. The days on which mothers had to report their child's intake were assigned during the home visits. Mothers received oral and written instructions about the online program and guidelines on how to precisely report the child's intake. Paper diaries were provided to record the child's dietary intake if they were at daycare or stayed with a babysitter on the assigned days (after which the intake was reported in Compl-Eat by the mother).

Mothers were asked to weigh vegetables separately on a kitchen scale for the duration of the recall days and report the amount eaten by the child in grams. In case vegetables were reported in household measures, standardized measures were used to convert the reported intake into grams [54]. Fruits were reported in pieces eaten or household measures. When commercially available infant meals were consumed, the proportion of fruit and vegetable in a particular meal was determined based on product labels and subsequently the total fruit or vegetable intake was calculated in grams based on the amount of the meal consumed. When fruits or vegetables were part of a home cooked mixed dish, mothers had the option to create a recipe within Compl-Eat and indicate the amount eaten by the child. From this, the proportion and the intake in grams was determined. Finally, when information about ingredients used in mixed dishes was lacking, a standardized list of recipes from Compl-Eat was used to determine the amount of fruits or vegetables in a specific dish. Intake of all other foods and drinks were reported in household measures or, when known, in grams. Child fruit and vegetable intake at 12 months was estimated by averaging the intake in grams of the recall days. All recalls were checked by trained dietitians and mothers were contacted for clarification when entries were unclear. Compl-Eat used the Dutch food composition database (NEVO) edition 2016/5.0 for the calculation of energy intake and food grouping of vegetables. The 24h recalls were used to assess children's vegetable-, fruit-, and energy intake.

Vegetable liking

Mothers' perceived liking scores of the two target vegetables (green beans and cauliflower) for the children were obtained from the provided diaries for the duration of the feeding schedule (t0, t1) and assessed by an online survey (t12). These scores were averaged to obtain a general liking score for vegetables per time point on the previously mentioned 9-point scale.

Variety in vegetable consumption

Vegetable variety was assessed in an online survey (t12). Mothers were asked to indicate on a list of 19 vegetables if, and how often their child consumed them. This was done on a 4-point scale ranging from 1=never, 2=once , 3= monthly to 4=weekly. The list was constructed using the 95th percentiles of the most frequently consumed vegetables among children aged 2-3 years according to the Dutch National Food consumption Survey (2005/2006)[55]. In addition,

it was possible to report four other types of vegetables in open fields in case they had been consumed but were not listed in the survey. Vegetable variety was determined by assessing the total number of different vegetable types children had consumed up until the moment of the questionnaire and the number of different vegetable types consumed weekly.

Other variables

Child and maternal anthropometric measurements were done during home visits (t0, t12). Bodyweight was assessed u.sing a calibrated digital scale. Child height was measured in supine position on an infant measuring mat. Maternal height was measured once (t0) with a portable stadiometer. Body Mass Index (BMI, kg/m^2) was calculated, and for children, transformed into age and sex-standardized z-scores (BMI-z) [46].

Child food neophobia (reluctance to eat and/or rejection of new food or avoidance of novel foods [56]) was assessed through the 6-item version of the Child Food Neophobia Scale (CFNS [57]), which mothers completed online (t12). The original instrument consists of ten items, of which four items were excluded because they were deemed inappropriate for the age of our sample (e.g. "Ethnic food looks too weird to eat"). The questionnaire was translated in Dutch. Items were scored on a 4-point scale ranging from 1= strongly disagree to 4= strongly agree. Higher scores indicate higher neophobia. Cronbach's alpha for the 6-item version was 0.81 in our sample.

Maternal dietary intake was assessed (t12) using a general Food Frequency Questionnaire (FFQ) with a reference period of one month [58]. Daily vegetable intake in grams was determined based on recorded frequency of consumption and standard portion sizes [59].

Maternal vegetable variety was assessed (t12) in an online survey constructed the same way as the list for children. Mothers reported their intake of the most frequently consumed vegetables among adults aged 20-50 years according to Dutch National Food consumption Survey (2007/2010) [60]. It was also possible to report four vegetable types in open fields in case they had been consumed but not listed in the survey.

General information that was collected as part of BFB such as infants' date of birth and sex, maternal ethnicity and education level (t0) and breastfeeding duration (t12) were obtained in an online survey.

Statistical analysis

Data were analyzed using SPSS (version 25; SPSS Inc., Chicago, IL, USA) and *P*-values < .05 were considered significant. For data on vegetable intake, a square root transformation was performed because of severe positive skewness. The effect of the 19-day feeding schedule on vegetable intake, liking and variety in consumption was assessed for the full sample, for the comparison between the four conditions separately and for comparison between the vegetable (RVE & COMBI) and fruit conditions (VIPP-FI & control).

Linear Mixed Models (LMM) were used to test the *difference* in vegetable intake and liking per condition over time (t0 (baseline) to t1 and t12), corrected for child sex. All participants with data on at least one time point were included in the analysis. A diagonal covariance

structure for time was used, as it had the most optimal fit. Vegetable intake at t0 was significantly higher in the RVE condition than the other conditions, therefore we corrected for baseline vegetable intake. For intake, interaction effects of condition, time and child sex were analyzed and were not significant, indicating that the difference in intake over time did not differ between conditions, that boys and girls behaved the same way within conditions and did not differ in vegetable intake over time. Interaction effects were, therefore, removed from the model. The remaining factors in the model were condition, time and child sex. For liking, interaction effects of condition, time and child sex were analyzed and only the interaction effect of time x condition was significant. Adjustment for breastfeeding duration and food neophobia did not change the results with regard to intake and liking and were therefore not included in the model. The final model included child sex, time, condition and interaction effect of time x condition. To assess the correlation between intake and liking at all time points (t0, t1, t12) Pearson correlations were used.

To correct for energy intake, a subsequent analysis was performed to assess mean vegetable intake between conditions at the age of 12 months (energy intake was assessed only at t12). An ANCOVA was carried out where we corrected for child sex, baseline vegetable intake and average daily energy intake. Energy intake data collected on days that children were sick were excluded from the analysis. Children's intake was based on one (3.2% of the children), two (17.6%) or three (79.2%) recall days. Daily energy intake was estimated per child by averaging the energy intake in kcal on the available recall days.

At the age of 12 months, differences in the number of different types of vegetables eaten (*variety*) between conditions was assessed by ANCOVA and corrected for child sex. As it was hypothesized that a higher variety in vegetable intake is associated with absolute vegetable intake, a Pearson correlation was calculated to assess the correlation between vegetable variety and vegetable intake in grams. In addition, a Spearman correlation was used to assess the correlation between maternal and child variety in vegetable intake.

Finally, an ANCOVA analysis was used to explore the associations between child vegetable intake, BMI-z, food neophobia, fruit intake and maternal vegetable intake and BMI at t12. We corrected for energy intake, sex of the child, and study condition by adding these as independent variables. Breastfeeding duration and maternal education level did not explain vegetable intake and were therefore not included in the model.

Results

Effect of repeated vegetable exposure on vegetable intake after the feeding schedule and at the age of 12 months

In our final model with only main effects, the LMM analysis showed that the effect of time was significant, with significant increases in mean vegetable intake from to to t1 ($P < .001$) and to to t12 ($P < .001$) and t1 to t12 ($P < .001$) in the full sample. Mean intakes (±SD) were 24 ± 23 g, 41 ± 31g and 86 ± 42 g at t0, t1 and t12 respectively. The effect of condition was not significant when comparing the four conditions and neither was the effect of child sex. When comparing the vegetable (RVE & COMBI) and fruit conditions (VIPP-FI & Control; i.e., comparing two aggregated conditions instead of four separate conditions), the effect of time was also significant ($P < .001$ for all comparisons). However, this LMM analysis revealed no differences in vegetable intake when comparing the fruit- and vegetable conditions over time. At the age of 12 months mean vegetable intake was similar in all conditions (Table 4). At that age, the ANCOVA analysis (correcting for daily energy intake, baseline vegetable intake and child sex) showed there were no differences in reported vegetable intake or average energy intake between conditions. Vegetable intake was positively related to daily energy intake ($r(214) = 0.15$, $P = .02$, which was on average (± SD) 940 ± 185 kcal (range 477 – 1846 kcal/d). This indicates that children with a larger intake in general consumed more vegetables.

TABLE 4 | Vegetable intake in grams (Mean ± SD) of the intervention and control conditions at t0, t1 and t12.

Condition	t0 n=241	t1[1] n=230	t12[1] n=214
RVE*	32.1 ± 31.0	50.8 ± 36.1	86.3 ± 42.0
COMBI	19.1 ± 15.7	41.9 ± 34.0	87.9 ± 47.7
VIPP-FI	22.1 ± 19.5	34.7 ± 25.2	87.2 ± 43.8
Control	22.7 ± 20.2	36.0 ± 26.5	82.5 ± 32.3

[1] Mean vegetable intake increased significantly in all conditions from to to t1, to to t12 and t1 to t12 ($P = <.001$).
* significantly higher baseline vegetable intake RVE condition vs other conditions (p-values .013 to .022).
Linear Mixed Model analysis showed the effect of condition was not significant.
t0= baseline (age 4-6 months), t1= after 19 day feeding schedule (age 4-6 months), t12 = at child age 12 months
RVE = Repeated Vegetable Exposure Intervention, COMBI = Combined condition of RVE and VIPP-FI, VIPP-FI = Video Intervention to Promote Positive Parenting Feeding Infants intervention, Control = Attention-control condition.

Effect of repeated vegetable exposure on vegetable liking after the feeding schedule and at the age of 12 months

Similar to intake, the LMM analysis for liking including main effects and a condition x time interaction, showed that the effect of time was significant. Mother-reported liking scores increased significantly from to to t1 ($P <.001$) and to to t12 ($P <.001$) and t1 to t12 ($P <.001$) in the full sample. Average liking scores (± SD) were 5.6 ± 1.5, 6.0 ± 1.5 and 7.4 ± 1.1 on t0, t1

and t12 respectively. When comparing the four conditions, the main effect of condition was significant (*P*= <.001). Pairwise comparisons showed differences between the RVE vs VIPP-FI, RVE vs Control, COMBI vs VIPP-FI and COMBI vs Control (*P*= <.001 for all comparisons) with greater liking scores in the RVE and COMBI conditions (see Table 5). Finally, the interaction effect of time x condition was significant (*P*= <.007). Reported liking scores increased similarly in all conditions from t1 to t12, except for the control condition in which reported liking scores increased significantly more (Table 5).When comparing the fruit (VIPP-FI & Control) and the vegetable (RVE & COMBI) conditions the main effects of time and condition were significant (*P*= <.001), liking in the vegetable conditions was higher than in the fruit conditions at all time points (Table 5). The main effect of child sex was not significant. Finally, the interaction effect of time x condition was significant (*P*= <.041). We observed a larger increase in vegetable liking in the fruit conditions from t1 to t12.

A significant correlation was found between vegetable intake of the infant and mother reported liking score at to ($r(227)=0.57$, $P = <.001$) and t1 ($r(219)=0.57$ $P = <.001$) but not at t12 ($r(204)=0.15$ $P = <.03$).

TABLE 5 | Vegetable liking (Mean ± SD) of the intervention and control conditions at t0, t1 and t12.

Condition	t0 n=229	t1[1] n=228	t12[1] n=219
RVE*	5.8 ± 1.6	6.6 ± 1.2	7.7 ± 1.3
COMBI*	5.7 ± 1.4	6.6 ± 1.3	7.8 ± 0.8
VIPP-FI	5.7 ± 1.4	5.8 ± 1.3	7.0 ± 1.1
Control	5.3 ± 1.7	5.4 ± 1.7	7.4 ± 1.1

Scoring on a 9 point scale ranging from 1= "dislikes very much" to 9= "likes very much"

[1] Mean reported vegetable liking increased significantly in all conditions from to to t1, to to t12 and t1 to t12 (*P* = <.001).

* Linear Mixed Model analysis showed the effect of condition was significant. Higher reported liking scores in the RVE and COMBI condition (vegetable conditions) than in the VIPP-FI and Control condition (fruit conditions) over time.

t0= baseline (age 4-6 months), t1= after 19 day feeding schedule (age 4-6 months), t12 = at child age 12 months RVE = Repeated Vegetable Exposure Intervention, COMBI = Combined condition of RVE and VIPP-FI, VIPP-FI = Video Intervention to Promote Positive Parenting Feeding Infants intervention, Control = Attention-control condition.

Effect of repeated vegetable exposure on children's variety in vegetable consumption at 12 months

In the full sample, the number of different types of vegetables consumed by the infant (as reported by the mother in an online survey) was on average 15.6 ± 3.7 (mean ± SD). The RVE, VIPP-FI, COMBI and Control condition had consumed on average 15.4 ± 3.2, 14.4 ± 4.4, 16.6 ± 3.6 and 15.9 ± 3.5 types of vegetables respectively. No significant differences were found when comparing the vegetable (RVE + COMBI) and fruit conditions (VIPP + Control). However, when comparing the four conditions significant differences were found in how many different types of vegetables infants consumed ($F(3,214) = 3.54$; $P = .015$). The COMBI and Control

conditions consumed significantly more types of vegetables than the VIPP-FI condition (P = .002 and P = .031 respectively).

A positive correlation was found between vegetable variety and vegetable intake in grams (r(212) = 0.19, P = .007). Finally, a significant positive correlation between maternal and child vegetable variety was found (r(217) = 0.50, P = <.001).

Association between child vegetable intake, BMI-z, food neophobia, fruit intake and maternal vegetable intake and BMI, at 12 months

At the age of 12 months average (mean ± SD) vegetable- and fruit intake was 86 ± 42 grams and 162 ± 62 grams respectively in the full sample. Food neophobia score was on average 1.5 ± 0.5 points. Mean maternal vegetable intake was 129 ± 82 grams. ANCOVA analysis showed that food neophobia was significantly negatively related to vegetable intake (F(1,180) = 8.456, P = .004). Child fruit intake was borderline significantly positively related to vegetable intake (F(1,180) = 3.856, P = .051). Other factors in the model such as BMI-z and maternal BMI and vegetable intake did not explain additional variation in vegetable intake.

Discussion

The present study investigated the effect of repeated exposure to vegetables on vegetable intake, vegetable liking and variety in types of vegetables consumed in infants. This was done directly after a feeding schedule, consisting of exclusively vegetables combined with four consultations (last session at 12 months) to stimulate repeated exposure to vegetables, and at the age of 12 months. This effect was compared to a control condition with a feeding schedule of fruits and a sweet vegetable (carrot) and combined with consultations on mother child interactions during mealtime or control questions. In addition, we examined how child and maternal factors are related to child vegetable intake.

The main findings indicated no differences in vegetable intake after repeated exposure to a variety of vegetables than after repeated exposure to fruits and carrot. However, reported liking scores were higher in the vegetable than in the fruit conditions over time. At the age of 12 months a larger variety in vegetable intake was associated with higher absolute vegetable intake, and vegetable intake was negatively associated with food neophobia.

Our experimental design was based on the study by Barends et al. [42], yet differed on a few points: the groups in the fruit conditions also received carrot, a sweet vegetable, all the measurements were home-based, and two additional consultation sessions (telephone calls) were carried out during the course of the feeding schedule to support mothers in offering their child vegetables daily. Despite these extra efforts to prolong and strengthen the potential effect of the repeated vegetable-exposure intervention, the present findings showed no added effects of repeated exposure to vegetables, as compared to exposure to fruits and a sweet vegetable (carrot) on infants' vegetable intake, neither directly after the feeding schedule, nor at the age of 12 months. Hence, this study failed to replicate the findings of Barends et al (2013).

The lack of effect despite a more intensive intervention to stimulate repeated exposure to vegetables on a daily basis, is contrary to what we hypothesized. It is noteworthy, however, that vegetable intake was on average high at the age of 12 months in all conditions: approx.

86 grams, which is well in line with the recommended daily vegetable intake of 50 – 100 grams for this age group [61]. The overall high intake of vegetables may be related to several factors. For one, recruitment partly targeted parents who had signed up to receive information and tips about pregnancy, baby and child health related topics. Therefore, our sample may have comprised parents with an above average interest in child nutrition and healthy eating habits (including vegetable consumption). Furthermore, participation in the current RCT, independent from the condition the infant was assigned to, may have increased parental awareness and motivation to offer healthy foods, which may have had a positive effect on vegetable intake in all groups.

A possible explanation for the discrepancy in findings between the current study and the study by Barends et al [42,43], is that the latter study was conducted almost a decade before the current study. During this time the importance of a healthy diet for infants and toddlers, including consuming a sufficient amount of vegetables, has received much public attention. Sources that Dutch parents turn to, such as the Netherlands Nutrition Centre, child healthcare services and (baby) food companies all promote offering vegetables from an early age. An upcoming publication of the Dutch National Food Consumption Survey, expected by the end of 2022, will have to confirm whether or not overall vegetable consumption in infants and toddlers is indeed on the rise.

Vegetable liking, based on mother reported liking scores, increased significantly over time in the full sample, with a greater liking scores in the vegetable conditions at all time points. From the feeding schedule to the age of 12 months liking scores increased similarly in all conditions, except for the control condition in which reported liking scores increased significantly more. Based on previous research it was hypothesized that children would maintain a preference for foods and flavours they had been repeatedly exposed to, up to months later [43,62,63]. The lack of result in our study may be due to the relatively large variety of vegetables all children were exposed to (on average 15 different types), and that both green beans and cauliflower are commonly consumed vegetables in the Netherlands [64]. Therefore, children in all conditions, including the control condition, may have been offered these vegetables regularly after the feeding schedule, resulting in an increase in liking in all conditions.

A positive, small to moderate correlation was found between vegetable variety and vegetable intake in grams, indicating that consuming a higher variety of different types of vegetables contributes to increasing absolute vegetable intake. Indeed, consuming a variety of vegetables has been associated with increased vegetable acceptance and liking [19,20]. This may in turn increase daily vegetable intake. In addition, children who ate a higher variety of vegetables also had parents (or at least mothers) eating a larger variety of vegetables. This suggests an effect of modelling which has been proven to be an effective method to increase vegetable intake in children [65].

As expected, vegetable intake was negatively associated with food neophobia, which is in line with previous research that has repeatedly shown that children who display more food neophobic behavior have lower vegetable intake [34-37].

The present study has some strengths and limitations worthwhile to discuss. Strengths of the present study include that we conducted an extensive repeated exposure intervention lasting well beyond the complementary feeding period. Moreover, the study was fully homebased. Children were in their familiar environment and for the most part without the

presence of a researcher to influence their eating behavior. We used commercially available products for the duration of the feeding schedule, ensuring that all children were exposed to the exact same taste, sensory properties and energy content. The purées were eaten in their familiar environment as part of their usual daily routine and 24h recalls were collected on all days of the week and in diverse natural settings (including day care, during weekends, holidays etc.), which increased ecological validity.

There are also some limitations of the study design that should be noted. Due to ethical considerations, the infants in the fruit conditions were also offered carrot instead of fruits exclusively. Additionally, after the feeding schedule, mothers were free to offer other foods from the family diet and these were not recorded. Therefore, infants in the fruit conditions may also have been offered vegetables daily after the first 19 days of complementary feeding. These factors may have clouded any effects of the repeated exposure intervention. Finally, the sample characteristics are not representative of the Dutch population, almost 60% was highly educated, compared to 40% in the general Dutch population [66]. These characteristics may have led to a well performing control condition and a ceiling effect among all conditions.

In summary, the reported average daily vegetable intake in our study was high in all groups, which may also be in line with a trend for increasing average vegetable intake among children in the Netherlands aged 1-3 years. Our study suggests that a repeated vegetable-exposure intervention may not always be necessary. However, it should be considered that this concerns *average* intake. There are still many children in the Netherlands who do not meet the recommendations for vegetable consumption. Future research could aim to target possible "risk groups" such as less privileged families, children with food neophobia or a one-sided diet, as they may especially benefit from early repeated vegetable exposure.

To conclude, the prolonged and intensified repeated vegetable-exposure intervention was effective in increasing vegetable liking, but we did not find added effects on child vegetable intake, with intake being relatively high in the full sample. A higher variety in types of vegetables consumed was associated with a higher daily vegetable intake. This may suggest that, on average, eating habits with regard to vegetables is shifting toward more favorable behavior.

Author contributions

The authors' contributions were as follows: JS designed the vegetable intervention protocol with input from JV, GJ, and SV. MV and JS conducted data collection, performed the intervention protocols, JS analyzed the data and wrote the manuscript with relevant input from all authors. All authors have read, reviewed and approved the final manuscript. We thank former employee of Danone Nutricia Research Hugo Weenen for input on the development of the RVE intervention, João Paulo for statistical advice and Corine Perenboom for support in dietary assessment.

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Competing interests

Danone Nutricia Research and Nutricia Nederland B.V. provided additional funding for Baby's First Bites (see Funding). VM is currently an employee of Danone Nutricia Research. CV is former employee of Danone Nutricia research and is currently employee of BASF Vegetable Seeds. The authors declare that they have no other competing interests.

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Chapter 5

Eating in the absence of hunger in 18-month-old children in a home setting

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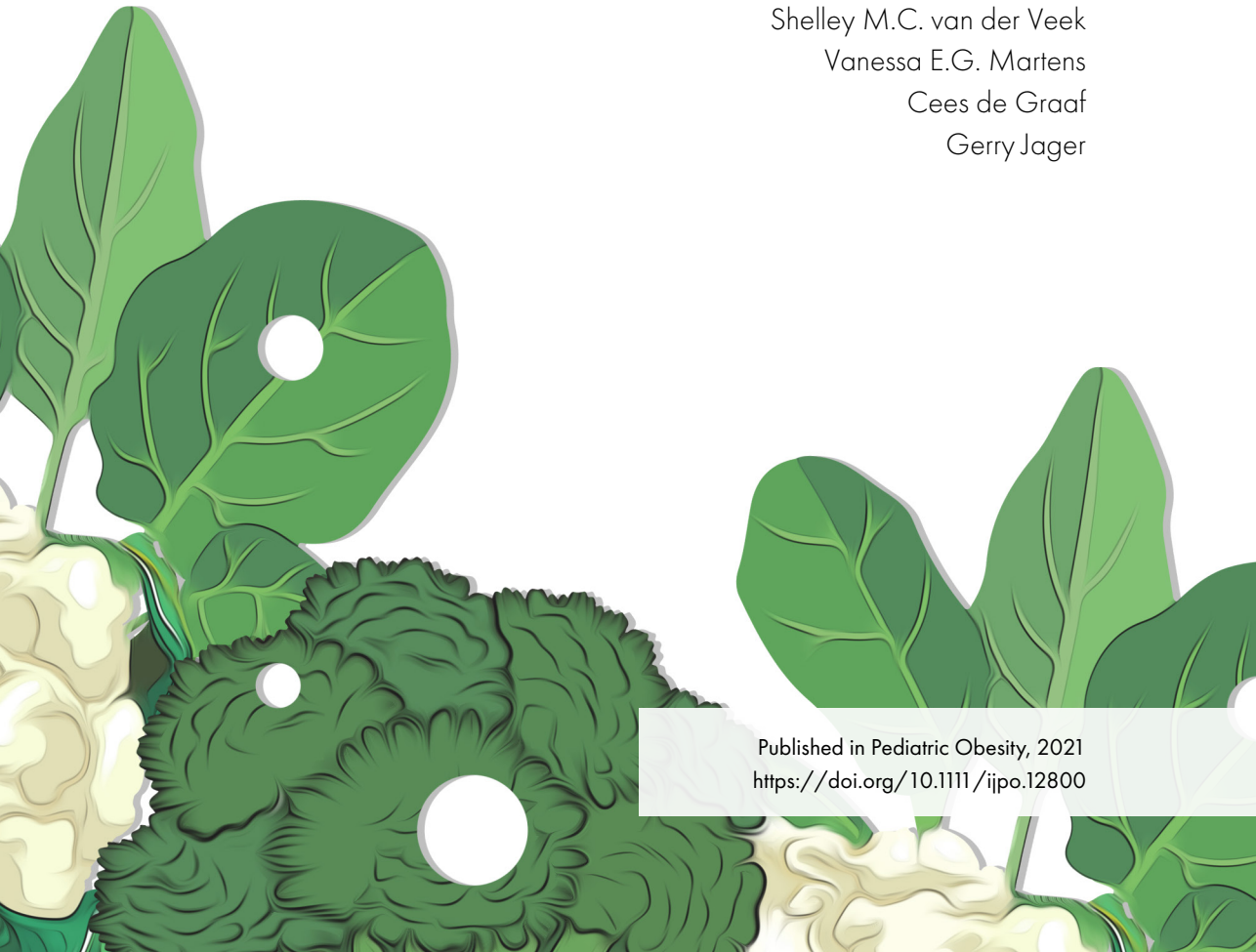

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Abstract

Background: Eating in the absence of hunger (EAH), the susceptibility to eat despite satiety, may increase overweight. While EAH has been established in school-aged children, less is known about it during toddlerhood.

Objectives: This study assessed to what extent 18-month-old children eat in the absence of hunger, the stability of this behavior at 24 months and the association of child eating behaviors with EAH.

Methods: Children were presented with four palatable finger foods (total 275 kcal) after dinner. Univariate GLM's were run to explore the association between EAH, child satiety and -eating behaviors, energy intake of the evening meal and the association between EAH at 18 and 24 months (n=206 and 101 respectively).

Results: Mean (± SD) energy intakes from dinner and finger foods were 240 kcal (±117) and 40 kcal (±37), respectively. No association was found between energy intake of dinner and finger foods. Enjoyment of food was significantly related to intake of finger foods (P = .005). EAH at 18 months predicted EAH at 24 months.

Conclusion: Eighteen-month-old children ate in the absence of hunger, irrespective of satiety. Thus, preceding energy intake was not compensated for. Other factors, e.g. enjoyment of food seem to determine finger food intake.

Keywords: eating in absence of hunger, self-regulation of energy intake, toddler, satiety, child eating behavior

Introduction

The rates of childhood overweight have increased dramatically over the last decades. To illustrate, worldwide the number of overweight or obese children below the age of 5 years increased from 32 million in 1990 to 38 million in 2019[1]. In the Netherlands in 2018, 12% of all children aged from 2 to 8 years were overweight [2].

The fundamental cause of overweight and obesity is a positive physiological imbalance between energy intake and energy expenditure over an extended period of time [3]. An imbalance between intake and expenditure of only two percent on a daily basis, sustained over time, can induce overweight in growing children [4]. Also, children who are overweight are at higher risk of remaining overweight in adulthood [3,5]. Therefore, prevention of overweight and obesity should start early in life since eating behaviors are learned and established during childhood, especially in the first two years of life [6].

There is a need for better understanding of behavioral risk factors contributing to overweight in childhood. For instance, individual eating behaviors affect children's responses towards food, and are related to a greater risk of overweight and obesity [7-12]. Larger appetite ratings, greater enjoyment of food, greater food responsiveness, faster eating rate and lower satiety responsiveness were found to be related to higher body weights and faster weight gain in infants aged 3-15 months [11]. In addition, lower satiety responsiveness and greater food responsiveness have been associated with higher prevalence of adiposity in older children aged 3-5 years [13].

Children are born with the ability to self-regulate short-term energy intake but this ability seems to reduce with age, when the effects of sensory, cognitive and social factors on energy intake become stronger [14-16]. For example, external cues such as availability of palatable foods, portion size effects, presence of other people, time of day, and parental feeding practices may overrule or have a greater influence on intake than internal cues of hunger and satiety and consequently reduce the ability to self-regulate energy intake [17,18]. A poor ability to self-regulate short-term energy intake is associated with a positive energy balance in children aged 5-12 years [19,20], thereby increasing the risk of developing overweight later in life [5,21].

Eating in the absence of hunger (EAH) refers to the failure to self-regulate energy intake, and the susceptibility to eat palatable, often energy-dense foods despite experiencing satiety [10], making it a behavioral risk factor for developing overweight [7,20,22,23]. Previous work in preschoolers and primary school age children has shown that EAH evolves with age and is consistent within individuals over time [20, 22,24-27]. Also, EAH has been observed in children as young as 21 months [25,28] suggesting it already occurs at a very young age. However, the age at which self-regulation of short-term energy intake diminishes and EAH emerges may be even younger than this. Also, it remains unclear how individual eating behaviors play a role in the emergence and dynamics of EAH over time.

Extending our knowledge on the determinants of EAH is important for early recognition of risk behaviors contributing to overeating in children, and for the timing of early targeted interventions to prevent overeating. Furthermore, such insights in risk behavior could be translated into practical guidelines for parents and caregivers. To this aim, we performed a study among18 month-old children (n=217) in a home setting to assess to what extent they eat in the absence of hunger. This procedure was repeated in a subset of the sample (n=107) when

the children were 24 months of age, to examine whether EAH remained stable over time. In addition, the association of satiety of the child (as perceived by the mother) and child eating behaviors with EAH was investigated. It was expected that children who ingested more energy during the evening meal, and were perceived as being more satiated, would ingest less energy from the finger foods presented during the EAH procedure. It was also hypothesized that certain child eating behaviors, such as greater enjoyment of food, greater food responsiveness, and lower satiety responsiveness would result in a relatively higher energy intake of finger foods. Finally, it was expected that EAH at 18 months would predict EAH at 24 months in the subset of children where EAH was measured twice, at 18 and 24 months of age.

Methods

Study design and participants

The current study presents data collected as part of a large longitudinal study, Baby's First Bites (BFB), of which a detailed description of the study protocol has been published elsewhere [29]. In short, BFB is a four-arm randomized controlled trial that studies the role of the start of complementary feeding in infancy in promoting vegetable intake. It included 243 first-time Dutch mothers and their infants. Interventions started from the moment children took their first bites of complementary food (age 4-6 months) and lasted until the age of 16 months. Home assessments were performed at the ages of 12, 18, 24 and 36 months. As part of this RCT, EAH was measured during the home assessment at the ages of 18- and 24 months. The home assessments were performed by trained Master- and PhD students and entailed anthropometric measurements and a videotaped meal and play session between mother and child [29].

Written informed consent was obtained from both parents before participation in the BFB trial and the protocol was approved by the Ethical Review Board of Education and Child Studies, Leiden University (protocol number ECPW-2015/116) and the Medical Ethical Review Board of Wageningen University and Research (METC-WU protocol number NL54422.081.15). The trial was registered during inclusion of participants at the Netherlands National Trial Register (identifier NTR6572) and at ClinicalTrials.gov (NCT03348176). For each assessment, mothers received a €25 gift voucher and the child received a small present (e.g. coloring- or reading book).

The EAH measurements were conducted between July 2017 and June 2019. In total, 217 mother-child pairs participated in the EAH procedure when the child was 18 months old. Due to constraints in budget and manpower, the repeated measurement at 24 months did not include the full sample, but a subsample of 107 mother-child pairs living in the surroundings of Leiden University.

General information, such as child's date of birth, sex and maternal ethnicity and educational level, was obtained from written- and online surveys completed at the start of the BFB trial.

Child eating behavior

Prior to the home visits at 18 and 24 months, mothers filled out the Child Eating Behavior Questionnaire for toddlers (CEBQ-T) [30] online. This is a well-validated, reliable and widely used questionnaire consisting of twenty-six items to assess six eating styles that have been related to e.g. overeating and overweight: food responsiveness (FR), satiety responsiveness (SR), enjoyment of food (EF), food fussiness (FF), emotional overeating (EOE), and slowness in eating (SE) [10,31]. Mothers reported on a five-point Likert scale ("1= never" to "5= always") how frequently they observed their child demonstrating a range of eating behaviors on a typical day. The scales have good internal consistency with Cronbach's Alpha ranging from .74 to .91 (FR: .80, SR: .74, EF: .91 FF: .91 EOE: .79 and SE: .74) [10].

Anthropometrics

Children's and maternal bodyweight was measured during every home visit using a calibrated digita.l scale (SECA robusta 813), in kilograms to the nearest 0.1 kg. Children's length was measured on an infant measuring mat to the nearest 0.5 cm. Maternal height was measured at the start of the BFB trial using a portable stadiometer to the nearest 0.5 cm. For children, Body Mass Index (BMI) was calculated and transformed into age and sex-standardized z-scores (BMI-z) based on the WHO Child Growth Standards for boys and girls aged 0 – 60 months [32]. Maternal height and body weight were used to calculate BMI in kg/m^2. In case the mother was pregnant or had recently given birth, the bodyweight of the mother measured during the home visit when the child was 12 months old was used to calculate maternal BMI (n= 37).

Measurement of child's EAH

The protocol for measuring EAH was based on the free-access procedure for children aged 3-5 years old in a laboratory setting as described by Fisher and Birch (1999), where children's snack food intake was measured after consuming their usual lunch. In that study, children were provided with ten snack foods and some toys for ten minutes and only children who indicated that they were not hungry following lunch participated in the experiment [33]. For the present study, the described protocol was adapted to suit 18- and 24-month-old children in a home setting. The following adjustments were made: (i) testing was done in a home-setting instead of a laboratory setting after an evening meal prepared by the parents, (ii) mothers estimated the level of satiety of their child, as children this young are not yet able to report this themselves, (iii) children participated in the procedure irrespective of the satiety score, (iv) intake of the child's evening meal was assessed, (v) toys were provided and mothers were asked to play with their child as usual for eight minutes. Thereafter four finger foods (Table 1) were presented to all children for the ten minute EAH procedure. Children had the opportunity to continue playing with the toys or eat the provided foods. Prior to the home visits, mothers were asked for permission to offer the child the selected foods. Only if the child was allergic to a food or the mother disapproved of a food an alternative was offered (Table 1). Twenty-four children were offered at least one alternative finger food.

The EAH procedure was piloted in four sessions at a day care center in Wageningen, The Netherlands (n=17, age 16-24 months), to test the procedure's feasibility and children's behavior toward multiple finger foods. In total, eleven foods were tested (breadsticks, cream crackers, Nibbit sticks, salty biscuits, cake, gingerbread, banana, Miffy shaped cookies, pouch of pureed fruit, raisins, plain sweet biscuits) of which four were selected to be offered during the EAH procedure (breadsticks, Nibbit sticks, gingerbread, plain sweet biscuit). Selection was based on the criteria that children were able to take and eat the food without help, the food attracted the interest of the children and was considered to be age appropriate by the Netherlands Nutrition Centre. Selected foods were frequently consumed according to the Dutch National Food Consumption Survey (2010) among one year old children. The procedure itself was considered feasible and remained unchanged.

TABLE 1 | Finger foods provided during the EAH procedure.

Standard foods	**Serving**	**Weight (g) per serving**	**Energy per serving (kcal)**
Savory			
Breadstick	2 sticks	14	57
Nibbits sticks	1 handful	15	72
Sweet			
Gingerbread	1 slice	27	84
Plain biscuit	2 pieces	14	62
Alternative foods	**Serving**	**Weight (g) per Serving**	**Energy per Serving (kcal)**
Savory			
Rice cracker	2 pieces	14	53
Cream cracker	2 pieces	16	72
Sweet			
Banana	0.5 piece	65	62
Raisins	1 spoonful	15	52

Parents were asked to prepare an evening meal for the child as part of their usual daily routine. The child's intake was assessed by obtaining a detailed description of the ingredients and preparation of the meal, drink and desert. Everything the child ate and drank was weighed on a calibrated digital kitchen scale (Soehnle, Fiesta 65106) and photographed by the researcher before and after consumption . Photographs were taken at a 45 degree angle and a ruler was placed under the plate as a visual reference for portion size estimation [34]. This method for assessing the weight, energy- and macronutrient content of the evening meal was evaluated within the sample of the BFB trial (*data not reported*) using a weighed food record as the reference method. The mean energy and macronutrient content intakes assessed by detailed description, weight and photographs were not significantly different from the reference method. Indicating it as a reliable method for estimating energy intake of the evening meal.

The nutritional data were processed by trained dietitians. Portion sizes of each food item were estimated based on the description, weight and photographs of the meal, food items were coded and converted into total amount eaten in grams, and energy- and macronutrient intake were calculated using the online program Compl-eat [35] using the Dutch food composition database (NEVO) edition 2016/5.0.

Directly after the evening meal mothers were asked to rate the child's satiety on a 5 point Likert scale (from "1= not at all satiated" to"5= very satiated"). This was followed by an eight minute free-play session between mother and child. After this the researcher offered the child a plate with two savory and two sweet finger foods (see Table 1) for ten minutes. The researcher told the child that these were for him/her to eat; *"hello <name child> these foods are for you"*. Mothers remained in the room but were asked not to interfere with the child's behavior so the child had the opportunity to continue playing with the toys or eat the provided foods without interference. Finger foods were weighed before and after the EAH procedure and the weight was multiplied by the energy content [36] of each individual food to determine the weight (grams) and energy (kcal) consumed by the child respectively. An EAH score was calculated using the following formula [37].

EAH score = EI from finger foods / EI from evening meal x 100%

A score of 0% indicates that the child did not consume any of the finger foods. A higher score indicates greater energy intake of the finger foods, proportionately to the energy intake of the evening meal [37].

Statistical analysis

Statistical analyses were carried out in SPSS (version 25; SPSS Inc., Chicago, IL, USA). For the measurements at 18 months, data of 11 participants (5.1%) were excluded from analysis because parents did not allow their child to participate in the EAH procedure as planned, for instance they did not consent to the standardized amount of finger foods or stopped the procedure within 10 minutes. At 24 months, data of 4 participants (3.7%) were excluded from the analysis because parents did not comply with the requirements of the procedure as described above.

Data are presented as mean values with standard deviations or numbers with percentages, unless otherwise specified. Tests were performed two-sided and *P*-values < .05 were considered significant. Distribution of the EAH scores was not normal and, therefore, the EAH score was log transformed. In addition, a one way ANOVA was run to test if EAH scores of the children differed between the four intervention groups, no significant differences were found and data were collapsed for further analysis. Maternal BMI was not related to EAH ($r(198) = -.07$, $P = .31$)) and not taken into account for further analysis.

Few children were rated as being '*not at all satiated*' and '*not satiated,* the lowest satiety scores after dinner (n < 20 for both measurements). Therefore, these categories were pooled into one group, resulting in a 4-point scale for satiety (i.e. 1 = not satiated; 2 = neutral; 3 = satiated; 4 = very satiated) for further analyses.

To explore the association of satiety of the child (as perceived by the mother), energy intake of the evening meal, child eating behaviors measured with the CEBQ-T at age 18- and 24 months and child BMI z-score with EAH, we used a Univariate General Linear Model (GLM) with energy intake of finger foods as the dependent variable. Child sex and intervention group were added as independent variables.

Finally, a Univariate GLM was used to investigate the association between EAH score at age 18 and 24 months in the group of children who had participated in both measurements. Sex and intervention group were added in the model as independent variables.

Assumptions for linearity, normality of residuals, homoscedasticity, and multicollinearity were checked. Boxplots revealed two outliers (> 3 SD) for EAH-scores. However, these outliers were not due to measurement error and re-running the analyses without these outliers did not change the results. Therefore, outliers were included in the analysis.

Results

Sample characteristics

The final sample consisted of 206 mother-child pairs (n= 98 boys and 108 girls) and 103 mother-child pairs (n=45 boys and n=58 girls) at the 18- and 24 month measurement, respectively. Mothers were on average (± SD) 31.6 (± 4.6) years old and 21.7% had a university degree or higher. The majority of the participants were from Dutch Caucasian origin (71%), with an additional 4% of mixed ethnicity (one parent Dutch, the other from a different ethnic group). The remaining 25% of participants came from different ethnic groups such as Surinamese, Turkish and Antillean. Maternal BMI (kg/m^2) was on average (± SD) 26.6 (± 5.8) kg/m^2. The majority of mothers, 53.5%, were overweight (BMI > 25 kg/m^2), 45% had a normal weight (BMI between 18.5 and 25 kg/m2) and 1.5% were underweight (BMI < 18.5 kg/m2). Characteristics of the children are presented in Table 2.

TABLE 2 | Characteristics of the children at 18 and 24 months.

	18 months n=206	**24 months n=103**
	Mean ± SD or n (%)	**Mean ± SD or n (%)**
Age (months)	18.0 ± 0.7	24.0 ± 0.7
Sex		
Boys	98 (47.6)	45 (43.7)
Girls	108(52.4)	58 (56.3)
BMI-z [a]		
Underweight	5 (2.4)	0 (0)
Normal weight	185 (89.8)	87 (84.5)
Overweight	16 (7.8)	16 (15.5)
Eating behavior [b]	n=182	n=98
Enjoyment of food	4.20 ± 0.57	4.06 ± 0.57
Satiety responsiveness	2.35 ± 0.53	2.58 ± 0.49
Food responsiveness	2.66 ± 0.78	2.55 ± 0.74
Emotional overeating	1.80 ± 0.61	1.78 ± 0.67
Slowness in eating	2.94 ± 0.44	3.06 ± 0.48
Food fussiness	2.94 ± 0.26	2.94 ± 0.27

[a] Underweight when BMI-z ≤ -2; normal weight when BMI-z between -2 and 2; overweight when BMI-z ≥ 2
[b] Eating behavior assessed with the CEBQ-T. Scores ranged from 1 to 5 on a 5-point Likert scale: 1= rarely, 2= never, 3= sometimes, 4= often, 5= always

EI, EAH score and mothers perceived satiety

The mean time (± SD) between the evening meal and the EAH task was 21 (± 5) minutes. EI from the evening meal (including drink and dessert), finger foods and total energy intake (EI from evening meal + EI from finger foods) and EAH scores are shown in Table 3.

Of the full sample, 185 (89.8%) children ate from the finger foods at 18 months with a mean (±SD) intake of 40 kcal (± 37), of whom 143 (69.4%) were considered satiated based on the mother's estimation (score 3 satiated or score 4 very satiated). At 24 months, 96 (93.2%) children ate from the finger foods with an average (±SD) intake of 33 kcal (± 29), of whom forty (41.7%) were considered satiated. Twenty-one children (10.2%) ate nothing from the finger foods at 18 months, of whom seventeen (81%) were considered satiated. Seven children (6.8%) ate nothing from the finger foods at 24 months, of whom four (58.8%) were considered satiated.

The EAH score between satiated and non-satiated children did not differ significantly (P = .31) and (P = .28) at 18 and 24 months respectively. Total EI of satiated children was significantly higher than that of non-satiated children (P < .001) and (P = .003) at 18 and 24 months respectively.

Furthermore, EAH at 18 months predicted EAH at 24 months $F(1, 88) = 8.520$, P=.004. The proportion of variance explained by EAH at 18 months after excluding variance explained by the other predictors (sex and intervention group) was 8.8% (partial eta squared, ηp^2= 0.088, a medium effect size).

TABLE 3 | Evening meal and finger foods intake and eating in the absence of hunger score in the full sample vs satiated children at 18 and 24 months.

Energy intake (N)	18 months			24 months		
	Full sample (206)	**Satiated children [a] (143)**	**Non-satiated children [a] (63)**	**Full sample (103)**	**Satiated children [a] (50)**	**Non-satiated children [a] (53)**
	Mean ± SD (min-max)			**Mean ± SD (min-max)**		
Intake evening meal[b] kcal	240 ± 117 (17-627)	263 ± 108 (23-597)	186 ± 122 (17-627)	209 ± 106 (8-705)	240 ± 125 (21-705)	118 ± 76.6 (8-344)
Intake finger foods kcal	40 ± 37 (0-237)	42 ± 38 (0-237)	34 ± 34 (0-150)	33 ± 29 (0-113)	35 ± 23.5 (0-109)	29.8 ± 25.4 (0-112)
Total energy intake[c] kcal	279 ± 127 (23-664)	306 ±118 (23-642)*	217 ± 128 (32-664)	242 ± 113 (36-733)	276 ±132 (41-733)*	207 ± 83 (36-408)
EAH score %[d]	23.1 ± 52.5 (0-704)	18.7 ± 21.2 (0-158)	33.1 ± 89.5 (0-704)	23.4 ± 38.8 (0-346)	19.9 ± 23.9 (0-128)	26.5 ± 49.9 (0-346)

* Statistically significant (P <.05)

[a] Score reported by the mother, satiety score ≥3 was considered satiated

[b] Energy intake of the evening meal including drinks and dessert

[c] Total energy intake = EI intake from the evening meal + EI from the finger foods

[d] EAH score = EI from finger foods / EI from evening meal x 100%

Association between EI finger foods, EI evening meal, mothers perceived satiety and eating behaviors

Mother's perceived satiety was significantly positively related to the energy intake of finger foods at child age 18 months, F(3,166) = 3.859, *P* = .01 (Table 4). Figure 1 shows the energy intake of finger foods grouped according to satiety score. It shows that group 1, consisting of children whose mother reported them to be "*not at all satiated*" or *"not satiated*" had a lower energy intake than the other groups. The other three groups ("*neutral*", "*satiated*" and "*very satiated*") were quite similar concerning energy intake from finger foods intake. In addition, Figure 1 shows that every satiety group included children who did not eat any finger foods. When removing the group with the lowest satiety score from the analysis, the association between satiety and the energy intake of finger foods was no longer significant F(2,152) = 1.867, *P* = .16.

Enjoyment of food was significantly related to the energy intake of finger foods in both the model with and without the group with the lowest satiety score, F(1, 166) = 8.040, *P* = .005 and F(1, 152) = 7.246 *P*= .008 respectively. As was expected, enjoyment of food was positively associated with finger food intake. The other factors in the model such as energy intake of the evening meal, food responsiveness and BMI-z score did not explain additional variation in finger food intake at 18 months, as can be seen in Table 4. A child's enjoyment of food was weakly marginally correlated with energy intake of the evening meal (*r*(180) = .14, *P*= .07)).

At child age 24 months only sex was marginally significantly related to the energy intake of finger foods, F(1,82) = 3.795, *P*= .06, as can be seen in Table 4. The energy intake of the evening meal was not significantly different between boys and girls. Figure 2 shows the finger food intake grouped according to satiety score at 24 months. It shows a different intake pattern of finger foods per satiety group compared to 18 months and the energy intake of group 1 does not deviate from the other groups.

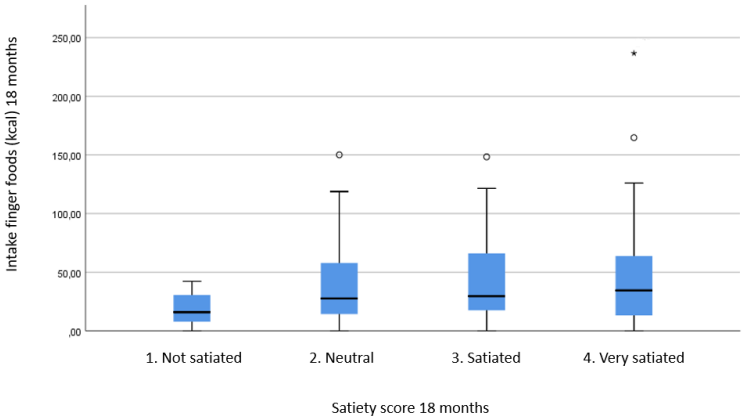

FIGURE 1 | Boxplot of children's finger food intake (kcal) at the age of 18 months categorized per satiety score (1-4). For group 1 the scores '*not at all satiated*' and '*not satiated* were pooled into one group resulting in a 4-point scale for satiety (i.e. 1 = not satiated; 2 = neutral; 3 = satiated; 4 = very satiated). Mild outliers are represented by circles (○) and extreme outliers are represented by asterisks (*).

TABLE 4 | Association between finger food intake, evening meal intake, mothers perceived satiety and sub scores of the CEBQ at 18 (n=182) and 24 months (n=98).

	18 months				24 months			
Variable	**Mean intake (kcal)**	**B**	**95% CI**	**P-value**	**Mean intake (kcal)**	**B**	**95% CI**	**P-value**
Intake evening meal	240	0.15	-0.34 - 0.64	.544	209	0.04	-0.03 - 0.10	.264
Satiety [a]				.011*				.384
1 not satiated	18	-22.91	-47.07 -1.25		34	8.053	-16.22 – 32.33	
2 neutral	42	14.98	-4.79 - 34.75		29	1.956	-20.11 – 24.02	
3 satiated	40	1.99	-14.04 - 18.04		37	13.32	-8.05 – 34.69	
4 very satiated	49	-	-		30	-	-	
Sex [b]				.103				.055
Male		9.09	-1.85 - 20.04			12.48	-0.27 - 25.22	
Female		-	-			-	-	
Eating behavior [d]								
Enjoyment of food		17.06	5.18 - 28.95	005*		2.24	-1.02 - 5.50	.175
Satiety responsiveness		-7.46	-22.54 - 7.62	.330		1.42	-1.77 - 4.61	.378
Food responsiveness		5.68	-4.22 - 15.58	.259		1.50	-1.31 - 4.32	.290
Emotional overeating		-1.55	-11.50 - 8.40	.758		-0.93	-4.93 - 3.07	.644
Slowness in eating		11.45	-3.32 - 26.22	.128		-1.93	-5.79 - 1.93	.322
Food fussiness		-13.34	-34.96 - 8.28	.225		0.32	-3.78 - 4.43	.877

* Statistically significant ($P < .05$)

[a] Satiety score 4 was the reference in the model, B's as shown for satiety are relative to the reference.

[b] Female was the reference in the model, B's as shown for sex are relative to the reference.

[c] Intervention group D was the reference in the model, B's as shown for intervention are relative to the reference.

[d] Eating behavior assessed with the CEBQ-T. Scores ranged from 1 to 5 on a 5-point Likert scale: 1= rarely, 2= never, 3= sometimes, 4= often, 5= always

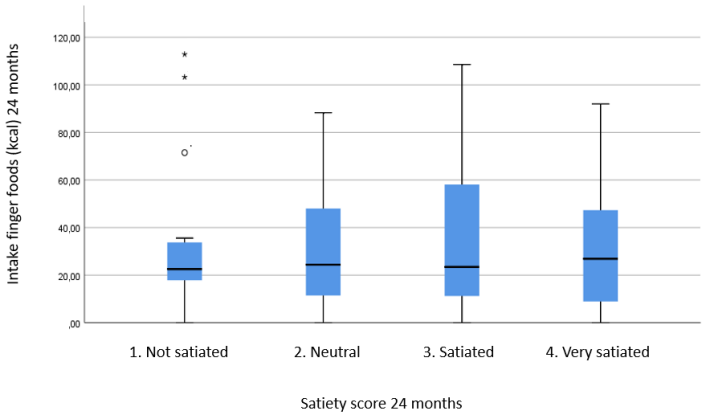

FIGURE 2 | Boxplot of children's finger food intake (kcal) at the age of 24 months categorized per satiety score (1-4). For group 1 the scores '*not at all satiated*' and '*not satiated* were pooled into one group resulting in a 4-point scale for satiety (i.e. 1 = not satiated; 2 = neutral; 3 = satiated; 4 = very satiated). Mild outliers are represented by circles (○) and extreme outliers are represented by asterisks (*).

Discussion

The present study performed an adapted EAH protocol in 18-month-old children to assess if children this young overeat when put in a situation where palatable foods are offered. In addition, we aimed to assess the stability of EAH at age 24 months in the same sample. Finally, the study aimed to examine how individual eating behaviors and satiety are related to EAH.

The main findings indicate that EAH occurs already at this very young age (18 months), with the majority (89.8%) of children consuming on average (±SD) 40 kcal (± 37) ranging from 0 to 237 kcal from palatable finger foods despite just having eaten a meal (240 kcal ± 117 (17-627)). Secondly, we found that EAH at 18 months predicted EAH at 24 months. Furthermore, unexpectedly, a positive association was found between satiety of the child (as estimated by the mother) and the energy intake of finger foods. Finally, a child's enjoyment of food was positively associated with the intake of finger foods; on average children increased their energy intake with 17 kcal for every point scored higher on the questions regarding enjoyment of food in the CEBQ-T. These findings and their implications will be discussed in more detail below.

We observed that 18-month-old children eat in the absence of hunger when offered palatable finger foods, indicating that EAH emerges at a very young age. In a previous home-based study, toddlers aged 21 months were found to eat on average (±SD) 87 kcal (±50) in the absence of hunger [25]. This is twice as much as we observed in our sample (40 kcal ± 37). An explanation for this difference could be the difference in the methodology applied between the studies. The EAH protocol in the previous study took place directly after children consumed their typical lunch (rather than after dinner in our study), satiety was not taken into account and the researchers modelled eating an Oreo cookie which could have encouraged children to increase their intake. Finally, the presented foods were more energy dense and more of a 'special treat', e.g. chocolate chip cookies, Oreo's and pringles, than the foods in our study, likely increasing intake.

We measured children's finger food intake on one occasion, after one meal. The intake ranged from 0 to 237 kcal with an average intake of 40 kcal in our study. We consider this to be quite substantial for children aged 18 months. Most healthy children are able to maintain a balance between energy intake, - expenditure, - storage and growth over the long term despite large day-to-day fluctuations [4]. However, if over the long term a positive energy balance of 2% was maintained children could be at risk of becoming overweight [3,4]. Possibly, children who display certain eating behaviors (e.g. high food responsiveness and low satiety responsiveness) are at greater risk of eating in the absence of hunger and ultimately increased weight.

EAH at 18 months predicted EAH at 24 months and showed a medium, yet significant, effect size. This implicates that EAH could be a behavioral trait that remains stable over time. In a previous longitudinal study with children aged 21-33 months [25,28,39], children ate more in the absence of hunger as they got older. Similarly cross-sectional studies in older children have repeatedly shown an increase in EAH with age [4,23]. We did not find an increase of EAH with age. An explanation for the absence of age effects in the present study could be the smaller age range, where six months is not sufficient to detect age-related increases in EAH.

The trend between sex and EAH did not emerge until the age of 24 months, with boys consuming slightly more energy from the finger foods than girls. This finding is in line with

previous studies among older children (3-13 years) [23,25,37,40,41]. In older children, this association with sex has been attributed to the fact that girls are more influenced by social desirability than boys and may therefore restrain their food intake more due to the desire not to be seen overeating [23]. However, considering the young age of our sample it seems unlikely that this was the case.

Counterintuitively, a positive association was found between satiety of the child and intake of finger foods (i.e. higher satiety scores were associated with an increased intake of finger foods). However, when removing the group with the lowest satiety score from the analysis, the association between satiety and the energy intake of finger foods was no longer significant. The variation in energy intake from the finger foods was small for the non-satiated group compared to the other groups. These children had on average a lower BMI-z score than the average of the total sample and were mostly boys. On other factors, such as CEBQ-T scores and BMI of the mother, the not-satiated children did not differ from the rest of the sample. It remains speculative, but a possible explanation for the lower finger food intake and BMI-z scores of these children is that they might be so-called "small eaters". In a study investigating repeated exposure to vegetables in children aged 4 to 38 months researchers observed four distinct patterns of eating behavior[42]. Children were categorized as "learners", who increased their intake over time; "plate cleaners", who consumed more than 75% of the meal that was offered from the start of the intervention onwards; "non-eaters", still eating less than 10 grams by the fifth exposure after the start of the intervention; and "others", whose eating pattern was highly variable. Possibly, the group of children we categorized as "small eaters" fall within the eating behavior pattern that the authors proposed to be "non-eaters".

Alternatively, previous research in older children (2-6 years) has shown that intra-individual variation in day-to-day regulation of energy intake is large [43,44]. Therefore, the ability of the mothers to estimate their child's fullness following a single meal, as was the case in the current study, may be limited, as a child's daily energy intake varies, and the intake per meal also fluctuates.

Energy intake of the evening meal was not significantly related to the energy intake of finger foods. This suggests that other factors than energy intake of the evening meal and satiety influenced finger food intake. Previous research in older children (3-6 years) suggested that a child's environment and the portion size of meals or snacks offered determine energy intake more than the amount of food and composition of the meal they ate previously [17,43,45,46]. In addition, it has been proposed that EAH reflects responses to external cues rather than the ability to regulate intake [23]. We cannot exclude the possibility that we observed a 'salience' effect. With the EAH procedure we placed the children in an unusual situation by presenting them with an abundance of palatable foods and giving them permission to do with it as they pleased. This context may have triggered the majority of children eating the finger foods despite having just finished a meal.

Both individual traits of the child and external factors such as parental behavior may contribute to the development of eating behaviors that make children prone to overeating at a young age [7,23,33,37,47]. However, of the six child eating behaviors measured in this study, only enjoyment of food was positively related to intake of finger foods. Other types of eating behavior (satiety responsiveness, food responsiveness, emotional overeating, slowness in eating, food fussiness) and BMI-z were not related to finger food intake in our study. This

suggests that the context or environment in which food is offered stimulates children to (over) eat more than individual eating behaviors.

This study has several strengths. To our knowledge this is the first study to examine EAH in children this young. We developed an accurate method for assessing evening meal intake in a home setting using photographs, a detailed description- and weight of the meal. The experiment was done in the natural environment of the child, and the food consumed was representative of the children's usual eating habits, which increased ecological validity. The longitudinal design and adequate sample size of the study allowed us to study the dynamics of EAH over time in a subsample of children.

However, there are some elements of the study design that should be noted. The presence of the mother, researcher and the camera may have influenced the child's behavior. For example, some children were very aware of the camera and wanted to touch it or danced in front of the lens. Also, some parents mentioned that their child always waits for permission to eat and parents were instructed not to interfere with the child's behavior for the duration of the experiment. Possibly these children would have behaved differently if the instruction had come from the parent instead of the researcher. Finally, the choice of highly palatable finger foods suitable for 18-month-old children was limited and the selected foods were different from previous studies investigating EAH in children.

In conclusion, this study showed that children as young as 18 months old already eat in the absence of hunger when offered palatable finger foods, and that EAH was moderately stable over a six month period. Contrary to our expectations, the majority of children ate finger foods irrespective of satiety as reported by the mother and no association was found between children's energy intake of the evening meal and energy intake of finger foods thereafter. Factors other than preceding energy intake, such as enjoyment of food or the simple availability of palatable snacks, may have determined intake. These findings suggest that even at this very young age children are sensitive to the context in which food is offered and factors in the environment that offer the opportunity to overeat.

The present study shows that EAH can be demonstrated in children well within the first two years of life, which is a critical time window for establishing healthy eating behaviors. This implies that the phenomenon of EAH in very young children deserves greater attention in feeding practices and awareness should be increased in parents and care givers, in order not to facilitate this type of eating behavior. Some children may be more sensitive to eating in the absence of hunger than others, and future research should focus on moderating factors, including child eating characteristics (e.g. high food responsiveness, low satiety responsiveness), context in which (finger) foods are offered, and social and environmental factors that facilitate eating in the absence of hunger.

Conflicts of interest statement

V. Martens is an employee of Danone Nutricia Research. The authors declare that they have no other competing interests.

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The authors' responsibilities were as follows: JS and VW developed the EAH protocol, with relevant input from GJ, JV, SV and MV. JS and MV conducted data collection. JS performed statistical analysis with relevant input from GJ and JV and SV. JS drafted the manuscript with critical input from all authors. All authors have read and approved the final manuscript. We thank former employees of Danone Nutricia Research Hugo Weenen and Carel Vereijken for input on the development of the EAH protocol, João Paulo for statistical advise and Corine Perenboom for support in dietary assessment. Danone Nutricia Research has provided cash funding for designing the protocol for measuring eating in the absence of hunger. *Baby's First Bites* was funded by the Netherlands Organisation for Scientific Research (NWO), grant number 057-14-002.

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Chapter 6

General discussion

Overweight in childhood is predictive of overweight in adulthood, and in light of the current obesity-epidemic and related diseases, targeted interventions are needed to promote healthy behaviors from an early age. Food preferences and related dietary habits are shaped in the first two years of life, and influence (healthy) food choices later in life [1-3]. Babies and young children are assumed to be intuitive eaters and, therefore, not likely to overeat. This ability diminishes as children grow older, when other factors become increasingly important in determining food intake [4-6]. It is known that poor diet quality and eating in the absence of hunger (i.e. failing to self-regulate energy intake) are risk factors for later health problems such as obesity. However, low diet quality is already observed in children as young as 1-3 years (e.g., low fruit and vegetable intake, high energy dense and processed food intake) [7-11]. Moreover, studies show that pre- and primary schoolers often struggle to regulate their energy intake and show a tendency to eat past the point of satiation [12, 13-17]. Therefore, utilizing the crucial first two years in a child's life can be a meaningful preventative approach to stimulate healthy dietary habits (i.e. self-regulation) and food preferences (i.e. vegetable intake and liking) from an early age, which can track into adulthood [1-3]. Within the Baby's First Bites (BFB) RCT we aimed to promote vegetable intake and liking, and promote child self-regulation of energy intake by advising parents on *what* and *how* to feed their infants from the very first bites of complementary food.

The aim of this thesis was to investigate whether vegetable intake and liking of babies and toddlers can be improved, and whether self-regulation of energy intake is present. To this end, the effect of repeated exposure to vegetables on children's vegetable intake and liking from the first bites of solid food, until the age of 24 months was investigated. Moreover, the association between toddlers vegetable intake and factors such as child sex, food neophobia, variety in vegetable intake and maternal vegetable was assessed. In addition, eating in the absence of hunger was studied in the same children at the age of 18- and 24 months. Lastly, we aimed to assess the effect of interventions of the BFB RCT on self-regulation of energy intake (assessed by the eating in the absence of hunger experiment) and child BMI-z. In this chapter, I will summarize the main findings of the research objectives, address methodological issues, discuss overarching conclusions, practical implications and recommendations for further research and finally provide an overall conclusion.

Main findings

The main findings of this thesis are presented in table 1. The Baby's First Bites (BFB) RCT tested interventions on the *what* and *how* in complementary feeding. As part of this RCT we assessed the effects of an intensified and prolonged intervention of repeated exposure to vegetables. Despite these extra efforts to strengthen the potential effect of the repeated vegetable-exposure intervention, the present findings showed no added effects of repeated exposure to vegetables (combined with consultation sessions to promote repeated exposure until the age of 16 months), as compared to exposure to fruits and a sweet vegetable (carrot) (combined with the sensitive feeding intervention or general contact in the control condition) on infants vegetable intake. This was neither the case directly after the feeding schedule, nor at the ages of 12, 18 and 24 months (chapters 3 and 4). It is noteworthy, however, that vegetable intake was on average high at these ages in the full sample: approx. 86 grams, 87 grams and 77 grams, respectively. This intake is in line with the recommended daily vegetable intake of 50 – 100 gram for this age group. At the age of 12 months a higher variety in vegetable intake was associated with higher absolute vegetable intake (chapter 4), suggesting that consuming a higher variety of different types of vegetables contributes to increasing absolute vegetable intake. In addition, children who ate a greater variety of vegetables also had parents (or at least mothers) eating more types of vegetables (chapter 4). This suggests an effect of parent modelling which has been proven to be an effective method to increase vegetable intake in children [18]. Of the other modifying factors we assessed, only food neophobia was associated with absolute vegetable intake. Food neophobic children ate less vegetables (chapter 4).

Vegetable liking, based on mother's reported liking scores, increased significantly over time in the full sample, with a stronger increase in liking in the repeated vegetable-exposure conditions. Liking scores were higher in the vegetable- compared to the fruit conditions over time (chapter 4). Finally, a significant positive correlation was found between liking and intake at the age of 4-6 months.

Chapter 5 described an eating in the absence of hunger experiment we carried out after dinner time at home. We found that children as young as 18 months displayed this behavior. The majority (90%) of children consumed on average (±SD) 40 kcal (± 37) ranging from 0 to 237 kcal from palatable finger foods despite just having eaten a meal. Secondly, we found that EAH at 18 months predicted EAH at 24 months. Furthermore, unexpectedly, a positive association was found between satiety of the child (as estimated by the mother) and the energy intake of finger foods (i.e. higher satiety scores were associated with increased intake of finger foods). Finally, a child's enjoyment of food was positively associated with the intake of finger foods. No differences in child self-regulation of energy intake were found between the conditions of the BFB RCT (chapters 3 and 5).

While the interventions of the BFB RCT, aimed at fostering healthy eating habits in children, showed no effect on child vegetable intake and self-regulation of energy intake, we found that the proportion of children with overweight was lower in the combined intervention condition compared to the sensitive-feeding condition (18 months) and the control condition (24 months). Nevertheless, this finding needs to be interpreted with caution, due to the small number of children with overweight in our sample and non-significant effects on the continuous measure of BMI-z.

TABLE 1 | Overview of the main findings.

	Findings	**Chapter**
Outcome: *Vegetable intake of the child*		
Repeated exposure	No effect of repeated exposure on vegetable intake.	3 & 4
Factor		
Child sex	No association with vegetable intake.	
BMI-z	No association with vegetable intake.	
Food neophobia	A higher food neophobia score was associated with a lower vegetable intake (r = -.24, p= .004).	
Variety	More variety in types of vegetables consumed was associated with higher vegetable intake (r = .19, p = .007).	
Amount of maternal vegetable intake	No association with vegetable intake.	
Outcome: *Vegetable liking*		
Repeated exposure	Main effects: • Mother-reported liking scores of the child increased over time (p= <.001). • Greater liking scores after repeated exposure to vegetables than fruits (p= <.001).	4
Outcome: *Self-regulation of energy intake* - eating in the absence of hunger (EAH)		
EAH experiment	• Children aged 18 months eat in the absence of hunger. The majority (90%) of children consumed palatable finger foods (40 kcal) despite just having eaten a meal. • EAH at 18 months predicted EAH at 24 months (p = .004). • A higher score on enjoyment of food was associated with an increased finger food intake (p = .005).	5
Outcome: *Findings Baby's First Bites RCT*		
Self-regulation of energy intake	No effect of condition on self-regulation of energy intake.	3 & 5
BMI-z	The percentage of children with overweight was lowest in the condition that received advise on what and how, both at 18 and 24 months (p = .02).	3

Abbreviations: EAH = eating in the absence of hunger

Methodological considerations

Some methodological elements of the study designs described in the present thesis have been noted and discussed in the chapters. In the following paragraphs I will elaborate on these elements and discuss some practical challenges we faced during the research process of this longitudinal trial.

Study design and population

The BFB RCT was the first trial to explicitly test the separate and combined effect of promoting *what* and *how* in complementary feeding. Three prolonged interventions were carried out to draw conclusions about what is important when promoting vegetable intake,

liking and self-regulation of energy intake in early childhood. This design was innovative, and also highly intensive for both participants and researchers. The interventions started when parents indicated their child was ready to take their first bites of complementary food (age 4-6 months) and lasted until the age of 16 months. Follow-up measurements lasted until the age of 36 months. During the initial phase, the feeding schedule, at least 4 home visits (depending on the intervention condition) were carried out for each family. These visits were time sensitive, as they had to be planned on the first, second, eighteenth and nineteenth day of the feeding schedule. Additionally, two consultation sessions were offered during the feeding schedule, except for families in the combined condition, who were offered four consultation sessions. This time-sensitive schedule was quite challenging. Visits often had to be planned on weekend days and mothers had to estimate the time that their infant would be awake and willing to have some food and fit these feeds and visits into their own schedule. After these first weeks, interventions were more scattered and timed in accordance with major transitions in eating and development of the child and home visits for follow-up measurements were (mostly) planned in the evening at dinner time. This time of day may also be considered "peak hour" in some households. Nevertheless, compliance to the study protocol was good and participants were highly motivated to take part in the trial. The recruitment went swiftly and attrition was low (dropout rate 14%). We made an effort to stay in touch with participants by informing them about the progress of the trial with quarterly newsletters and sending postcards on children's birthdays.

The intense nature of BFB and the fact that recruitment was partly targeted at parents who had signed up to receive information and tips about pregnancy-, baby- and child health related topics, may have resulted in a somewhat higher educated sample with an above average interest in child nutrition and healthy eating habits (including vegetable consumption). Moreover, participant contact was the same and just as often in all conditions, irrespective of the intervention components. This also raises the question whether the intervention for the control group was indeed really a control condition. It is possible that the characteristics of the sample and the fact that all conditions received attention from the researchers led to a well performing control condition and a ceiling effect in vegetable intake among all conditions.

In summary, while testing interventions on *what* and *how* in complementary feeding was innovative, it was complex and challenging to execute. Future studies may focus their point of interest or combine aspects of both forms of interventions in order to work more efficiently and make participation in the trial less intensive. For example feeding guidelines (from the *how* intervention), such as respecting satiety ques, adjusting eating rate to the child and not pressuring to eat can be combined with advice about repeated exposure to vegetables. This could also aid in attracting a more suitable sample, consisting of for instance less privileged families or children with food neophobia or a one-sided diet, who may especially benefit from such advice.

Finally, the focus of all interventions performed within the BFB RCT was on mother-infant pairs. There might be differences in the way mothers and fathers parent and interact with their children at mealtimes [19]. For comparison of the effect of the interventions within our sample and with other studies, and thus to reduce potential variation, we choose to focus on mother-infant pairs.

Test environment and feeding schedule

The study was fully homebased. We believe this has strengthened the validity of the study. Children were in their familiar environment and for the most part without the presence of a researcher to influence their eating behavior. We used commercially available products for the duration of the feeding schedule, ensuring that all children were exposed to the same taste, sensory properties and energy. The purées were eaten in their familiar environment as part of their usual daily routine. A drawback of this ecological setting is that there is less experimental control. Parents received an instruction for feeding the purées (i.e. make sure the infant tasted some of the purée at least three times per feed), were asked to offer the designated purée to the infant daily, save the leftovers as best they could and rate the infants liking in a provided diary. The leftovers and diaries were returned by 93% of the sample, indicating high involvement and compliance during the feeding schedule. Therefore, we consider it unlikely that deviation from the procedure caused an effect on our results.

Finally, due to ethical considerations, the fruit conditions in the current study were also offered carrot instead of fruits exclusively. Additionally, after the feeding schedule, mothers were free to offer other foods from the family diet and these were not reported. Indeed, the vegetable-exposure conditions received consultations and advice about daily vegetable exposure. However, no guidelines or restrictions were given in the fruit conditions, therefore infants in these conditions may also have been offered vegetables daily after the first 19 days of complementary feeding. These factors may have clouded any effects of the repeated exposure intervention.

Assessment of vegetable- and energy intake

To assess vegetable- and energy intake at the ages of 12, 18 and 24 months, mothers were asked to fill in three 24h dietary recalls on three randomly assigned non-consecutive days using the online program Compl-Eat [20]. These recalls were collected on all days of the week and in diverse natural settings (including day care, during weekends, holidays etc.), which increased ecological validity. To increase accuracy of the information on vegetable consumption, participants were asked to weigh vegetables separately on a kitchen scale for the duration of the recall days and report the amount eaten by the child in grams. In case vegetables were reported in household measures, standardized measures were used to convert the reported intake into grams [21]. A downside of this approach is that mothers were aware of the days on which they had to report on their child's intake. This may have (unconsciously) caused mothers to prepare certain meals that are easy to report, considered to be healthy (i.e. vegetables) or over-/underestimate their child's intake. Moreover, reporting the intake in Compl-Eat and weighing the vegetables the child consumed was quite time consuming. In spite of these possible sources of bias, reported vegetable intake was the same, and on average high, in all conditions. In addition, average daily energy intake did not differ between conditions and was considered normal for this age group. Moreover, it is has been shown that parents can accurately report on their young children's (>7 years) food intake [22]. Quality of the collected food intake data was thoroughly checked by trained research dietitians. Errors or unclear entries were identified and parents were contacted for clarifications when necessary. Taken together, we expect that these points of consideration had limited effects on the results.

EAH protocol

To assess children's ability to regulate their energy intake we performed an eating in the absence of hunger protocol. After their evening meal at home, children were presented with four palatable finger foods for ten minutes. To our knowledge this is the first study to examine EAH in children this young. We developed an accurate method for assessing evening meal intake in a home setting using photographs, a detailed description- and weight of the meal. This method was evaluated within the BFB trial using a weighed food record as a reference method. The results showed no significant differences between energy and macronutrient intakes between the two methods, indicating it as a reliable method to estimate energy intake of the evening meal. Furthermore, the experiment was done in the natural environment of the child, and the food consumed was representative of the children's usual eating habits, which increased ecological validity. A possible downside from the setting of the protocol was decreased experimental control and it was quite time consuming for the researchers. If the experiment were to be done in a lab it would have been achievable to measure food intake more than once (or from a different perspective, i.e. energy compensation) as seen in other studies [12,23]. Other points of discussion are that the presence of the mother, researcher and the camera may have influenced the child's behavior. For example, some children were very aware of the camera and wanted to touch it or danced in front of the lens. Also, some parents mentioned that their child always waits for permission to eat, while parents were instructed not to interfere with the child's behavior for the duration of the experiment. Possibly these children would have behaved differently if the instruction had come from the parent instead of the researcher. Finally, the choice of highly palatable finger foods suitable for 18-month-old children was limited and the selected foods were different from previous studies investigating EAH in children. Taken together, these factors may have resulted in an underestimation of usual child behavior with regard to energy intake of finger foods. Future experiments aimed at assessing eating in the absence of hunger in this age group may consider involving the parent in instructing the child about the procedure and using snack foods with a higher energy density (i.e. cake instead of plain cookie, crisps instead of breadstick) and perceived as more indulging to obtain more substantial results.

Discussion, implications and suggestions for future research

Vegetable intake

There was no added effect of the repeated vegetable-exposure intervention on children's vegetable intake at the age of 6, 12, 18 and 24 months. These findings are consistent across the post-intervention and follow-up measurements (chapters 3 & 4). However, they are in contrast to findings in previous research on repeated exposure in which this approach was proven to be the most powerful method to enhance vegetable intake in infants and toddlers [1,24-27] It should be noted that these concern studies with an immediate or short-term follow-up. Few RCT's have investigated the long-term effects of repeated exposure and came up with mixed results. The study by Barends et al. (2013), on which our intervention was based, found

short-term effects of repeated vegetable exposure in the first year of life and no longer at 23 months, suggesting that intervention effects might not be robust enough to have long lasting effects [28,29]. The study by Maier et al. (2016) did show lasting effects of repeated exposure to a high vs low variety of vegetables at the start of complementary feeding on vegetable intake and liking at the age of 3 and 6 years [25,30]. Yet, the effect was absent at the age of 15 months in the same study. This could suggest that children may still benefit from exposure to vegetables at the start of complementary feeding later in life, but other studies to confirm this theory are lacking. The follow-up measurement at 36 months will provide more insight in the longer-term effects of the intervention.

In addition to the complementary feeding schedule consisting of vegetables only, we intensified the vegetable-exposure intervention with five consultation sessions beyond the first weeks of complementary feeding. Thereby we stimulated parents to offer vegetables daily after the feeding schedule. Nevertheless, we did not observe an effect on vegetable intake between conditions. The lack of an effect in our trial might be explained by several factors. Firstly, due to ethical considerations, infants in the fruit conditions were also offered carrot instead of fruits exclusively. This is in fact also repeated exposure to a vegetable, albeit to a relatively sweet one, especially in comparison to the flavors of green beans, cauliflower, broccoli and spinach offered in the vegetable condition. More importantly, after the feeding schedule, parents were free to offer other foods and these were not recorded. Therefore, infants in the fruit conditions may also have been offered vegetables daily after the first nineteen days of complementary feeding. The daily family routine with regard to mealtimes and the family diet may have a bigger impact on children's vegetable intake than the feeding schedule and intervention thereafter. Therefore, these factors may have clouded any effects of the repeated exposure intervention. However, a recent RCT by Rapson et al. (2022) incorporated the same approach with a complementary feeding schedule of four weeks consisting of vegetables only compared to a control group receiving fruits and vegetables and did find effects on infant vegetable intake at the age of 9 months [27]. Mother reported average daily vegetable intake was on average 86 grams compared to 67 grams in the vegetable- and combined conditions respectively. In contrast to our trial, no additional advice regarding vegetable intake was given and all participants received the same general advice about infant feeding after the feeding schedule. Albeit the follow-up time was considerably shorter than in our trial, this result is noteworthy. There was a clear difference in guidance and participant contact after the feeding schedule. This further supports the point raised earlier, whether increased participant contact increased vegetable intake in our sample irrespective of the intervention components.

Moreover, the sample characteristics may also be an important factor for the lack of effective findings. The recruitment and commitment to a highly intensive and long-term study may have caused inclusion of a highly educated and health minded sample. These characteristics may have led to the adequate vegetable intake in the full sample. These results indicate that repeated exposure may not always be necessary and future research should aim to target possible "risk groups" (e.g. lower income families, food neophobic children, children with a one-sided diet) who may still benefit from early repeated exposure to vegetables.

Another possible explanation for the discrepancy between our findings and those of previous research is that, on average, eating patterns with regard to vegetable intake may be shifting. Over the past decades the importance of diets high in vegetables and advice

given in this regard by sources parents turn to (e.g. Netherlands Nutrition Centre, baby food compagnies, child healthcare services) all promote offering vegetables from an early age. They provide information on the importance of vegetable consumption, practical advice on how to prepare and offer vegetable (meals) to infants and toddlers and even mention repeated exposure (i.e. offering vegetables on at least 10-12 separate occasions). An upcoming publication of the Dutch National Food Consumption Survey, expected by the end of 2022, will have to confirm whether or not overall vegetable consumption in infants and toddlers is indeed on the rise. Nevertheless, this still concerns average intake, and there are still children who do not meet recommendations for vegetable intake. Therefore, the message that parents should introduce vegetables at an early age and keep offering vegetables remains highly relevant. This message is important during the complementary feeding phase, when infants easily accept new and more difficult flavors but perhaps even more so thereafter. Results of the current study show that vegetable intake decreased as children got older. Average intake decreased significantly in all conditions from the 18 to 24 month assessment. This result is in line with previous findings that show children become more selective about the foods they consume as they get older. This may be explained by the onset of the 'picky eating phase' that about half of the children between 1.5 and 6 years experience [31-33]. This, combined with other behavioral developments in the toddler years (e.g. wanting autonomy, food refusal) can make this a challenging phase at the (dinner) table. Interventions or health promotion programs directed at coping with challenges around mealtime and suggesting ways to create a healthy eating environment during toddlerhood could play a role in stimulating healthy eating behavior (including sufficient vegetable intake) and child health outcomes as children grow older. These programs may need to target a scope of behaviors, instead of only focusing on repeated exposure. For instance parental vegetable intake and modelling, increasing variety of vegetables offered, respecting satiety ques or expressions of food neophobia and creating a healthy eating environment (availability of vegetables, flexible meal schedule, no pressure to eat).

Vegetable liking

As expected, the extended repeated exposure intervention had a significant effect on vegetable liking over time (chapter 4). Mother reported liking scores increased with age in the full sample, the increase was strongest in the vegetable conditions and absolute liking scores were higher at all time points. Our findings are in line with several previous studies that observed an effect on liking after repeated exposure [1,26,34,35]. The increased liking scores in the fruit conditions at the age of 12 months can be explained by the relatively large variety of vegetables all children were exposed to after the feeding schedule (on average 15 different types by their first birthday). Additionally, all children may have been exposed to green beans and cauliflower regularly as these are popular and commonly consumed vegetables in the Netherlands [36]. In summary, these results indicate that repeated exposure is an effective strategy to increase vegetable liking. However, effects beyond the age of 12 months were not investigated in this thesis. This result raises the question why increased liking did not result in increased intake, as liking supports intake. It would be interesting to assess long-term effects (i.e. follow-up at 36 months) of liking and intake in this sample. If increased liking persists over time, perhaps this will also translate to increased intake in the long run.

Another point of attention for future research in general, is the method used for assessing liking in young children. We were bound to mother reported liking due to the age of the children. However, slightly older toddlers are able to make simple yes or no decisions and could be involved in rating their own preferences for vegetables. As food liking largely determines intake in young children it is relevant to develop a method for determining liking directly in young children [37-39].

Self-regulation of energy intake

We aimed to assess whether toddlers aged 18 months eat in the absence of hunger (i.e. fail to self-regulate energy intake). Extending our knowledge on the determinants of EAH is important for early recognition of risk behaviors/factors contributing to overeating in children, and for the timing of early targeted interventions to prevent overeating. Furthermore, such insights could be translated into practical guidelines for parents and caregivers.

We observed that 18-month-old children eat in the absence of hunger when offered palatable finger foods, indicating that this behavior emerges at a very young age (chapter 5). A previous home-based study also found that toddlers (aged 21 months) eat in the absence of hunger [14]. Compared to our findings, this study reported double the energy intake of palatable finger foods than in our study. This difference could be due to methodological factors, such as the energy density of the offered foods. The foods we used had lower energy density (e.g. plain biscuits vs Oreo cookies) therefore the same amount in grams eaten would have resulted in a lower energy intake in our study. Although the energy intake in our study may not have been huge in absolute terms (40 kcal on average), we do consider this to be relevant for this age group. Most healthy children are thought to be able to maintain a balance between energy intake, - expenditure, - storage and growth over the long term despite large day-to-day fluctuations [40]. However, when a positive energy balance is maintained over a longer period of time a child could be at risk of becoming overweight [2,40]. Possibly, children who display certain eating behaviors (e.g. enjoyment of food, high food responsiveness and low satiety responsiveness) are at greater risk of eating in the absence of hunger and ultimately increased body weight. Alternatively, it has been suggested that the eating environment and the portion size of meals or snacks offered determine energy intake more than the amount of food and composition of the meal children ate previously [41-44]. In addition, it has been proposed that EAH reflects responses to external cues rather than the ability to regulate intake [45]. We cannot exclude the possibility that we observed a 'salience' effect. The context we placed children in may have triggered the majority to eat the finger foods despite having just finished a meal. Indeed, previous research has indicated that the availability of foods is an important determinant of consumption [46-48]. Taken together, the indication that children seem to eat when palatable foods are available and that they do this past the point of satiety may, when it occurs regularly, lead to an unhealthy diet and increased risk of developing overweight.

Previous studies have focused on different strategies to reduce overeating in children. Interventions to increase appetite awareness and dealing with cravings have been tested in older children (8-12 years) and may potentially be effective [49]. Moreover, a recent study assessed if eating in the absence of hunger can be redirected to healthier snacks by comparing the intake of fruit or high energy dense snacks (e.g. potato chips, chocolate chips cookies)

after lunch and dinner [50]. The results indicate that this strategy can increase healthy food intake and decrease energy intake in the absence of hunger. The findings of the current thesis suggest the importance of the eating environment in which parents and caregivers can play an important part in the prevention of overeating. In contrast to intervening at a later age, and trying to alter behavior that has already developed, future research could focus more on assessing factors in the eating environment of young children in relation to eating in the absence of hunger, for instance the availability of palatable foods, (semi)fixed mealtimes and parental modelling of healthy eating behavior (e.g. modelling healthy food intake, less snacking or grazing throughout the day).

Findings of the Baby's First Bites RCT

The eating in the absence of hunger experiment described in chapter 5 was (also) designed to assess possible effects of the overarching BFB RCT. One of the study's goals was to promote self-regulation of energy intake. The interventions of the BFB RCT showed no effect on self-regulation of energy intake (i.e. no differences in eating in the absence of hunger between conditions). This is in contrast to the hypothesis that the sensitive-feeding intervention (*how*) and combined intervention (*what* & *how*) would be more effective in supporting self-regulation of energy intake. Possibly, the effects of the intervention were not yet present or not large enough and might evolve more after the age of 24 months. Alternatively, the intervention did not have the desired effect. Although parents are known to have a key influence on their children's eating behaviors [51-53], evidence that self-regulation of eating in toddlerhood can be influenced by improving maternal feeding practices is still lacking. As discussed in the previous paragraph, appetitive traits of the child play a role in both children's appetite regulation and their susceptibility to environments that stimulate overeating [54,55]. In that case interventions may need to specifically target children's environment and behavioral traits rather than focus on maternal feeding.

Among the child health outcomes of the BFB trial was child BMI-z and weight gain. With respect to this outcome measure we found that the proportion of children with overweight was lower in the combined intervention condition compared to the sensitive-feeding condition (18 months) and the control condition (24 months) (chapter 3). However, we did not find an effect on the continuous measure of BMI-z or rapid weight gain, suggesting that solely focusing on the *what* and *how* is not enough to achieve effects on child weight (gain). This finding is in contrast to findings of other RCTs that found effects on rapid weight gain at 12-14 months [56,57], and on BMI-z at 36 months; [58]. However, those intervention programs included elements on a much broader level, such as avoiding unhealthy foods, portion sizes, and daily physical activity [59,60]. It is difficult to draw conclusions based on our findings as the prevalence of children with overweight in our sample was low, children's average daily energy intake did not differ between conditions and physical activity was not assessed. Moreover, the follow-up time may not have been sufficiently long enough to observe an effect on weight status. Future research may target their interventions aimed at assessing the effects of feeding interventions on child weight (gain) on samples consisting of children who are (at risk of) overweight and follow-up until children are older.

General conclusion

This thesis demonstrates that repeated exposure of vegetables does not have an added benefit in infants and toddlers who already have sufficient vegetable intake, as intake was relatively high in the full sample. The control condition in our trial may have been a positive control as no guidelines or restrictions were given on vegetable exposure after the feeding schedule, which could have led to (a high) vegetable exposure in the period thereafter. We did demonstrate that repeated exposure is effective in increasing liking of vegetables. If increased vegetable liking persists over time, perhaps this will also translate to increased intake in the long run. Moreover, we found that food neophobia and variety in vegetable intake play a role in determining vegetable intake. These factors may be taken into account in future studies by targeting groups who may still benefit from early repeated exposure to vegetables (e.g. children with a one-sided diet or food neophobia). Moreover, we showed that eating in the absence of hunger occurs within the first two years of life. Our findings suggest the importance of the eating environment in which parents and caregivers can play an important part in the prevention of overeating. The contemporary living environment seems to revolve around easy access and convenient foods, it is therefore important to create awareness that toddlers are sensitive to the eating environment and to stimulate healthy eating behavior at a young age. Factors that play a key role in this are 1) targeting vegetable intake, 2) self-regulation of energy intake, 3) the context in which food is offered and 4) the type of food that is offered. To further enhance diet quality and consequently health of toddlers it is important to stimulate a multidisciplinary approach in which researchers, parents and caregivers, daycare centers, community and the government collaborate in finding ways to enhance healthy eating behavior of young children to prevent overweight and obesity and to promote health.

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Summary

The prevalence of overweight and related health problems is increasing globally. Low vegetable intake and failing to self-regulate energy intake (i.e. eat in the absence of hunger) increase the risk of developing overweight. Interventions promoting healthy eating behaviors from an early age are needed as food preferences and related dietary habits are shaped in the first two years of life, and track into adulthood.

The aim of this thesis was to investigate whether vegetable intake and liking of babies and toddlers can be improved, and whether self-regulation of energy intake is present. To this end, the effect of repeated exposure to vegetables on children's vegetable intake and liking from the first bites of solid food (age 4-6 months), until the age of 24 months was investigated. Eating in the absence of hunger was studied in the same children at the age of 18- and 24 months.

The components studied in this thesis were part of an overarching randomized controlled trial, *Baby's First Bites*, which tested interventions on the *what* and *how* in complementary feeding. **Chapter 2** described in detail the rationale and the design of this trial including a repeated vegetable-exposure (*what*) and sensitive-feeding (*how*) intervention.

In **Chapter 3** we evaluated the effects of the vegetable-exposure and sensitive-feeding intervention in terms of child health outcomes and maternal feeding behavior (outside of the scope of this thesis) at child ages 18 and 24 months. **Chapter 4** described the intervention in more detail and evaluated the effects of the intervention on infant's vegetable intake, liking and variety of vegetables consumed during the first weeks of complementary feeding and at the age of 12 months. We found no added effects of repeated exposure to vegetables (combined with consultation sessions to promote repeated exposure until the age of 16 months), as compared to exposure to fruits and a sweet vegetable (carrot) (combined with the sensitive feeding intervention or general contact in the control condition) on infants vegetable intake. This was neither the case directly after the feeding schedule, nor at the ages of 12, 18 and 24 months. It is noteworthy, however, that vegetable intake was on average high at these ages in the full sample: approx. 86 grams, 87 grams and 77 grams respectively. At the age of 12 months a higher variety in vegetable intake was associated with higher absolute vegetable intake (chapter 4), suggesting that consuming a higher variety of different types of vegetables contributes to increasing absolute vegetable intake. In addition, children who ate a higher variety of vegetables also had parents (or at least mothers) eating a larger variety of vegetables (chapter 4). This suggests an effect of parent modelling which has been proven to be an effective method to increase vegetable intake in children. Of the other modifying factors we assessed, only food neophobia was associated with absolute vegetable intake. Food neophobic children ate less vegetables (chapter 4). We did not find differences in child self-regulation of energy intake and BMI-z between conditions (chapter 3).

Chapter 5 described an eating in the absence of hunger (EAH) experiment that was designed and conducted within the BFB RCT. We found that children as young as 18 months displayed this behavior. The majority (90%) of children consumed palatable finger foods despite just having eaten a meal. Secondly, we found that EAH at 18 months predicted EAH at 24 months. Furthermore, unexpectedly, a positive association was found between satiety of the child (as estimated by the mother) and the energy intake of finger foods (i.e. higher satiety

scores were associated with increased intake of finger foods). Finally, a child's enjoyment of food was positively associated with the intake of finger foods.

This thesis demonstrates that repeated exposure does have an added benefit in infants and toddlers who already have sufficient vegetable intake, as intake was relatively high in the full sample. The control condition in the trial may have been a positive control as no guidelines or restrictions were given on vegetable exposure after the feeding schedule, which could have led to (a high) vegetable exposure in the period thereafter. We did demonstrate that repeated exposure is effective in increasing liking of vegetables. If increased vegetable liking persists over time, perhaps this will also translate to increased intake in the long run. Moreover, we found that food neophobia and variety in vegetable intake play a role in determining vegetable intake. These factors may be taken into account in future studies by targeting groups who may still benefit from early repeated exposure to vegetables (e.g. children with a one-sided diet or food neophobia). Moreover, we showed that eating in the absence of hunger occurs within the first two years of life. Our findings suggest the importance of the eating environment in which parents and caregivers can play an important part in the prevention of overeating. The contemporary living environment seems to revolve around easy access and convenient foods, it is therefore important to create awareness that toddlers are sensitive to the eating environment and to stimulate healthy eating behavior at a young age. Factors that play a key role in this are 1) targeting vegetable intake, 2) self-regulation of energy intake, 3) the context in which food is offered and 4) the type of food that is offered. To further enhance diet quality and consequently health of toddlers it is important to stimulate a multidisciplinary approach in which researchers, parents and caregivers, daycare centers, community and the government collaborate in finding ways to enhance healthy eating behavior of young children to prevent overweight and obesity and to promote health.

Samenvatting

Overgewicht en daaraan gerelateerde gezondheidsproblemen nemen wereldwijd toe. Het eten van weinig groenten en het onvermogen tot zelfregulering van de energie-inname (d.w.z. eten zonder hongergevoel) doen het risico op het ontwikkelen van overgewicht oplopen. Daarom zijn interventies nodig die, vanaf jonge leeftijd, gezonde eetgewoonten stimuleren. Dit omdat voedselvoorkeuren en de daaraan gerelateerde eetgewoonten in de eerste twee levensjaren ontstaan en doorwerken tot in de volwassenheid.

Het doel van dit proefschrift was vaststellen of de consumptie van groenten en de waardering daarvan door baby's en peuters verbeterd kan worden en of peuters in staat zijn om zelf hun energie-inname te reguleren. Om deze vragen te beantwoorden is het effect van herhaaldelijke blootstelling aan groente op de groente-inname en de waardering daarvan onderzocht. Dit is gedaan vanaf de eerste hapjes vast voedsel (leeftijd 4-6 maanden) tot de leeftijd van 24 maanden. Het eten zonder hongergevoel (hierna aangeduid met: EAH, 'Eating in the Absence of Hunger') is onderzocht bij dezelfde kinderen op de leeftijd van resp. 18 en 24 maanden.

De onderzoeken die in dit proefschrift beschreven worden, maakten deel uit van een overkoepelende gerandomiseerd gecontroleerde studie, genaamd: 'Baby's eerste hapjes', die interventies onderzocht in het '*wat*' en '*hoe*' van bijvoeding. In **hoofdstuk 2** wordt de opzet van dit onderzoek beschreven, w.o. het herhaaldelijk aanbieden van groenten (*wat*) en een interventie gericht op 'sensitief voedingsgedrag' (*hoe*).

In **hoofdstuk 3** worden de effecten van het aanbieden van groenten en sensitief voedingsgedrag op de gezondheid van kinderen van 18 en 24 maanden gemeten, plus het voedingsgedrag van de moeder (dit valt buiten deze dissertatie). In **hoofdstuk 4** volgt een meer gedetailleerde beschrijving van de groente-interventie. Ook worden de effecten ervan op de groente-inname van de baby's, hun waardering van groenten en de variatie aan groentesoorten besproken. Dit tijdens de eerste weken van bijvoeding en op een leeftijd van 12 maanden. Er is geen effect gevonden van de groente-interventie op de groenteconsumptie. De interventie bestond uit een voedingsschema van exclusief groentehapjes bij het starten van de bijvoeding i.c.m. interventiesessies om het dagelijks aanbieden van groenten tot de leeftijd van 16 maanden te bevorderen. Dit in vergelijking met een voedingsschema bestaande uit fruit en een zoete groente (wortel), gecombineerd met de interventie gericht op 'sensitief voedingsgedrag' of de controle conditie. Opvallend was daarbij dat de gemiddelde groente-inname op de bovengenoemde leeftijden hoog was in alle groepen: resp. gemiddeld 86 gram, 87 gram en 77 gram. Bij 12 maanden werd geconstateerd dat een hogere variatie in groente-inname gekoppeld was aan een hogere absolute inname van groenten. Dit kan erop wijzen dat het eten van meer verschillende soorten groenten de algehele groenteconsumptie doet toenemen (hoofdstuk 4). Daar komt nog bij dat kinderen die meer verschillende soorten groenten aten, ouders (of i.e.g. moeders) hadden die meer variatie in hun eigen groenteconsumptie aanbrachten (hoofdstuk 4). Dit suggereert een effect van de voorbeeldfunctie van ouders, waarvan al bewezen is dat die de groente-inname bij kinderen verhoogt.

Van de andere onderzochte factoren die van invloed kunnen zijn op de groenteconsumptie bleek alleen de angst voor nieuw voedsel (voedselneofobie) van invloed op de absolute groente-

inname: kinderen met een hogere fobie voor nieuw voedsel aten minder groenten (hoofdstuk 4). Er werden geen verschillen gevonden tussen de interventiegroepen in de zelfregulatie van energie-inname en BMI-z van de kinderen (hoofdstuk 3).

In **hoofdstuk 5** wordt een experiment beschreven dat was ontworpen en uitgevoerd om EAH te onderzoeken binnen 'Baby's eerste hapjes'. EAH werd al waargenomen bij kinderen van slechts 18 maanden oud. De meerderheid (90%) van deze kinderen at van aantrekkelijke snacks, ondanks het feit dat ze net een maaltijd op hadden. Daarnaast kon worden aangetoond dat EAH op de leeftijd van 18 maanden een indicatie was voor EAH bij 24 maanden. Een onverwacht verschijnsel daarbij was dat er een positieve correlatie was tussen de verzadiging van het kind (geschat door de moeder) en de energie-inname uit de snacks (d.w.z. hoe meer verzadigd de moeder het kind inschatte, hoe meer snacks het kind nog consumeerde). Ten slotte was er een positieve correlatie tussen hoezeer het kind van eten geniet en de consumptie van de snacks.

Dit proefschrift laat zien dat het herhaaldelijk aanbieden van groenten geen extra voordeel oplevert bij zuigelingen en peuters, die al voldoende groente eten. Dit omdat in alle onderzoeksgroepen de groente-inname relatief hoog was. De omstandigheden in de controlegroep kunnen relatief gunstig zijn geweest, omdat er geen regels of beperkingen waren opgelegd op het gebied van het aanbieden van groenten na het voedingsschema. Dit heeft mogelijk geleid tot een hoger aanbod van groenten in de periode na het onderzoek. Wat wel kon worden aangetoond is dat het herhaaldelijk aanbieden van groenten een positief effect heeft op de waardering van groenten. Als de waardering van groenten doorzet, zou dit kunnen leiden tot een verhoogde groente-inname op latere leeftijd. Daarnaast kon worden aangetoond dat voedselneofobie en het consumeren van een variatie aan verschillende groentesoorten een rol spelen in het bepalen van de groente-inname. Met deze factoren zou in toekomstig onderzoek rekening kunnen worden gehouden, door zich te richten op groepen die nog baat kunnen hebben bij een herhaaldelijke blootstelling aan groenten vanaf een jonge leeftijd, bv. kinderen met een eenzijdig dieet of voedselneofobie.

In dit onderzoek is tevens aangetoond dat EAH gedurende de eerste twee levensjaren optreedt. Daarom is de rol van ouders en verzorgers van groot belang als het gaat om de omstandigheden waaronder gegeten wordt, waardoor overeten voorkomen kan worden. In de huidige leefomgeving is voedsel alom tegenwoordig. Daarom is het belangrijk om het bewustzijn te creëren dat peuters gevoelig zijn voor de omstandigheden waaronder gegeten wordt. Daarnaast is het stimuleren van gezonde eetgewoonten vanaf jonge leeftijd cruciaal. Factoren die hierbij een belangrijke rol spelen zijn: 1) zich richten op groente-inname, 2) zelfregulatie van energie-inname, 3) de context waarin voedsel wordt aangeboden en 4) het type voedsel dat wordt aangeboden. Om de kwaliteit van het voedingspatroon bij peuters verder te verbeteren is het van belang dat onderzoekers, ouders en verzorgers, kinderdagverblijven en de overheid worden gestimuleerd om samen te werken om manieren te vinden om gezond eetgedrag te stimuleren. Dit ter voorkoming van overgewicht en obesitas en bevordering van algehele gezondheid.

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About the author

Curriculum vitae

Janneke Meta Schultink was born on 21 July 1989 in Wageningen, The Netherlands. After completing secondary school at 'Pantarijn' in Wageningen (2007), she started her study Nutrition and Dietetics at HAN, University of Applied Sciences in Nijmegen. During this time, she worked as a nutritional assistant at Radboud University Medical Center. She graduated in 2011 and continued her studies with a post graduate course Sports Dietetics at the University of Applied Sciences (HAN). Concurrently, she worked in a practice as a dietitian for one year before starting the Masters program Nutrition and Health at Wageningen University. For her MSc thesis, she investigated the dietary intake of celiac patients using a food frequency questionnaire she co-developed specifically for this patient group. Janneke did an internship at InnoSport NL, Arnhem, the Netherlands, where she carried out an intervention study to assess the effect of a nutritional supplement on sports performance and recovery. She graduated in 2014. After she graduated, Janneke worked as a research assistant on multiple research projects at the Division of Human Nutrition and Health at Wageningen University and for the Food and Safety Research institute in Wageningen. In 2015, she was appointed as a PhD candidate at the Division of Human Nutrition and Health at Wageningen University. Her PhD project was part of the public-private private partnership called 'The What and How in Weaning' focusing on promoting healthy eating behavior in babies and toddlers. Within this project Janneke focused on vegetable intake and eating in the absence of hunger. The results are presented in this thesis. During her PhD project, she attended and presented at several (international) conferences and was involved in teaching and supervision of students. Additionally, she completed the course 'Video-feedback intervention to Promote Positive parenting and Sensitive Discipline' (VIPP-SD) at Leiden University, Leiden, the Netherlands. Currently Janneke is working as an advisor at the Knowledge institute of the Federation of Medical Specialists, Utrecht, the Netherlands.

List of Publications

Janneke M. Schultink*, Merel S. van Vliet*, Gerry Jager, Jeanne H.M. de Vries, Judi Mesman, Cees de Graaf , Carel M.J.L. Vereijken, Hugo Weenen, Victoire W.T. de Wild Vanessa E.G. Martens, Hovannouhi Houniet, & Shelley M.C. van der Veek. The Baby's First Bites RCT: Evaluating a vegetable-exposure and a sensitive-feeding intervention in terms of child health outcomes and maternal feeding behavior during toddlerhood. Journal of Nutrition, 2022; https://doi.org/10.1093/jn/nxab387

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Merel S. van Vliet, Judi Mesman, **Janneke M. Schultink**, Jeanne H.M. de Vries, Carel M.J.L. Vereijken, Ralph C.A. Rippe, Shelley M.C. van der Veek. Baby's first bites: Association between observed maternal feeding behavior and infant vegetable intake and liking. Appetite, 2021; https://doi.org/10.1016/j.appet.2021.105316

Merel S. van Vliet, Judi Mesman, **Janneke M. Schultink**, Carel M.J.L. Vereijken, Vanessa E.G. Martens, Shelley M.C. van der Veek. Maternal sensitivity during mealtime and free play: differences and explanatory factors. Infancy, 2022; https://doi.org/10.1111/infa.12465

Shelley M.C. van der Veek, Cees de Graaf, Jeanne H.M. de Vries, Gerry Jager, Carel M.J.L. Vereijken, Hugo Weenen, Nicole van Winden, Merel S. van Vliet, **Janneke M. Schultink**, Victoire W.T. de Wild, Sofie Janssen & Judi Mesman. Baby's First Bites: A randomized controlled trial to assess the effects of vegetable-exposure and sensitive feeding on vegetable acceptance, eating behavior and weight gain in infants and toddlers. BMC Pediatrics, 2019; DOI: 10.1186/s12887-019-1627-z

Submitted for publication

Janneke M. Schultink, Gerry Jager, Merel S. van Vliet, Shelley M.C. van der Veek, Cees de Graaf, Vanessa E.G. Martens, Carel M.J.L. Vereijken, & Jeanne H.M. de Vries. Effects of repeated vegetable exposure on infants' vegetable intake, liking and variety of vegetables consumed during the first weeks of complementary feeding and at the age of 12 months.

Overview of completed training activities

A. Discipline specific activities

Course 'VIPP-SD training', 2015-2016, Leiden University, Leiden, The Netherlands.
Symposium 'Voedseleducatie in Nederland: alle kinderen voedselvaardig', 2015, Wageningen University & Research, Wageningen, The Netherlands.
Meeting WEVO (Werkgroep Voedingsgewoonten), 2016, Wageningen University & Research, Wageningen, The Netherlands, Oral presentation.
Symposium 'Programmadag Food, Cognition and Behaviour', 2016, NWO, Utrecht, The Netherlands.
Meeting WEVO (Werkgroep Voedingsgewoonten), 2017, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands.
5th International Conference of Nutrition and Growth, 2018, N&G network, Paris, France, Poster presentation.
42nd annual meeting of the British Feeding and Drinking Group, Institute Paul Bocuse, Lyon, France, Oral presentation.
Meeting WEVO (Werkgroep Voedingsgewoonten), 2018, Maastricht University, The Netherlands.
Course 'Exposure Assessment in Nutrition Research', 2018, Graduate School VLAG, Wageningen, The Netherlands.
43rd annual meeting of the British Feeding and Drinking Group, 2019, University of Swansea, Swansea, United Kingdom, Oral presentation.
9th European Conference on Sensory and Consumer Research (EuroSense), 2020, European Sensory Science Society, Rotterdam, The Netherlands, Oral presentation.
10th International Conference on Diet and Activity Methods, 2021, Wageningen University & Research, Rotterdam, The Netherlands, Oral presentation.

B. General courses

PhD week, 2015, Graduate School VLAG, Baarlo, The Netherlands.
Course 'Introduction to R', 2018, Graduate School VLAG, Wageningen, The Netherlands.
Course 'Applied Statistics', 2018, Graduate School VLAG, Wageningen, The Netherlands.
Course 'Scientific Writing', 2018, Wageningen Graduate School, Wageningen, The Netherlands.
Course 'Career perspectives', 2020, Wageningen Graduate School, Wageningen, The Netherlands.

C. Assisting in teaching and supervision activities

Assisting in the course 'Clinical Nutrition Research', 2015, Division of Human Nutrition and Health, Wageningen, The Netherlands.
Assisting in the course 'Methodology Nutrition Research', 2017, Division of Human Nutrition and Health, Wageningen, The Netherlands.
(Co-) supervision of 27 thesis students (HBO, university bachelor, university master), 2015-2021, Division of Human Nutrition and Health, Wageningen, The Netherlands.

D. Other activities

Preparation of research proposal, 2015, Chair group Sensory Science and Eating Behavior, Wageningen, The Netherlands.

Co-organizing PhD tour, 2016, Chair group Sensory Science and Eating Behavior, Wageningen, The Netherlands.

Weekly group meeting, 2016-2021, Chair group Sensory Science and Eating Behavior, Wageningen, The Netherlands.

Co-reviewing scientific article, 2019, Chair group Sensory Science and Eating Behavior, Wageningen, The Netherlands.

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