Encouraging vegetable intake in children

The role of parental strategies, cognitive development and properties of food

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ABSTRACT

Background

Despite the health benefits, children's fruit and vegetable intake is below that recommended. This thesis focuses on the role of parental strategies, children's cognitive development and properties of food in order to develop new approaches to increase fruit and vegetable preferences and intake in 4 to 12-year-old children.

Methods

First, we conducted a qualitative study (N=28) with three age groups representing different cognitive developmental stages, and a parental survey study (N=242). These studies indicated that texture was more important for 4-5-year-old children's food preferences than for 11-12-year olds and that the parental strategy of 'Choice' was positively related to both children's fruit and vegetable intake. Subsequently, in three intervention studies, the focus was on vegetables only, because previous approaches have been less effective for vegetable intake than for fruit intake. We investigated three approaches for their effectiveness in increasing children's vegetable acceptance:

1. *Varying the preparation method* (4-12y; N=94): Carrots and French beans were prepared in six ways: mashed, boiled, steamed, grilled, stir-fried and deep-fried.
2. *Flavour-nutrient learning* (7-8y; N=19): During a 14-day learning period, vegetable flavours were combined with energy (maltodextrin) or without energy in a drink.
3. *Choice-offering* (4-6y; N=303): Children had no choice, a choice before a meal, or a choice during a meal regarding which vegetable out of two they were going to eat.

Results

Varying the preparation method demonstrated that steamed and boiled were preferred over the other preparations ($p<0.05$). Positive predictors of vegetable liking were a uniform surface, the typical vegetable taste and crunchiness, whereas brown colouring and a granular texture negatively predicted liking. Due to insufficient consumption of the vegetable drinks (≈3 grams of 150 grams), flavour-nutrient learning could not take place. The pure vegetable taste was too intense. In the choice-offering study, the children appreciated a choice before the meal, but the three conditions did not differ for vegetable liking ($p=0.43$) or intake (≈52 gram; $p=0.54$). In the no-choice condition, high reactant children consumed less vegetables than low reactant children ($\Delta=28$ grams; $p=0.04$).

Conclusion

To encourage children's vegetable liking and intake, the following approaches may be most promising: 1) serve vegetables as crunchy as possible without brown colouring or a granular texture; 2) provide children with choice during vegetable eating; 3) stimulate a positive vegetable-eating context. Finally, serving vegetables in mixed dishes is a good way to facilitate flavour-flavour and flavour-nutrient learning, but the effectiveness of flavour-nutrient learning for increasing children's vegetable acceptance needs to be determined in future research.

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Introduction

1

INTRODUCTION

The aim of this PhD thesis is to develop new approaches to increase fruit and vegetable preferences and intake in 4 to 12-year-old children. In this introduction chapter, we provide a background to children's fruit and vegetable intake, describe the factors that influence their fruit and vegetable intake, and introduce the main focus areas of this thesis: the role of cognitive development, the role of parents and the development of food preferences. The chapter ends with the rationale and outline of the thesis.

Fruit and vegetable intake in children

Fruit and vegetables are essential components of a healthy diet. They provide essential nutrients, such as vitamins, minerals, fibre and various bioactive components. A high consumption of fruit and vegetables has been related to a reduced risk of chronic disease, such as cancer and cardiovascular disease [1-4]. Therefore, the WHO recommends to eat 400 grams of fruit and vegetables daily [4]. Since fruit and vegetables are relatively low in energy, they can be helpful in weight loss and weight maintenance, and this is beneficial in the light of the growing obesity epidemic [5-7].

The Dutch recommendation for children is 100-150 grams of vegetables and 150 grams of fruit daily for 4 to 8-year-old children. For 8 to 12-year-old children, a daily consumption of 150-200 grams of vegetables and 200 grams of fruit is recommended [8]. However, in practice, children do not meet these recommendations. The most recent Dutch Food Consumption Survey of 2005-2006 showed that only 21-30% of the Dutch 4 to 6-year-old children reach the recommendations for fruit intake. None of them reaches the lower limit of the recommended vegetable intake [9]. In addition, fruit and vegetable consumption has declined among Dutch children in the period between 1988 and 1998 [10]. In other European countries and the US, similarly low consumption levels have been found for children's fruit and vegetable intake [11-13]. Therefore, action is needed to increase children's fruit and vegetable consumption.

During the past few decades, the number of intervention studies that aim to increase children's fruit and vegetable intake has risen enormously [14]. Most of these interventions were school-based and multi-component, including a classroom curriculum, a food service component and a parental component. The majority of these interventions aimed to increase availability, accessibility and familiarity of fruit and vegetables, and strived for an encouraging social environment [14-18]. The effect sizes of such intervention studies vary enormously: from no effect to an increase of 2.5 servings of fruit and vegetables daily [15, 17-19]. The effects for fruit intake are often larger than for vegetable intake [15-17, 20]. The length of follow-up varies among the interventions [18], effects may drop over time or due to the finishing of the intervention program [15-17, 19] and long-term sustainability is usually not studied [19].

To summarize, despite the health benefits, children's fruit and vegetable consumption is below that recommended. Intervention studies have shown that it is a challenge to increase children's fruit and vegetable intake substantially and sustainably. The increases in fruit and vegetable intake have been relatively small, short-term and less effective for vegetables.

New strategies are needed to increase children's fruit and vegetable intake, which is the starting point for this thesis. In order to change children's fruit and vegetable intake, we need to understand which factors influence children's food choices and eating behaviour. These factors are described in the next paragraph.

Factors influencing children's fruit and vegetable intake

Children's fruit and vegetable intake is influenced by various food-related, person-related and environmental factors, which interact with each other in a complex way, as is shown in Figure 1.1. All these factors play a role, but the importance of a factor varies according to the specific situation and life stage of the individual child.

We have assigned a prominent role to children's food preferences in this thesis, because preference is an important determinant of their food intake. Children eat what they like and leave the food they dislike [21]. Children's liking or preference for fruit and vegetables is a crucial determinant of their fruit and vegetable intake [14-16, 22-26]. Various factors depicted in Figure 1.1 influence fruit and vegetable intake directly, but they can also influence fruit and vegetable intake indirectly via preferences.

Food-related factors have received little attention when studying fruit and vegetable intake. Different fruit and vegetable types can, however, vary greatly in their physical-chemical properties, and this can influence children's preference and intake [27, 28]. In addition, it has been shown that children prefer fruit and

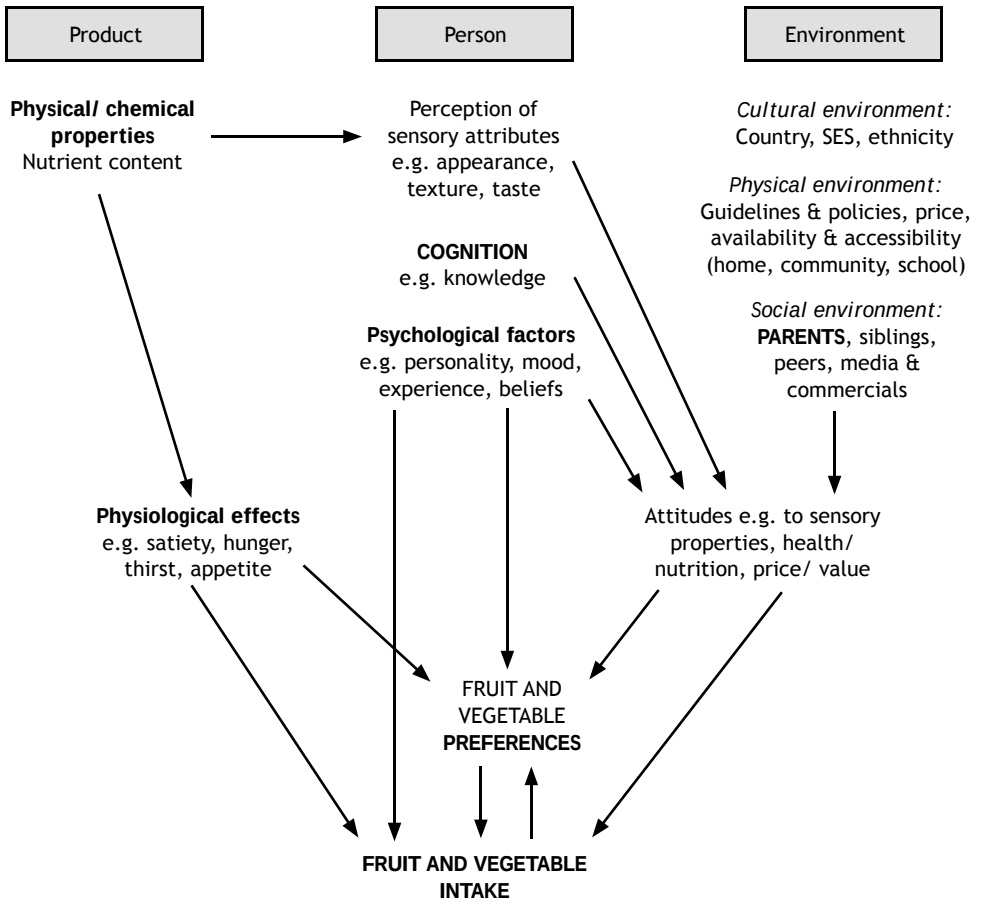

Figure 1.1 Overview of factors influencing children's fruit and vegetable intake (adapted from Shepherd & Pro-children framework [34, 35]). The main focus areas of this PhD thesis are in bold.

vegetable types with relatively higher energy densities [29], which indicates the importance of food-related factors.

Various individual factors influence children's fruit and vegetable intake. High sensitivity to bitter tastes has been associated with lower vegetable liking and intake [30, 31]. Certain beliefs or perceived barriers may hinder intake, such as "eating vegetables at school is weird" or "my own fruit and vegetable consumption is sufficient" [26]. Self-efficacy has been linked to higher fruit and vegetable intakes [15, 22, 26], as well as knowledge of intake recommendations [15, 22, 26, 32] and good preparation skills [15, 16, 26, 33]. A person-related determinant that has hardly been studied in relation to children's fruit and vegetable preferences and intake, is children's level of cognitive development.

The environment has a large impact on children's fruit and vegetable intake. Parents play a crucial role in this environment and have a strong influence on children's fruit and vegetable intake through their own intake [12, 14, 15, 23, 36], their modelling behaviour [12, 26, 37] and the practices they apply [38-40]. Furthermore, availability and accessibility are two important and consistent predictors of children's fruit and vegetable intake [14-16, 22, 23, 37, 41]. Availability refers to whether the food is present in the current environment. Accessibility refers to whether the food is available in a form, location and time that facilitates consumption, in other words: 'ready to eat' [41]. Parental involvement has been identified as a success factor in school-based intervention programmes. Yet, it is often difficult to engage families, active parental involvement may be low and family participation may drop over time in these programmes [16, 18, 42, 43].

In summary, children's fruit and vegetable intake is influenced by several factors. Preference is a crucial determinant of children's intake; it is essential to increase children's fruit and vegetable preferences in order to increase their intake. Parents have a prominent role as well, but their involvement in school-based interventions may be low. Factors related to the properties of food and the role of cognitive development have hardly been studied in relation to children's fruit and vegetable preferences and intake.

In the next paragraphs, the possible role of cognitive development will be described, followed by a more detailed description of the role of parents and the development of food preferences.

Role of cognitive development

Cognition refers to the mental processes responsible for perception, attention, learning, memory, thought and communication [44]. Cognition is a static concept, in contrast to cognitive development, which is related to the sequence of changes in cognition as the child grows up or in other words, 'how the child perceives, thinks, and gains understanding of his or her world through the interaction and influence of genetic and learned factors' [45]. The work of Jean Piaget (1896 – 1980) is considered as the base for studying cognitive development [46-49]. He developed a model with four successive stages: sensory motor period (0-2 years), pre-operational stage (2-7 years), concrete operational stage (7-11 years) and the formal operational stage (11-15 years). Along these stages, children's thinking changes from concrete to abstract, they develop the ability to replace overt actions by mental representations, egocentrism and centration diminishes, children get more eye for detail, and their problem solving, logical thinking and reasoning becomes gradually more advanced.

Whereas Piaget focused on the child's interaction with the physical environment as a solitary person, others have shown that the social environment is an

active force in children's development [48, 49]. Piaget's work has been refined and adapted by other researchers and applied to other disciplines, such as consumer behaviour [50, 51]. However, little research has been devoted to the role of cognitive development in relation to children's food preferences and eating behaviour.

A major developmental task for children is to learn what is edible and what is not edible, when to eat, in which amounts and what are appropriate combinations [52, 53]. The different categories of food acceptance and rejection that emerge when children grow up, require an increasingly sophisticated level of cognitive development [54-56]. Furthermore, children's language development, their reasoning, categorization capacities, attention abilities and conceptual thinking influences how they think about, behave towards and form expectations about food. These abilities also influence how they interpret and evaluate eating experiences [57-62]. Additionally, children of different cognitive stages may have different motivations for their food choices [55].

To our knowledge, there is a lack of research concerning the relationship between cognitive development and children's perceptions and preferences for fruit and vegetables in particular. As their beliefs, thoughts, motivations and reasoning may differ, it is possible that children of different cognitive stages need different strategies to change their perceptions, preferences and behaviour regarding fruit and vegetables. Understanding the cognitive level of children may be a critical step in the design of appropriate intervention strategies that promote health and prevent disease in children [63].

In summary, children move along various cognitive stages when growing up. Cognitive development has scarcely been applied into the nutrition research area. Because children from different cognitive stages have different thoughts, attention abilities, reasoning, categorization capacities, food rejection categories and decision making strategies, this may influence their eating experiences and behaviour. It is unclear how these aspects of cognitive development are related to children perceptions and preferences regarding fruit and vegetables, and how we can change these perceptions and preferences in an effective and cognitive appropriate way. By taking cognitive development into account, we may be able to develop age-specific strategies for increasing children's fruit and vegetable intake.

Role of parents

Parents have a tremendous influence on children's food consumption patterns [40, 64-69]. Not only do parents provide genes, they largely make up the social and physical environment of the child's eating behaviour. Until now, most interventions have been school-based, with relatively low parental involvement. Effects were moderate and often short-term. In addition, Dutch children consume their vegetables habitually at home. It is therefore important to focus on parents

when trying to increase children's fruit and vegetable intake.

Parents make various conscious and unconscious decisions which influence their child's eating behaviour. The first decision parents make is about the type of infant feeding, thereby influencing the early flavour experiences of the child [70, 71]. Furthermore, parents decide which foods become available and accessible to the child, how foods are prepared, in what quantities and when they are consumed [40, 68, 72, 73]. Moreover, parents' own food related behaviour influences the eating behaviour of their child through modelling [38, 40, 65, 72, 73]. In addition, via the food socialisation process, parents transmit their knowledge, attitudes and beliefs to their child [65, 69, 74]. Finally, parents can apply specific practices to guide and control the child's eating behaviour [40, 67, 73, 75], such as restriction, pressuring, giving health information, using rewards and bribery.

Some practices or strategies that parents use with best intentions are counterproductive; the effect on their child's eating behaviour is opposite to that intended [67, 69, 76-79]. On the other hand, strategies that are effective, are not always employed or are not used effectively [69, 80, 81]. Many parents are eager to encourage healthy eating in their children, but they may become in conflict as they also want to have pleasant and peaceful meals [69, 79, 82]. It is therefore important to distinguish beneficial parental strategies from unhelpful behaviour. However, the literature is not always conclusive about the effects of parental strategies on eating behaviour [38, 83] and the specific mechanisms are not always clear [84].

Previous research has mainly focused on understanding the effects of controlling practices, such as restriction and pressure, on children's fruit and vegetable intake [38, 73]. Both practices can have counterproductive effects [38, 73]. Less is known about what other strategies parents apply to encourage fruit and vegetable intake in their child. In addition, fruit and vegetables are often studied as one food group [37, 85-87], whereas they vary considerably in taste, energy content and moment of consumption.

In summary, parents can use specific strategies with the intention to encourage healthy eating in their children. However, these strategies may work counterproductive. It is unclear which parental strategies are used for fruit and vegetables in particular, whether there are differences between fruit and vegetables and whether these strategies encourage or discourage children's fruit or vegetable preferences and intake.

Development of food preferences

Since food preferences are an important determinant of children's food intake, it is essential to know how food preferences are acquired and how they can be changed. Human infants are born with a few innate taste preferences. They show a positive hedonic response to sweet, whereas the response to sour and

bitter is negative [88, 89]. In addition, humans have a tendency to reject new foods, a phenomenon that is called neophobia. There are large individual differences as well as large situational differences in the extent to which neophobia occurs [90]. Neophobia is low in very young children and there is a peak between the age of 2 to 5 years [90-92].

Besides the innate taste preferences and neophobia, most food preferences are learned. The central principle for acquiring food preferences is conditioning [93-96]. In the conditioning process, an association is established between the flavour of a food and 1) the atmosphere of eating i.e. social learning; 2) a familiar and liked flavour i.e. flavour-flavour learning; or 3) the post-ingestive consequences i.e. flavour-nutrient learning.

Flavour-nutrient learning can increase liking for high-energy foods through the association between the flavour of the food and the pleasantly satiating effects of fat or carbohydrates. Evidence for this learning principle is strongest in children [97-99]. Negative post-ingestive consequences, such as nausea, serve as a strong cue and lead to robust food aversions [93, 95]. During flavour-flavour learning, often a sweet taste is repeatedly paired with an initially neutral or disliked flavour, leading to an increase in liking for this neutral or disliked flavour. Flavour-flavour learning has been proved to be effective in increasing liking for specific tastes, as well as for specific foods [93, 100, 101]. Finally, social learning occurs when positive or negative contexts in itself become associated with the food eaten, resulting in an increased or decreased preference [78, 102, 103]. Just observing the association between the food and the social affective context in others can be enough to increase or decrease liking [104, 105]. This is one of the aspects that occurs during role modelling, where the behaviour of the model serves as a stimulus for similar behaviour in the child [87, 106-108].

Repeated exposure influences the development of food preferences as well [81, 109]. This principle is called 'mere exposure' [110]. Research has shown that 5 to 10 exposures to the food are required to increase liking [109, 111]. Real tasting is necessary, only observing the food is not enough [112]. This principle occurs already early in life. Via amnion fluid or breast milk, foetuses and young babies are exposed to a variety of flavours coming from the mothers diet [70, 71, 113].

How can we use these abovementioned principles to understand children's current fruit and vegetable preferences? Two properties of vegetables may explain why vegetables are among the least liked foods of children [114-116]: vegetables are often bitter and vegetables are low in energy, which makes flavour-nutrient learning hardly possible. In contrast, many fruits have the appealing property of sweetness and are therefore better appreciated by children than vegetables [33, 43, 114, 117, 118]. Early experiences with fruit and vegetable flavours via amnion fluid and

breast milk seem to facilitate fruit and vegetable acceptance patterns later in life [36, 111, 113, 119, 120]. Furthermore, high levels of food neophobia have been related to lower fruit and vegetable preferences [121] and intakes [36, 122] in children. Although flavour-nutrient learning has been applied effectively to increase preference for fruity and nutty flavours [97, 99], this principle has never been applied to vegetable flavours.

In summary, children's food preferences are formed through a few inborn taste preferences and mostly via learning processes, such as mere exposure and conditioning. As a result, children's preferences for vegetables are generally low, whereas fruit is better accepted. It is unclear whether flavour-nutrient learning is effective in increasing children's preference for vegetables.

Measuring food preferences

In order to change children's fruit and vegetable intake via their preferences, an accurate and valid method is needed to assess (small) changes in their preferences.

A well-accepted and often used method to assess children's food preferences is Birch's preference rank-order procedure [21, 102, 123]. During this two-stage procedure, children first use three smiley faces to make a classification in 'like', 'just ok/neutral' and 'dislike'. Second, the child is asked to indicate the best liked product within the 'like' category. This product is removed and the child is asked to indicate the best liked product of the remainders in the like category. This is repeated for all products in the like category, and for the 'just ok/neutral' and 'dislike' categories, resulting in a complete preference rank-order (1=*best liked*). This method shows good discrimination and is related to children's food selection behaviour [123].

An alternative procedure, which can be used when many products are involved, is a 5-point smiley scale ranging from 1=*dislike a lot* to 5=*like a lot* [124, 125]. This format has been used successfully in other studies with children [114, 124].

However, both these child-friendly methods rely on the memory, knowledge and cognitive capacities of the child. The capacities of young children are limited regarding attention span, linguistic skills, serialization, memory, taking multiple attributes into account, logical thinking, concept understanding, and task comprehension [124, 126-129]. Therefore, it would be useful to have a method that is independent of children's cognitive capacities.

In summary, a widely accepted method to measure children's food preferences is Birch's preference rank-order method. An alternative method is the 5-point smiley scale. However, it would be valuable to have a method that is independent of children's cognitive skills.

Rationale and thesis outline

Despite the health benefits, children's fruit and vegetable consumption is below that recommended. Attempts to increase children's fruit and vegetable intake have resulted in relatively small and short-term effects. Therefore, new approaches are needed to increase children's fruit and vegetable consumption. Since children's level of cognitive development has mainly been disregarded when studying children's fruit and vegetable preferences and intake, taking this into account is one approach to develop new, relevant and meaningful strategies. In addition, despite the fact that parents play an important role in children's eating behaviour, most intervention programmes have been school-based and parental involvement has been low. Therefore, we focus on parents as a second approach. It is unclear which strategies parents use for encouraging fruit and vegetable intake and which strategies are beneficial or detrimental for children's fruit and vegetable intake. Thirdly, food-related factors have received minor attention when trying to increase children's fruit and vegetable intake, whereas these factors play an important role in children's liking and disliking for fruit and vegetables.

Taking together, the overall aim of this thesis is: *To develop age-specific strategies to encourage fruit and vegetable intake in 4 to 12-year-old children*. Since preference is a crucial determinant of children's fruit and vegetable consumption, many studies described in this thesis focus on increasing preferences, as an effective way to increase children's intake. Figure 1.2 gives an overview of the empirical chapters of this PhD thesis.

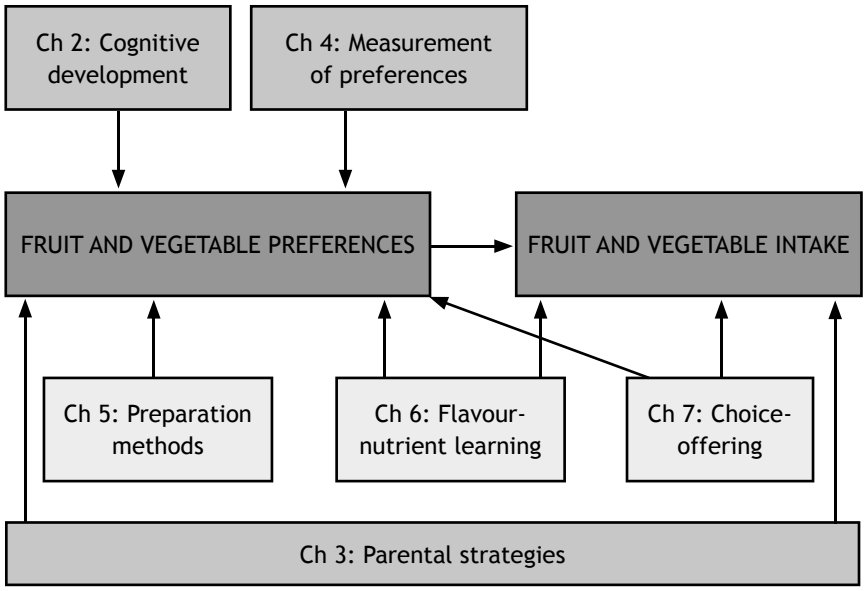

Figure 1.2 Schematic overview of the empirical chapters in this PhD thesis.

The studies in the first three empirical chapters are observational, aiming to gain more insight into the perceptions and experiences of Dutch children concerning fruit and vegetables. The objective of these observational studies is to reveal cognitive developmental characteristics relevant for altering children's fruit and vegetable intake (Chapter 2), particular parental strategies (Chapter 3) and suitable, accurate measurement methods (Chapter 4) that are promising for application in future intervention programmes. Three groups of children from different developmental stages have been studied: 4-5-year-old, 7-8-year-old and 11-12-year-old children. The specific research objectives were:

- To explore the relationship between cognitive development and children's preferences and perceptions regarding fruit and vegetables (Chapter 2).
- To investigate which strategies Dutch parents use to stimulate their children to eat fruit or vegetables (Chapter 3).
- To examine how these strategies are related to children's fruit or vegetable preferences and intake, with the aim to reveal strategies that have the potential to increase children's fruit and vegetable intake (Chapter 3).
- To study the accurateness and suitability of facial expressions as a new method for assessing children's food preferences (Chapter 4).

The results of these three observational studies have formed the basis for the other three empirical chapters. Because intervention programmes have been less effective for vegetables than for fruit and children have low vegetable preferences, these three studies focused on vegetables only. Three intervention studies were designed to encourage children's vegetable preferences and intake. The starting point for these interventions was to focus on strategies that are easily applicable by parents at home. The objective was to make vegetables more attractive from a sensory perception point of view (Chapter 5), from a physiological point of view (Chapter 6) and from a psychological point of view (Chapter 7). In chapter 6 and 7, known and effective methods for increasing preferences have been applied to vegetables for the first time. The specific research objectives were:

- To study the effect of different preparation methods on children's liking for vegetables in different age groups (Chapter 5).
- To examine drivers of vegetable liking (Chapter 5).
- To investigate whether flavour-nutrient learning is an effective mechanism to increase children's vegetable preferences (Chapter 6).

- To investigate whether vegetable liking and consumption can be increased by providing children with a choice during vegetable eating, thereby stimulating their feelings of self-control, autonomy and motivation (Chapter 7).

In the final chapter (Chapter 8), the main findings, the methodological considerations and the implications of our findings are discussed. In addition, suggestions for future research and recommendations for public health are provided.

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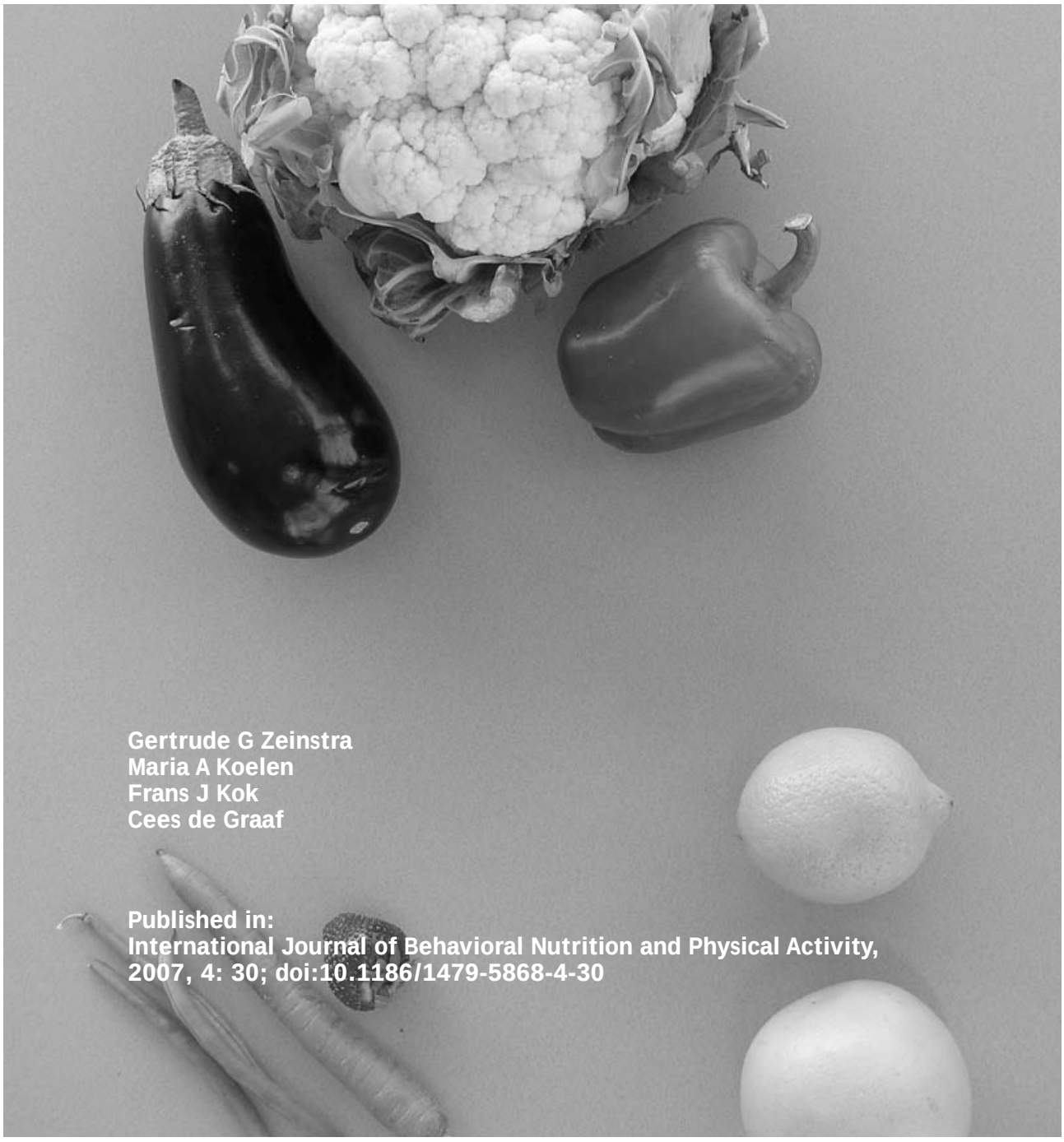
Cognitive development and children's perceptions of fruit and vegetables; a qualitative study



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2

ABSTRACT

Background: Most children do not meet the recommended guidelines for fruit and vegetable intake. Since preference is an important predictor of intake, more knowledge is needed about children's preferences and about how these preferences develop. As most research about preferences has ignored cognitive development, this study was designed to explore the relation between children's perceptions and preferences for fruit and vegetables and their cognitive development.

Methods: The study population consisted of eight 4-5-year-old children, eight 7-8-year-old children and twelve 11-12-year-old children, recruited via a primary school in Wageningen, The Netherlands. Qualitative in-depth information was obtained by duo-interviews and focus group discussions. A structured guide with questions and game tasks was applied to address different domains in a consistent way.

Results: The developmental progress at the abstraction level was seen in children's reasoning across all domains. Children's preferences expanded and increased in complexity as they moved to a higher age bracket. The most important determinants for liking and disliking shifted from appearance and texture attributes in 4-5-year olds towards taste attributes in 11-12-year olds. Children's knowledge of basic tastes increased. Their understanding of health improved as they grew older. The emergence of social norms and perspectives of others as the children grew older was also seen in relation to fruit and vegetables. Child-reported parental strategies to stimulate healthy eating appeared to vary with age in line with cognitive development.

Conclusion: Cognitive development is paralleled by changes in the importance given to the attributes that determine whether a child likes or dislikes fruits and vegetables; children's understanding of and reasoning about health; and parental use of strategies. These developmental differences should be incorporated in programs designed to increase long-term fruit and vegetable intake in children.

INTRODUCTION

The beneficial effects of eating fruit and vegetables are widely acknowledged [1, 2]. However, many children do not meet the recommended guidelines for fruit and vegetable intake [3-5]. The Dutch recommendations for 4 to 12-year-old children of 150 grams of vegetables and two pieces (≈200 gram) of fruit, are in line with international guidelines [6]. Because food preferences and eating habits established in childhood often persist into adulthood, children are an appropriate group to target in order to positively influence dietary habits [7-9].

In recent years, several studies and programs have been set up to increase fruit and vegetable intake in children [10, 11]. Positive changes have been found in knowledge, self-efficacy, skills, awareness, liking and intake. However, real, long-term successes have been difficult to establish [10, 11]. To our knowledge, there is one recent study that did show long-term effects of a one-year free school fruit programme on children's fruit and vegetable consumption [12].

Preference is an important predictor of children's food intake [8, 13-15]. For vegetables in particular, children's preference is low [15-18]. Therefore, to stimulate fruit and vegetable consumption among children, more should be known about their preferences, how these develop and how they can be influenced.

Most research about children's preferences does not take the possible role of children's cognitive development into account. Cognitive development represents 'the sequence of changes that occur to the cognition of a person as they mature' [19]. Cognition refers to 'the mental processes responsible for perception, attention, learning, memory, thought and communication' [20]. The aim of this study is to explore the relation between children's cognitive development and their perceptions of, and preferences for, fruit and vegetables.

Cognitive development and nutrition behaviour

Jean Piaget developed a cognitive development model with four successive stages: sensory motor period (0-2 years), pre-operational stage (2-7 years), concrete operational stage (7-11 years) and the formal operational stage (11-15 years). Along these stages, children's thinking changes from concrete to abstract, they develop the ability to replace overt actions by mental representations, egocentrism and centration diminishes, children develop more eye for detail, their information processing capacities increase, and their problem solving becomes more and more advanced [21-24].

For our study, we selected three age categories to study a broad range of cognitive development: 4-5-year-old, 7-8-year-old and 11-12-year-old children. Table 2.1 summarizes the cognitive developmental differences between the three age groups.

Table 2.1 Overview of general and nutrition related cognitive characteristics of children

Pre-operational stage	Concrete operational stage	Formal operational stage
Limited information processors	Cued processors	Strategic processors
Egocentric	Aware of perspective of another	Able to consider different perspectives
Focused on one attractive external characteristic	Focused on two or more functional and underlying attributes	Focused on multiple functional and underlying attributes
Decisions based on salient perceptual attributes	Decisions more flexible and thoughtful	Decisions more strategic
Do not consider transformations	See intermediary processes	Eye for detail
Concrete thinking	Thinking more logical, but concrete	Abstract thinking
Pre-logical thinking	First type of causality thinking	Logical reasoning
No distinction between foods and snacks	Distinction between foods and snacks	[a]
Ingested foods not changed in stomach	Ingested foods are changed somehow in the stomach	[a]
Can mention healthy foods, but not explain why it is healthy	Healthy foods make you strong, healthy and grow (do not know how)	[a]
Brand preferences based on perceptual and affective attributes	Brand preferences based on cognitive attributes	[a]
Rejection based on distaste, danger or ideational	Rejection based on distaste, danger, disgust or inappropriateness	Rejection based on distaste, danger, disgust or inappropriateness
No idea of contamination	Basic idea of contamination	Full adult idea of contamination

[a] No data available for this age group; these studies did focus on children in the pre-operational and concrete operational stage

A few studies in the area of nutrition behaviour have taken cognitive development into account. Contento's [25] investigation about how children think about food and eating revealed that children in the pre-operational stage did not make a distinction between foods and snacks, whereas children in the concrete operational stage did. Pre-operational children believed that the ingested food went into the stomach and did not change in the body. Concrete operational children understood that food was changed somehow in the stomach. Pre-operational children could mention foods that were healthy, but they could

not explain why. Concrete operational children could tell that food made you strong, healthy and made you grow, but they could not explain why or how this occurred.

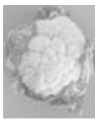
Bahn [26] studied brand preferences and brand discriminations. Affectively based attributes, such as liking the taste or liking the colour of the package, were dominant in pre-operational and concrete operational children when they were distinguishing brands. Regarding preferences, concrete operational children focussed more on cognitively based attributes, such as healthiness and adultness, than pre-operational children.

It is interesting to note Rozin et al.'s perspective in this context. They showed that there is a gradual emergence of different categories of food rejections as the child matures [27, 28]. Very young children of 1 to 2½ years old accept almost all kind of edible and inedible substances. The first rejection category to appear is distaste; disliked products are rejected. Secondly, rejections based on danger appear. This means that products are rejected because negative consequences of ingestion are expected. The third rejection category is based on the idea of what something is or where it comes from (ideational). This category can be split into disgust, and inappropriateness. Disgust means that the association with the food product is averse, whereas inappropriateness means that the food product is not considered to be a food. It is not until the age of 7 that children differentiate between disgust and inappropriateness. The idea of contamination appears gradually between the ages of 3½ years and 12 years. A food is contaminated when even a trace amount of a disgusting or inappropriate product has been or is present in the food [27, 28]. This development of rejection is in line with the development of the child. Between the ages of 2 and 7, children become more independent eaters and they have to learn which foods are edible and which foods are not [21, 28].

The nutrition studies above show that children in distinct cognitive stages think, decide and perceive food topics differently. The ideas children have about specific foods can influence their preferences, their willingness to taste and their whole eating experience [29]. Consequently, these different thoughts, perceptions and decision strategies may significantly impact on interventions aimed at changing food preferences and intake. Because most current approaches have not been effective in establishing long-term changes in fruit and vegetable consumption, cognitive development may be a promising field for achieving such changes; new approaches that are appropriate with regard to cognitive development will correspond closely with the children's natural development. In this study, we explored how the differences in cognitive development relate to children's perceptions of, and preferences for, fruit and vegetables. On the basis of the cognitive development theories, we expect that the number of cognitions

about fruit and vegetables will increase as children grow up and that these cognitions will increase in complexity and abstraction.

METHODS



Participants

Participants were recruited via a primary school in Wageningen, The Netherlands. Three age groups were included in the study, each age group representing a different stage of cognitive development: 4-5-year-old children (pre-operational stage: group A), 7-8-year-old children (concrete operational stage: group B) and 11-12-year-old children (formal operational stage: group C). The age groups correspond to the first, fourth and last grade of primary school in The Netherlands.

In group A, the two youngest and two oldest boys and the two youngest and two oldest girls who had permission to participate joined the study. In group B, four boys and four girls were selected by lottery. In group C, three groups were formed: one group of four girls, one group of four boys and a mixed group of two boys and two girls. The principal of the school and the parents of the children provided their informed consent.

Qualitative research

Because little is known about the relation between cognitive development and children's preferences, a qualitative approach was used to gain more insight and understanding about this relationship [30, 31]. Qualitative research provides the opportunity to explore new topics and directions; thereby using the respondents' own words to give meaning to their world [30].

In our study, we used focus group interviews for group C children. The purpose of a focus group is to elicit respondents' personal perceptions of a defined area of interest through carefully planned, semi-structured discussions [32]. Respondents can react and build upon other members' responses, and this in turn leads to more thoughtful and in-depth information [31, 33, 34]. In addition, it is possible to ask follow-up questions for clarification [31]. Focus groups are especially valuable for obtaining data from children [31-33].

Duo-interviews were held with the younger children in groups A and B. Children of this age need more assistance and have fewer communication skills. That is why duo-interviews are often used for this age group in market research [35]. Two children of the same sex and same age are interviewed together. Advantages are that the situation for the children is more natural and less scary than if they were alone, they speak more freely when they are with a child of the same age and same sex, and the attention of the interviewer is not all the time

on one child. When the children know each other, there is another advantage: the children can point each other to untrue statements. The children can build upon each other's responses, but do not have to process responses of many other group members. Although the children can interfere with each other, we expected that the advantages of this method would compensate for the disadvantage of interference. Besides, care was taken to prevent dominant children from biasing the results: the moderator used different questioning strategies to include all participants' opinions and, if there was a dominant child in the group, the moderator took care to invite the less dominant child to give his or her opinion before the dominant child.

Procedure

In May and June 2005, three focus group sessions (four children in each) were held with group C. Each session took approximately 90 minutes. In group B, four duo-interviews were held, each lasting approximately 75 minutes. All four duo-interviews in group A took about 60 minutes. Because young children have a short attention span, the 4-year-old children were interviewed twice, for half an hour each time, on two different days. The interviews were held in a separate, quiet room at school during lessons with no parents or teacher present. All interviews were recorded and video taped. A research assistant was present to take notes, keep track of the time, record non-verbal information and control the video and sound recording. On finishing the conversation, each participant received a small present.

Question route

As advised by Morrison-Beedy et al. [34] for multiple group comparison, a structured interview guide was devised to ensure consistency in data collection. This guide was applied in the focus group discussions as well as in the duo-interviews and ensured a proper introduction, which is very important to make the children feel at ease. The rules of conversation were explained to them, as well as confidentiality, anonymity, recording of the sessions, and the fact that there are no wrong answers [21, 34].

In addition to questions, game tasks and fruit tasting were included, to get richer information and to keep the children concentrating. Health was the final topic introduced during the conversations to prevent the children from focussing on health during the whole interview. An expert in child interviewing checked the interview guide and made suggestions for improvement. The guide was pilot tested on three children aged 5-6 years. Improvements were made to ensure that the questions and game tasks were clear and understandable.

To get a better understanding of children's preferences and their perceptions,

thoughts, learning and communication about fruit and vegetables, diverse topics were addressed during the conversations: spontaneously probed preferences and dislikes, attributes leading to liking and disliking, categorization of fruit and vegetables, tasting fruits, healthy eating strategies, appropriate eating situations for fruit and vegetables, free associations and the concept of health. To make it easier and concrete for the children, various real fruits and vegetables were brought to the sessions. Picture cards were used to assist the children in pointing out appropriate eating times and occasions (six eating times: breakfast, morning break, lunch, afternoon, dinner and evening + six occasions: home, school, party, sport, being with friends and TV/computer). Seven fruits were chosen for tasting. We included fruits that varied widely in their taste, appearance, frequency of use and familiarity: strawberry, apple, mango, papaya, kiwi, grapefruit and lemon. Six vegetables were chosen based on the same arguments, but these were not tasted: carrot, cauliflower, egg plant, red peppers, French beans and chicory. The question route can be found in Table 2.2.

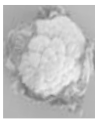


Table 2.2 Question route

Spontaneously probed (dis)likes	"If you think about food, what do you like best in the world?" "If you think about food, what do you think is the worst food in the world?"
Attributes responsible for (dis)liking	"What is it that makes this product so nice/awful?"
Categorization of fruit & vegetables	The children were invited to group the 15 fruit and vegetable products according to their opinion. They could choose how many groups they wanted to make.
Tasting seven pieces of fruit	The children were asked to taste the fruit pieces (in random order) and to tell what they liked or disliked about it. The characteristics of the product were also discussed.
Healthy eating strategies	"If you are served a food that you do not like, what happens then?" "What do your parents say about fruits/vegetables?"
Appropriate eating situations	"Which picture depicts the most appropriate moment for eating fruit/vegetables?" "Which picture depicts the most appropriate occasion to eat fruit/vegetables?"
Free associations	Associations and images for fruit and vegetables were explored by questions, free associations and game tasks about coolness, boringness, and appropriate target population for fruit and vegetables.
Concept of health	"Can you explain what health means?" Then the children were shown five pictures of products: grapes, leek, French fries, tart and candies. For each product they were asked: "Do you think this product is healthful?" "Why do you think that it is healthful/not healthful?"

Data analysis

The recorded interviews were transcribed by the interviewer and the assistants. The interviewer checked the transcript with the video records, in order to add non-verbal information. We developed a coding framework based on the research aims, the interview guide and findings in the literature. The qualitative data analysis package N6 from QRS International (version 2002) was used to code and organise the data systematically. Significant statements were coded with a label and corresponding statements were coded with the same label. Based on the children's statements, we chose an appropriate term for each label to summarize the statements within a category. This organisation of data into different categories and sub-categories assisted a more effective comparison of the groups.

Initially, data analysis was carried out by the first author, who was physically present in the room when the duo-interviews and focus groups were conducted, as is advised by Krueger and Casey [32]. First, the data within an age category were analysed. Subsequently, the data of the three age groups were compared thoroughly to detect patterns and find similarities and differences. In discussion sessions with all authors of the manuscript, the results of the analyses were repeatedly and thoroughly discussed. In addition, the results were presented and discussed with other researchers and with external experts in the field of research with children and taste, to check interpretations and conclusions. Key concepts and patterns are discussed below.

RESULTS

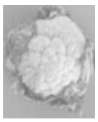
Preferences, dislikes and attributes leading to liking and disliking

Table 2.3 summarizes children's spontaneously mentioned preferences and dislikes. The results show that children's preferences and dislikes expand as they grow up. Group A spontaneously mentioned soft, high-energy foods, such as pancakes and French fries, and sweet fruits as their most preferred food. Group B mentioned composite dishes and meat, besides soft, high-energy foods and fruits. Composite dishes are food dishes with various ingredients, such as pizza or vegetable pie. Spontaneously mentioned favourite foods of many children in group C were composite dishes with vegetables as the principle component. The other preferred foods were comparable to groups A and B.

When asked about the food they disliked most, almost all children spontaneously mentioned a vegetable. Group A referred to bitter vegetables, such as Brussels sprouts, spinach and chicory. In group B, children indicated also vegetables with a more bland taste, French beans for example. Children in group C mentioned bitter, sour and bland tasting vegetables as their least favourite foods.

Table 2.3 Preferred and disliked food groups together with the top 3 of most often mentioned attribute categories based on the children's reasons for liking and disliking

	4-5 years	7-8 years	11-12 years
Preferences	Soft, high-energy foods Fruit	Composed dishes Soft, high-energy foods Fruit	Vegetable dishes Composed dishes Soft, high-energy foods Fruit
Dislikes	Bitter vegetables	Bitter vegetables Bland vegetables	Bitter vegetables Sour vegetables Bland vegetables
Basis for liking	1. Texture 2. Taste 3. Preference	1. Texture 2. Taste 3. Sweetness 3. Sourness	1. Taste 2. Texture 3. Preference for topping
Basis for disliking	1. Texture 2. Taste 3. Appearance	1. Taste 2. Sourness 3. Texture	1. Sourness 2. Bitterness 3. Negative (expected) experiences



In Table 2.3, also the reasons for liking and disliking provided by the three age groups are summarized. The most important attributes for liking in group A were based on texture, taste and preference ("I just like it"). Additional reasons for liking in group B were based on more specific tastes: sweetness and sourness. Preference based reasons were mentioned less often than in group A. *Familiarity of the taste* and *liking everything about the product* were new reasons compared to group A. The most important reason for liking in group C was a good taste, followed by texture and preference for topping (For example: the sauce on cauliflower). Some children said they liked saltiness or bitterness. These attributes did not come out in groups A and B.

Important reasons for disliking in group A were based on texture, taste and appearance. Reasons for disliking in group B were derived from taste in general, followed by sourness and texture. Disliking in group C was founded on specific tastes such as sourness and bitterness and negative (expected) experiences (For example: "It makes me feel sick" or "It feels like spittle").

Perception of fruit and vegetables

When the children were asked to make groups of different fruit and vegetable products, the youngest children made groups based on concrete characteristics: colour and shape. For example, the lemon and grapefruit were put together, because they are both yellow. A few children in group B based their categorization

on concrete characteristics as well. The others used abstract characteristics: a liking dimension or the dimension fruit versus vegetables. All children in group C used abstract characteristics to categorize the products: 'liking' or 'fruit versus vegetables' or 'a mixed dimension', which included frequency of use combined with liking or with fruit versus vegetables.

When the children were asked to explain whether fruits or vegetables were appropriate for adults and/or for children, different perspectives were found. Groups B and C considered fruit to be appropriate for adults as well as for children. Children in group A, however, made a distinction between tasty and non-tasty products. They mentioned that tasty fruits or vegetables were for both children and adults. Non-tasty products were considered appropriate only for adults. Groups A and B mentioned their own preference and physical growth ("Helps you grow") as arguments for making the distinction between adult and child food. Healthfulness ("It is healthy") and social norm arguments ("Everybody eats it") emerged in groups B and C.

Knowledge of tastes

The older the children were, the more comprehensive was their understanding of the basic tastes. Children in group A used salty in the correct way. They did not know what bitter was. Although the children had some understanding of the tastes sour and sweet, they had difficulties in labelling the products with these terms. Many children in groups A and B labelled a lemon as sweet. In group B, sourness was used in the correct way, and a few children were familiar with the term bitter. It was not until group C that the children used salt, sour, sweet and bitter in the correct way.

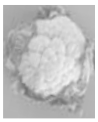
Associations and images

To find out whether the image of fruit and vegetables is a barrier to consumption, children were asked whether fruit and vegetable products were cool or boring. These terms were difficult for group A. Groups B and C stated that these terms were not really appropriate terms: fruit and vegetables are neither cool nor boring.

It was surprising to see that the younger the child, the more enthusiastic and happy the child was when it saw a highly liked product, such as strawberries for most children. Free associations for fruit and vegetables were quite difficult for the children. With increasing age, children made more abstract and functional associations.

Appropriate times and occasions

Children's ideas about appropriate eating situations for fruit and vegetables are shown in Table 2.4. All groups considered lunch and the afternoon as appropriate times for eating fruit. Strawberries were the only type of fruit thought to go well with breakfast. Group B mentioned that fruit as a dessert after dinner was possible. Only group C considered the evening as a possible time for eating fruit. When asked about an appropriate time for vegetables, children of all ages agreed that dinner was the right time.



All age groups associated the home environment with eating fruit. Only group A associated eating fruit with school and a party. In group B, half of the children agreed that sport and being with friends were appropriate occasions for fruit, besides home. This was similar to group C, but at this age half of the children also saw the computer/TV as a good occasion for eating fruit. Group C stated that fruit and vegetables were too healthy for a party. A party was associated with eating candy and other 'unhealthy stuff'.

Table 2.4 Summary of children's statements about appropriate fruit- and vegetable-eating situations and parental and child-invented healthy eating strategies

	4-5 years	7-8 years	11-12 years
Appropriate times for eating fruit	Fruit for lunch or afternoon Vegetables for dinner	Fruit in afternoon, for lunch or dinner dessert Vegetables for dinner	Fruit in afternoon, evening, lunch or when you feel like eating it Vegetables for dinner
Appropriate occasions for eating fruit	Home School Party	Home Being with friends [a] Sport [a]	Home Being with friends [a] Sport [a] TV/computer [a]
Arguments for appropriate times and occasions based on	Features of picture Own behaviour	Own behaviour Parental & school rules Busyness status Features of picture [a]	Own behaviour Social norm Availability Busyness status Function of fruit
Parental healthy eating strategies	Moderation Health arguments Instrumental rewarding Taste masking	Moderation Health arguments Taste Masking	Moderation Health arguments Parental cooking effort
Child-invented strategies to cope with vegetables	Not mentioned	Various strategies present	Various strategies present

[a] Stated by 50% of the children in this age group

The three age groups used different arguments when deciding on appropriate times or occasions. Group A relied on their own behaviour or on the features of the picture cards. Group B referred to their own behaviour, parental and school rules or the opportunity for eating. A few children used the features of the picture cards in their argumentation for appropriate times. In group C, social norms emerged in reasoning about appropriate times. The children took into account what they had seen their peers doing or not and they were aware of a general norm ("It is not common to do this"). In addition, they used arguments relating to their own behaviour, the availability of food, the (time) opportunity for eating and the functions of fruit (energy for example).

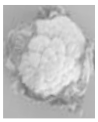
In summary, children of all ages had fixed ideas about appropriate times and occasions for eating fruit and vegetables. With increasing age, the children saw more opportunities for eating fruit. In addition, older children used a broader range of arguments and their arguments were more abstract.

Parent and child healthy eating strategies

The conversations made clear that almost all parents try to influence the eating behaviour of their child. The children were very well aware of the rules and strategies their parents apply in relation to eating. To promote healthy eating, parents in all age groups used 'moderation' and 'health' arguments. Moderation refers to children's statements where they indicated that the intake of some foods was restricted to certain times of the day or week. However, there were also differences found between the three age groups (see Table 2.4). In group A, instrumental eating was used more often than in the other age groups. Instrumental eating means that the children are promised a reward if they eat well [36]. Another often-used strategy was permission to use apple sauce in combination with disliked vegetables, which is a form of taste masking. This tactic was applied quite often in group B too. Children in this age group said that they invented their own ways of dealing with disliked products: they made vegetables very flat and added a lot of apple sauce or they ate ten very small bites, so they actually ate five normal bites. In group C, adding apple sauce was a less used strategy. In this age category, parents mentioned the effort they had put into cooking the vegetables as an argument to get the children to eat them. All children in group C had invented their own creative strategy to cope with eating disliked vegetables, such as squeezing their nose, finishing first the non-tasty food or adding ketchup to the vegetables.

Concept of health

A clear trend was seen for the concept of health. Young children could not describe health. The older the children, the more comprehensive and abstract the concept. Most of the 4-5-year olds could not categorize products correctly into healthy or not healthy. They used concrete and simple 'rules' to categorize products as healthy or not. The most popular justification rule was a food-colour link, such as "It's healthy, because it's green". This fits for the leek, but not for a green candy. Second and third most popular arguments were food-health links (food related to healthy food group such as "It is fruit and fruit is healthy") and preference links ("It's healthy, because I like it"). The other two age groups could correctly categorize products into healthy or not. In groups B and C, food-health and food-nutrient links (food classification linked to its provision of a specific nutrient such as "It is healthy, because it contains vitamin C") were most popular justification categories. Social influence ("Family says" or "Others say") and general knowledge ("I just know") were the third and fourth most often mentioned.



DISCUSSION

This study indicates that the stage of children's cognitive development plays a role in their preferences for, and perceptions of, fruit and vegetables. As children mature, their cognitions relating to fruit and vegetables increase in number and become more abstract.

Although cognitive development as a viewpoint from which to study fruit and vegetable *preferences* is new, our findings are not incompatible with previous research. Age related differences in preferences have been found in other studies [8, 37]. An interesting finding from our study was that cognitive development is related to the attributes children consider when evaluating products. Young children focus on appearance and texture, whereas older children focus on taste aspects. Rose et al. [38] found similar results with sensory preferences for meat. For 6-7-year-old children, mouth feel characteristics were most important for liking, whereas in 10-11-year olds taste and smell were most important. The diminished importance of textural attributes is possibly due to children's development of their teeth and jaws [29, 39]. Szczesniak [39] stated that texture would be especially important for disliking products, but in our study it was also the most important attribute for liking among the two youngest age groups.

Young children could tell whether they liked or disliked the taste of a product, but could not identify the specific taste. This finding is in line with the study of Liem et al. [40] where 4-year-old children could indicate which solution they preferred but failed to distinguish sweetness intensities during discrimination

tests. In our study, the 4-5-year-old children knew and could properly use the taste salt, but not the other basic tastes. Older children had an improved understanding of the four basic tastes and, consequently, were more specific about taste when talking about likes and dislikes.

A shift from appearance to more functional attributes was found in children's reasoning with regard to preferences, the appropriate situations to eat fruit and vegetables, and healthiness. In other studies, it has been found that pre-operational children focus on the most striking attributes that catch the eye, whereas older children use more functional and underlying attributes [23, 41].

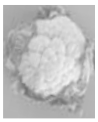
One aspect of cognitive development is an increase in the level of abstraction [21, 22]. This development was clearly seen in children's improved understanding of health and the basic tastes, the shift in categorization from concrete categories to abstract categories, the expansion of abstract associations, and more abstract arguments concerning healthiness. Furthermore, the arguments for appropriate occasions were very concrete in groups A and B, whereas this was not the case in group C. The reduction of egocentrism [21, 22] was reflected in the emergence of social norms and consideration of others' behaviour in the older age group in relation to their argumentation for appropriate eating times.

Roos [42] found that 9 to 11-year-old children could correctly identify which foods are considered healthy, a finding that is in line with ours. As in the findings of Hart et al. [43] among 7 to 11-year-old children, food-nutrient and food-health links were most often used in groups B and C as an explanation for the healthiness of a food. In our study, only pre-operational children mentioned preference links as an explanation for healthiness. This is in contrast to the findings of Hart et al. [43], where preference links were especially used by the older boys (10-11 years).

Parents play an important role in the nutrition behaviour of children [44-46]. Hart et al. [43] showed that parents used different rules depending on the age of the child. Food deals were more frequently reported by younger children (7-8 years) compared to older children (10-11 years). Although the age range is somewhat different, these findings are in agreement with our findings, where instrumental rewarding, which is comparable to a food deal, was used in respect of the youngest children but disappeared as children grow up. Probably, parents use instrumental rewarding, because it is a concrete strategy for the child ("If you eat your vegetables, you will get a candy"). The finding that parental effort is used as an argument in the oldest age group appears to fit their cognitive capacities. At this age, children are less egocentric [21, 22], they can see another's perspective [22, 23], and have a better understanding of value [23]. So children of this age can understand this argument. The strategies that children in group B invent to cope with eating vegetables reveal their emergent idea of conservation [22].

Limitations

Although a qualitative approach is the best method to explore a new topic, the limitations should be acknowledged. A small number of children participated in the conversations. Therefore it is not easy to generalize to a larger and broader population [31]. Further research is needed to confirm our findings.



Qualitative research is sometimes criticized for being low in both reliability and validity because of the subjective interpretation of results [31, 32]. Several different actions were taken in this study to ensure reliability and validity. We used accepted systematic procedures for data collection, data handling and data analysis. The fact that children were assured that there were no wrong answers and that we did not finish their responses for them supports validity [47]. As advised by Morrison-Beedy et al. [34], the conversations were discussed immediately afterwards by the moderator and research assistant. Major topics, confusing and conflicting data were discussed. The analyses and interpretations were thoroughly discussed with the co-authors, with other researchers and with experts in research with children and taste. In addition, the comparison of our results with other findings in the literature strengthens evidence [47]. We have been very careful with interpretation and are confident that the findings are an accurate reflection of what the children said.

Another limitation is that we did not measure cognitive development. It is true that children develop at different rates, and this can result in differences within an age group. However, on the basis of cognitive development theories, we are convinced that the differences in cognitive development between children of distinct age groups are larger than the differences between children within an age group. Besides, it would have been very impractical to measure the whole concept of cognitive development, as this is enormously time consuming and would have been a heavy burden for the children.

Practical implications and future research

A great advantage of our study method is that we found important practical implications and fruitful directions for future research that would have been missed with a quantitative approach. In our study, vegetables came out as least favourite food in all age groups. This barrier needs to be tackled in order to increase children's vegetable consumption. A promising finding was that fruits (especially apples and strawberries) were liked and that almost all children liked at least one vegetable. It was also positive that children considered fruit and vegetables as food for themselves as well as for adults; it would be a barrier if they perceived it only as adult food. It is often thought that fruits and vegetables are not cool enough for children. However, our study found that this did not play a role in children's consumption.

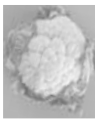
A reason often mentioned for eating fruits and vegetables at a particular time was "Because I eat it at that time". So if we teach children to have more fruit and vegetable eating times during the day, we could increase their intake. In our study, just a few children in group C associated fruit with the computer or TV. Because children spend many hours in front of the TV or computer nowadays [48], making this activity a fruit or vegetable eating time would be a first step towards improving children's diet.

In group C, it became apparent that the children did not think of cucumber and tomato as vegetables. When the research assistant mentioned that cucumber and tomato are also considered vegetables, then the children suddenly saw more time opportunities for eating vegetables: slices of tomato on bread during lunch or a piece of cucumber during the morning break at school. This finding could be very valuable in promoting vegetable intake by increasing the number of daily vegetable eating times.

In our study, older children were more specific about the preferred preparation of vegetables, and young children valued textural attributes and appearance more, whereas older children valued taste aspects more. Thus by using different preparation methods to match the right attributes to the desires of each specific age group, we might be able to change children's fruit and vegetable preferences and consequently their intake.

A very surprising finding in our study was that the youngest children argued that foods are healthy, because they taste nice. Research has shown that children associate healthy with distaste [49-51]. However, the age of the children in these studies was nine years and older, whereas the children in this group in our study were 4-5 years. It may be that young children associate healthy with tasty through the connecting term 'good'; tasty food is good and being healthy is also good. However, at a certain age point, there seems to emerge a differentiation: not all healthy foods taste good. It would be interesting to investigate at what age this negative change in association occurs and how this change comes about.

In concordance with Hart et al. [43], our results indicated that parents do not take many positive actions. The children should eat healthily, are restricted to specific foods and are often persuaded to eat fruit and vegetables because they are healthy. It is not clear whether parents did not apply more positive strategies or whether more positive strategies were just not reported by the children. If parents use many negative strategies for healthy products, then this may be a reason why children develop a negative taste association for these healthy foods [36]. Our study suggests that children's cognitive development influences the strategies that parents use to shape the eating behaviour of children. It would be very interesting to investigate this interaction between parents and children further, together with the effects of this interaction.



Conclusion

This study is the first step in understanding how cognitive development and preferences are interrelated. Differences in cognitive development are reflected in changes in attribute importance in relation to liking and disliking fruits and vegetables, in children's understanding of, and reasoning about, health, and in the child-reported parental use of strategies. Further research should focus on the role of parental strategies in their children's preferences and intake of fruit and vegetables, children's underlying reasons for liking and disliking in different age groups, and how the concept of health develops during childhood years. For optimal results in the long term, children's thoughts, perceptions, decision arguments and abstraction capacities should be taken into account in the development of interventions for promoting fruit and vegetable intake among children.

Authors' contributions

GGZ, MAK and CG contributed to the design of the study. GGZ coordinated and carried out the study in practice. GGZ was in charge of the transcription process and did the data analyses, with critical input from MAK, CG and FK. GGZ wrote the original draft and incorporated the comments on the manuscript from all other authors. All authors have read and approved the final manuscript.

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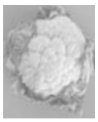

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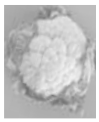
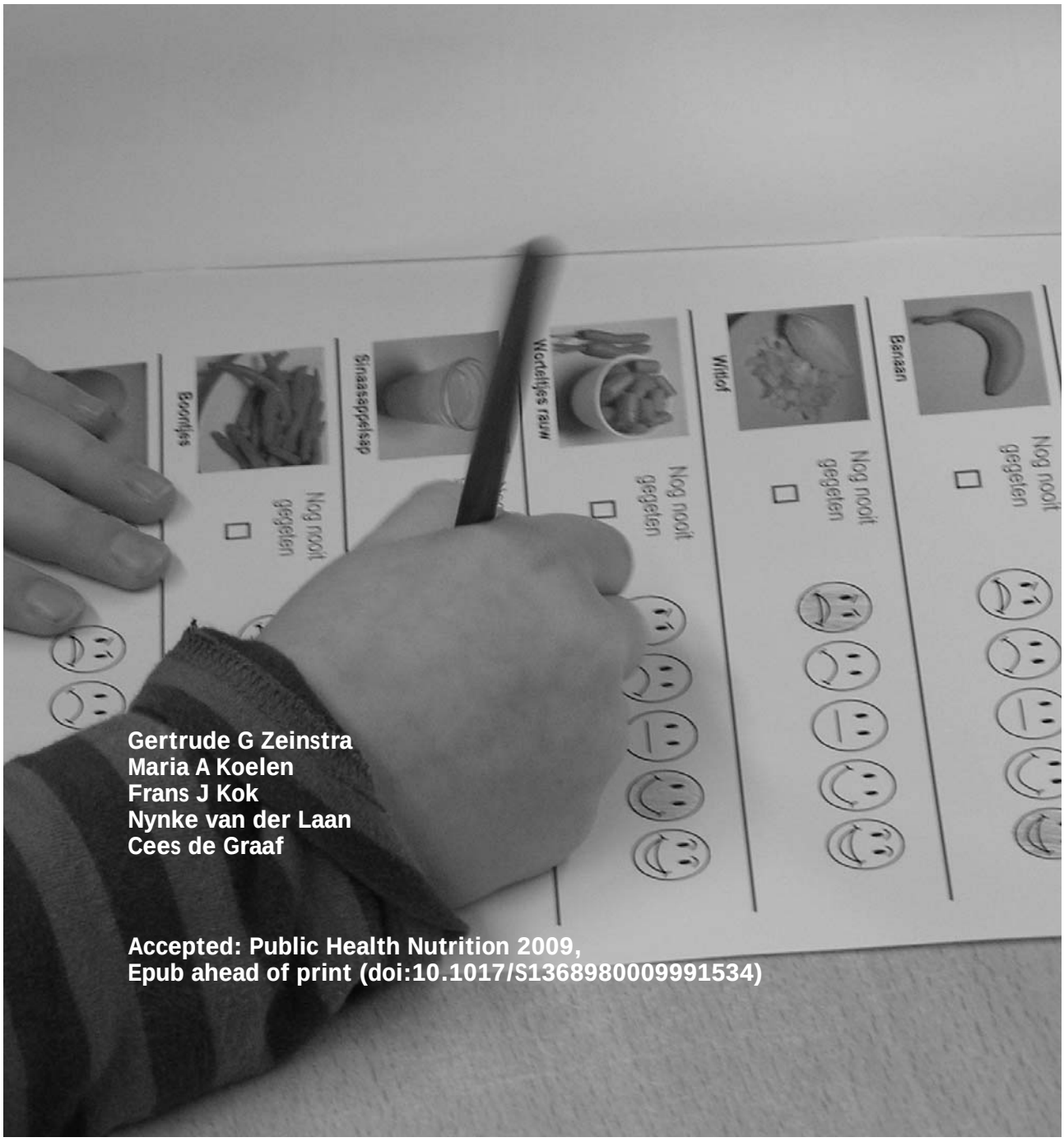


Parental child-feeding strategies in relation to Dutch children's fruit and vegetable intake



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ABSTRACT

Objective: To identify parental child-feeding strategies that may increase children's fruit or vegetable intake, since the relationship between these strategies and children's intake has never been investigated for fruit and vegetables as two separate food groups.

Design: A survey study, where parents provided information about their practices in relation to feeding their children and about their own and their children's fruit and vegetable intake. Children completed a preference questionnaire about fruit and vegetables. To find underlying parental child-feeding strategies, factor analysis was applied to parents' practices in relation to fruit and vegetables separately. Regression analysis was used to predict the effect of these strategies on children's fruit and vegetable intake. The impact of the strategies was further analysed by estimating children's intake based on the frequency of use of specific strategies.

Setting: The study was conducted at three primary schools in The Netherlands.

Subjects: A total of 259 children between 4 and 12 years and their parents (N=242).

Results: Parents used different strategies for fruit as compared to vegetables. The vegetable-eating context was more negative than the fruit-eating context. Parental intake and presenting the children with choice were positive predictors of children's intake of both fruit and vegetables. The intake difference based on frequency of use of the strategy 'Choice', was 40 grams/day for vegetables and 72 grams/day for fruit ($p<0.001$).

Conclusion: Future interventions should focus on presenting children with choice during fruit- and vegetable-eating situations, since this is a powerful strategy to stimulate children's fruit and vegetable intake.

INTRODUCTION

Parents play an important role in children's food intake: they make foods available and accessible for the child and they act as role models [1-4]. Parents also create the social eating environment by the use of parental child-feeding (PCF) strategies, such as rules, table food management and verbal instructions [1, 5, 6]. There is substantial evidence that such child-feeding strategies influence children's eating [5]. Although parents use these strategies with the best intentions, research has shown that the effects of these parental strategies on children's food intake are not always in the intended direction.

Modelling, mere exposure, verbally rewarding for eating, increasing availability and accessibility of food, and using foods as rewards for good behaviour are strategies that have proved effective in increasing intake of specific foods [2, 3, 6-10]. Restricting the intake of unhealthy food and giving health information about a product appear to foster an unhealthy eating pattern [11-14]. Pressuring a child to eat and offering rewards using instrumental eating ("If you eat your spinach, you will get a dessert") also decrease children's intake or preferences [9, 13, 15, 16]. However, the consequences of these strategies appear to be less straightforward, since pressure and reward may have positive effects under appropriate circumstances [17-20]. Offering unfamiliar foods with a familiar topping or providing the child with taste information can increase children's willingness to taste [21, 22].

The use and role of PCF strategies in relation to food consumption is usually studied with fruit and vegetables as one food category [2, 6, 23]. Since fruit and vegetables vary considerably in taste, energy content, and consumption moment, parents may use different strategies for fruit as compared to vegetables. Additionally, the relationship between parental strategies and children's intake may depend on whether fruit or vegetables are involved.

The aims of the present study were to: 1) investigate which PCF strategies Dutch parents use to stimulate their children to eat fruit or vegetables; 2) determine how frequently these strategies are used; and 3) examine the relationship between these strategies and children's intake of, and preference for, fruit and vegetables. Fruit and vegetables were analysed as two distinct food groups. We strove to reveal strategies that have the potential to increase primary school-aged children's fruit or vegetable intake.

METHODS

Subjects

Participants were recruited via three primary schools in three Dutch cities (Wageningen, Franeker and Zeewolde) in order to include participants from

various backgrounds. The participants consisted of children of varying ages to ensure that the whole range of primary school was included (4-5 years, 7-8 years and 11-12 years) and their parents. At each school, three classes participated in the study, one class per age group.

All parents of the participating classes (280) were invited to participate. Those children whose parents signed an informed consent form were included in the study. Two hundred and sixty parents (93%) signed the informed consent for themselves and their child/children and 242 parents (86%) returned the questionnaire. The response rate for the children was 93% (259 children).

Study design

The study protocol was approved by the Medical Ethical Committee of Wageningen University. Parents completed a booklet with questions about four topics: 1) their practices in relation to feeding fruit and vegetables to their children; 2) fruit and vegetable intake of the parent and child; 3) parental control practices; and 4) demographic variables. The parent most involved in family eating was requested to fill in the booklet. The children completed a preference questionnaire concerning fruit and vegetables.

Parent-reported variables

Parental child-feeding strategies

Various questions were asked about specific, practical behaviours that parents can apply to influence their children's food choice. These practical actions are defined as parental practices [24]. We use the term 'strategies' to indicate the more general concepts underlying the practices.

To our knowledge, there are no questionnaires available that focus on fruit or vegetables separately in a comprehensive way. Therefore, we developed a PCF strategies questionnaire on the basis of existing questionnaires [2, 18, 23-26]. One set of questions was adjusted for fruit-eating situations (35 practices) and another for vegetable-eating situations (40 practices). Four additional questions were included for vegetables with regard to adding sauces. Response categories were on a 5-point scale where 1=*never*, 2=*rarely*, 3=*sometimes*, 4=*often* and 5=*always*. The questionnaire was improved after a pre-test on 20 parents (not participants).

Fruit and vegetable intake

The eight-item food frequency questionnaire (FFQ) of Bogers et al. was used to determine fruit and vegetable intake of parents and children. This FFQ is validated in mothers aged 29-50 years with vitamin C and carotenoids as biomarkers [27], and has been used in further research to assess fruit and vegetable intake of parents and their children [28, 29]. Parents completed the questions for themselves and their child. They were asked to report their average intake frequency during

the previous month and their usual portion size. Standard portion sizes were used to calculate intake in grams [30].

Child Feeding Questionnaire

Parents completed the parental control sections of the Child Feeding Questionnaire (CFQ) [25]: 'Monitoring', 'Restriction' and 'Pressure to eat'. Questions were on a 5-point scale from 1=*disagree* to 5=*agree* or from 1=*never* to 5=*always*.

Demographic variables

Parents completed questions about their age, gender, educational level and the educational level of their partner.

Child-reported variables

Preference questionnaire

The questionnaire consisted of photographs of 24 products from five product categories: fruits, vegetables, fruit juices, neutral products and energy-dense products. There were eight fruit types, eight vegetable types and the two fruit juices most frequently consumed by Dutch children [31]. Carrots were included twice (raw and cooked), because both forms are frequently eaten and differ in liking [32]. To enable a comparison, three neutrally tasting products (potatoes, bread, and milk) and two energy-dense products (chocolate and French fries) were included.

The response format was a 5-point-smiley scale ranging from 1=*dislike a lot* to 5=*like a lot* along with the option *never tried*. This format has been used successfully in other studies with children [33, 34]. A pre-test with eight children (not participants) confirmed comprehensibility.

Procedures

Parents received the questionnaire booklet at home and returned the completed booklet to their child's teacher.

The child sessions were performed at school during regular school hours. To ensure consistency in the instructions during data collection, an instruction sheet was developed for these sessions.

The youngest children (4-5 years) were guided individually in a separate, quiet room. After practising the smiley scale, the researcher assisted the child with completing the preference questionnaire. The other two age groups completed the preference questionnaire in their own classroom following the instructions of the researchers, who were available for assistance. Each individual session and each classroom session took about 15 minutes.

Statistical analyses

All statistical analyses were performed with the SPSS statistical software package version 12.0.1 (SPSS Inc., Chicago, IL, USA). The child questionnaire and parental booklet had pre-assigned identical codes to link the child-parent couples. Three child-parent couples were excluded from the fruit analysis because the children were allergic to fruit. Children's mean preference scores were calculated for each of the five product categories.

When more than 20% of the parent-reported intake questions were missing, the subject received a missing value for intake of that category. When 20% or less were missing, 'frequency' and 'portion size' were replaced by the mean population value. This replacement procedure was applied for 25 parents (10%) and 17 children (7%) to calculate their fruit intake.

Exploratory principal component analysis (PCA) with varimax rotation was applied to the 40 PCF practices for vegetables and the 35 practices for fruit to find underlying PCF strategies. Factor loadings of 0.50 were assumed practically significant and an internal consistency (Cronbach's alpha) of 0.60 was considered sufficient for exploratory research [35]. In addition, the final factor structures were based largely on the interpretation of the factors. Factor values were calculated as the mean score of the items comprising the factor.

To investigate the predictive value of the different strategies on children's fruit and vegetable intake and preference, we performed a stepwise multiple regression analysis. To further analyse the impact of a particular strategy, tertiles were composed based on parental use of the particular strategy. For each tertile, children's fruit or vegetable intake was estimated. ANOVA with Bonferroni as post-hoc test was used to compare the tertiles.

Pearson correlation coefficients were calculated between 'Monitoring', 'Restriction', 'Pressure to eat' (CFQ) and the fruit and vegetable strategies specific to our study, in order to explore validity. Correlation coefficients above 0.25 were regarded as relevant.

For all analyses, a p-value ≤ 0.05 was considered significant.

RESULTS

Demographic characteristics

The demographic characteristics of the study population are shown in Table 3.1. Mainly mothers completed the parental booklet. Less educated parents were underrepresented. Children's participation rates were high for all three schools: Franeker 94% (107/114); Wageningen 97% (77/79); Zeewolde 86% (75/87).

Table 3.1 Demographic characteristics of the study population in which the association between parental child-feeding strategies and children's fruit and vegetable intake was studied (N=242 parents and 259 children)[a]

Characteristic	Category	N	(%)
School	Wageningen	77	30
	Franeker	107	41
	Zeewolde	75	29
Gender of child	Boy	132	51
	Girl	127	49
Age group	4-5 years	99	38
	7-8 years	84	32
	11-12 years	76	29
Gender of parent	Male	24	10
	Female	216	90
Educational level of parent	High	110	46
	Middle	114	48
	Low	15	6
Educational level of parent's partner	High	115	50
	Middle	86	38
	Low	27	12

[a] Due to missing data, totals can be lower than 242 or 259

Liking

Children's liking for vegetables (mean=3.1; SD=0.9) was the lowest, followed by the neutral product group (mean=3.8; SD=0.8). Preference for fruit (mean=4.0; SD=0.7) and fruit juice (mean=4.0; SD=1.0) was similar. The energy-dense products (chocolate and French fries) were the most appreciated by the children (mean=4.6; SD=0.6).

Factor analysis

The PCA on the PCF practices for vegetables yielded eight factors (R^2=52%, see Appendix 3.1). Six factors had an internal consistency acceptable for exploratory research (Cronbach's $\alpha > 0.60$; see Table 3.2) and were used for further analyses. Eleven of the 40 practices for vegetables were not included because ten did not load highly on any of the factors and one loaded moderately highly on two factors. We labelled the six acceptable PCF strategies for vegetables as: 'Positive information', 'Distraction', 'Choice', 'Negative atmosphere', 'Pressure' and 'Taste masking'.

The PCA on the PCF practices for fruit yielded five factors (R^2=44%, see Appendix 3.2). One factor did not have an acceptable internal consistency (α=0.54; see Table 3.2) and was therefore omitted from further analyses. Thirteen of the 35 items for fruit were not included since they did not load highly on any of the factors. The four acceptable factors for fruit were labelled as 'Negative atmosphere and Pressure', 'Positive information', 'Choice' and 'Availability'.

Although the PCF practices for both fruit and vegetables were almost identical in the questionnaire, factor analyses showed some differences in the underlying structure. 'Pressure' and 'Negative atmosphere' were separate PCF strategies for vegetables, whereas they belonged to one strategy for fruit. 'Availability' was an acceptable factor for fruit, whereas this strategy did not emerge as a separate factor for vegetables. 'Choice' for fruit seemed to focus on child participation, whereas for vegetables the focus was more on making a choice possible. For vegetables, 'Distraction' included instrumental eating and positive, playful practices; for fruit, this strategy was not reliable. The composition of the strategy 'Positive information' was exactly the same for fruit and vegetables.

The mean factor scores for each PCF strategy for fruit and vegetables are shown in Table 3.2. 'Positive information' and 'Pressure' were the strategies

Table 3.2 Mean factor values, standard deviation (SD) and Cronbach's alpha (α) for the parent-reported parental child-feeding (PCF) strategies for fruit and vegetables separately[a]

	VEGETABLES (N=242)		
PCF Strategy	Mean	SD	α[b]
Positive information[c]	4.0	0.7	0.84
Negative atmosphere	2.6	0.8	0.80
Pressure	3.4	0.9	0.76
Choice	2.1	0.6	0.70
Distraction	1.7	0.7	0.67
Taste masking	1.6	0.6	0.62
Extra vegetables[e]	2.9	0.8	0.59
Habit[e]	4.8	0.4	0.42
	FRUIT (N=239)		
PCF Strategy	Mean	SD	α[d]
Negative atmosphere and Pressure	2.0	0.7	0.85
Positive information	3.8	0.7	0.82
Availability	4.8	0.4	0.66
Choice	3.6	0.6	0.60
Distraction[e]	1.3	0.4	0.54

[a] Response categories were on a 5-point scale where 1=*never*, 2=*rarely*, 3=*sometimes*, 4=*often* and 5=*always;* [b] N=238-242; [c] N=240; [d] N=233-239; [e] Excluded from further analyses, due to low Cronbach's alpha (<0.60)

most frequently applied for vegetables. 'Taste masking' and 'Distraction' were the least used strategies for vegetables. For fruit, 'Availability' was the most used PCF strategy, followed by 'Positive information' and 'Choice'.

Relation between parental child-feeding strategies and children's intake

The final regression model explained 47% of the variance in children's vegetable intake. The model included seven variables, shown in Table 3.3. 'Distraction', 'Negative atmosphere' and 'Positive information' were negative predictors of children's vegetable intake. 'Parental vegetable intake', 'Choice', 'Pressure' and 'Age 7-8 years or 11-12 years' were positive predictors of vegetable intake.

The regression model for children's fruit intake included three variables, which accounted for 28% of the variance (Table 3.3). 'Parental fruit intake' and 'Choice' were positive predictors of children's fruit intake, whereas 'Negative atmosphere and Pressure' was a negative predictor.

The regression models to predict children's preference explained a much smaller amount of variance: 3% for vegetables and 18% for fruit (results not shown). However, both models included the PCF strategy 'Choice' as a significant positive predictor.

Table 3.3 Final stepwise multiple regression model for children's vegetable (R^2=47%) and fruit intake (R^2=28%) with parental child-feeding strategies, age and parental intake as independent variables

	Unstandardized Coefficients		Standardized Coefficients	Sig.	R^2 (%)
Predictors of vegetable intake	B	Std. Error	Beta		
Parental vegetable intake	0.28	0.03	0.45	0.00	24.9
Choice	25.1	4.72	0.28	0.00	8.4
Distraction	-11.1	4.98	-0.13	0.03	5.7
Dummy variable age (Age 4-5y = 0; Age 7-8y and 11-12y = 1)	15.1	6.50	0.13	0.02	2.1
Negative atmosphere	-13.7	4.13	-0.19	0.00	1.9
Pressure	13.4	3.57	0.21	0.00	2.8
Positive information	-10.8	4.52	-0.13	0.02	1.5
Predictors of fruit intake	B	Std. Error	Beta		
Parental fruit intake	0.37	0.05	0.45	0.00	23.3
Choice	30.7	10.73	0.17	0.01	3.4
Negative atmosphere and Pressure	-18.1	8.92	-0.12	0.04	1.3

Additional analyses

Additional analyses were conducted with the PCF strategies that were positive predictors of children's intake. Since it is unlikely that parents use these strategies more because their children eat already large quantities of fruit or vegetables, it seems plausible that a high use of these strategies results in a higher intake. For that reason, tertiles were made based on the use of the strategies: 'Choice' and 'Pressure' for vegetables, and 'Choice' for fruit. The differences in children's intake between the tertiles was calculated to estimate the impact of the particular strategy.

Figure 3.1 shows that there is no significant difference in children's vegetable intake between the three tertiles for 'Pressure' (p=0.56). For the strategy 'Choice', the difference in children's intake between the lowest and highest tertile was 40 grams/day for vegetables (p<0.001) and 72 grams/day for fruit (p<0.001). The mean use of 'Choice' for vegetables in the highest tertile was 2.8 compared to 1.4 in the lowest tertile, whereas for fruit, these values were 4.2 and 3.0 on a 5-point scale.

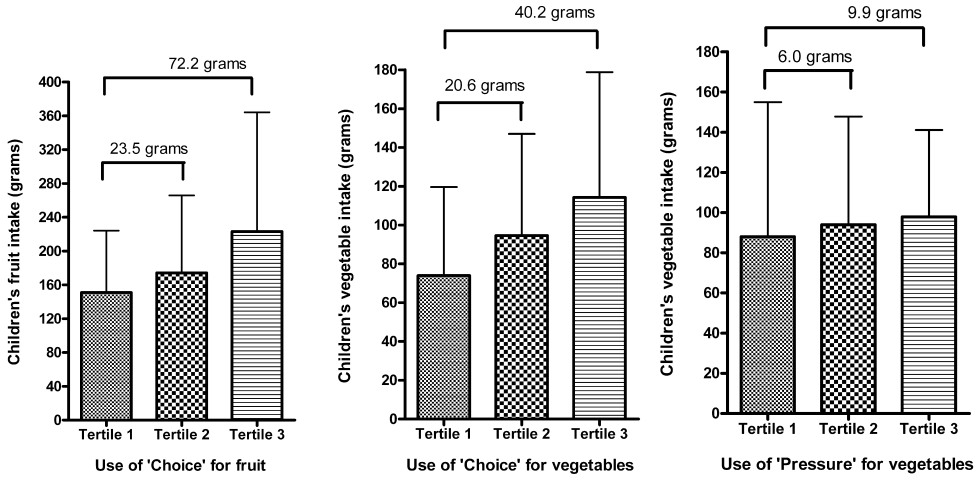

Figure 3.1 Comparison of children's vegetable or fruit intake between the tertiles (N=72-84) of three parental child-feeding strategies (Response categories were on a 5-point scale where 1=*never*, 2=*rarely*, 3=*sometimes*, 4=*often* and 5=*always*): 'Choice' for fruit, 'Choice' for vegetables and 'Pressure' for vegetables. Tertiles are based on the frequency of use of the specific parental child-feeding strategy. P-values regarding comparisons between the three tertiles (ANOVA + Bonferroni) as follows: 'Choice' for fruit (p<0.001): tertile 1 vs. 2, p=0.52; tertile 1 vs. 3, p<0.001; tertile 2 vs. 3, p=0.02. 'Choice' for vegetables (p<0.001): tertile 1 vs. 2, p=0.06; tertile 1 vs. 3, p<0.001; tertile 2 vs. 3, p=0.09. 'Pressure' for vegetables (p=0.56).

Relation between parental child-feeding strategies and Child Feeding Questionnaire

For vegetables, CFQ 'Restriction' was positively correlated with the PCF strategies 'Distraction' ($r=0.37$; $p<0.001$) and 'Negative atmosphere' ($r=0.28$; $p<0.001$). CFQ 'Pressure to eat' was positively related to the PCF strategies 'Distraction' ($r=0.40$; $p<0.001$), 'Negative atmosphere' ($r=0.38$; $p<0.001$) and 'Pressure' ($r=0.27$; $p<0.001$).

For fruit, the PCF strategy 'Negative atmosphere and Pressure' was positively associated with the CFQ factors 'Restriction' ($r=0.37$; $p<0.001$) and 'Pressure to eat' ($r=0.39$; $p<0.001$).

DISCUSSION

Our study showed that parents applied different strategies for fruit compared with vegetables. For fruit, 'Availability', 'Positive information' and 'Choice' were the most used, which all seem positive strategies. For vegetables, 'Positive information' and 'Pressure' were the most used strategies, making the vegetable-eating context more negative than the fruit-eating context. This difference in use of strategies could be due to differences in cultural habits [36] or to a difference in liking: parents may use different strategies because their children like fruit but dislike vegetables [33, 37].

The strategies 'Negative atmosphere', 'Distraction' and 'Positive information' were negatively related to children's vegetable intake. This could mean that parents use these PCF strategies often because their child does not want to eat vegetables, but it could also indicate that the use of these strategies results in a low vegetable intake. Similarly for fruit: frequent use of the strategy 'Negative atmosphere and Pressure' could be caused by a child's low fruit intake or could lead to a lower fruit intake. Hence, the use of a particular strategy may be the cause or the consequence of low consumption. Further research is needed to investigate the direction of these relationships.

It was remarkable that 'Pressure' was positively related to children's vegetable intake, whereas this strategy was negatively related to fruit intake, although for fruit, 'Pressure' formed one strategy together with 'Negative atmosphere'. In the literature, negative correlations are often found between pressure and intake, although Wind et al. [20] found a positive correlation as well between parental demand (~pressure) and children's vegetable intake. Presumably, the impact of a particular strategy on children's intake depends on the product in question. The fact that children preferred fruits above vegetables may be the reason for this contrasting finding. Consumption of disliked products, such as vegetables, may need some pressure, whereas liked products, such as fruits, may not need

pressure. Variation in product liking may partly explain the different results in the literature regarding intake and pressuring strategies [13, 16, 18, 20].

Parental intake and the PCF strategy 'Choice' were the strongest positive predictors of children's intake for both fruit and vegetables. Modelling, genetic similarity and a similar food availability have been suggested to account for the strong influence of parental intake [13, 38].

'Choice' as a potential strategy to promote children's fruit and vegetable intake is a new finding. A high use of 'Choice' compared with a low use of 'Choice' is associated with a higher daily intake of 40 grams of vegetables and 72 grams of fruit, corresponding to 27% of the recommended vegetable intake for children and 36% for fruit. Additionally, 'Choice' was a positive predictor of children's preference for both fruit and vegetables. The potentially powerful role of 'Choice' is in accordance with motivation theories. Choice gives children a feeling of autonomy, and this enhances their intrinsic motivation [39]. It has indeed been shown that food liking scores in adults are higher when there is some degree of choice compared with no-choice conditions [40]. Although children themselves often state that they dislike being 'preached to' and want to have some autonomy over their food behaviour [41, 42], this strategy does not receive much attention in interventions. Especially for vegetables, there is room for improvement in the use of 'Choice', since the mean use in the highest tertile in our study was only 2.8 on a 5-point scale.

The results concerning pressure can be viewed in the light of motivation theories as well. Eating vegetables is not intrinsically satisfying or enjoyable for children, so they need an external motivation (pressure) to eat them. In contrast, fruit is liked, thus eating fruit is an enjoyable activity in itself. External controllers, such as parental pressure, can result in reactance or diminish children's internal motivation for eating fruit [39, 43]. More research is needed to investigate how pressure works in the long term.

In view of general parenting styles, the strategy 'Pressure' for fruit or vegetables probably fits into an authoritarian style, which is typified by extensive external control, strict discipline, little responsiveness [18, 26] and which is positively associated with 'Restriction' and 'Pressure to eat' [44]. 'Restriction' and 'Pressure to eat' were positively correlated to our strategies 'Pressure' for vegetables and 'Negative atmosphere and pressure' for fruit, strengthening the abovementioned assumption. 'Distraction' for vegetables was also positively correlated to 'Restriction' and 'Pressure to eat', suggesting that 'Distraction' is a type of external control as well.

'Choice' may fit into an authoritative style, which is characterized by warmth, responsiveness, setting limits without controlling, reasoning, some flexibility

and which has been related to more positive child outcomes [18, 26]. In our study, 'Choice' was neither for fruit nor for vegetables correlated with 'Restriction', 'Pressure to eat' or 'Monitoring', indicating that this is a distinct concept that deserves further attention.

Limitations and strengths

Interpretation of our findings should take the limitations into account. First, the data are cross-sectional, so no conclusions can be drawn about cause and effect. Longitudinal studies and experimental work is required to elucidate cause and effect.

Another limitation is that the data about intake and the strategies were self-reported, which may have led to socially desirable answers. Besides, parents may not always be consciously aware of how often they use specific practices with regard to fruit and vegetables. Parents completed the questions about their children's fruit and vegetable consumption, which may have led to under- or overestimation. The alternative, an observational study, would be impossible in practical terms with this number of participants.

For future research, the validity and reproducibility of our PCF strategies questionnaire for fruit and for vegetables should be assessed. The correlations between our strategies and the parental control practices of the CFQ [25] give initial support for the validity of our questionnaires.

Although we tried to include subjects from various educational backgrounds, the research population consisted mainly of more highly educated people. Since fruit and vegetable intake as well as parental use of strategies may differ by educational level [8, 45], future studies should also include parents with a lower educational background.

Because the fruit and vegetable intake data are validated to rank order individuals according to their intakes [27], we have to be careful with conclusions about the absolute quantities for intake.

Yet, this study has important strengths. First, we studied the role of parental strategies in relation to fruit and vegetables separately, which has not been done before. Furthermore, we did not use a pre-determined factor structure, but extracted the underlying strategies from the data themselves. Finally, the high response rate is a strength. Comprehensible, timely information, thorough preparation by the research team, enthusiastic teachers and an up-to-date, hot topic, have probably led to this high response rate.

Conclusion and recommendations

We aimed to identify strategies that have the potential to increase primary school-aged children's fruit or vegetable consumption. Our study showed that a high parental intake and giving children choice are promising strategies to encourage children's fruit and vegetable intake. Healthy eating programmes should make a distinction between fruit and vegetables, since there is a difference in how they are handled at home. Using pressure to encourage the child to eat some vegetables every day can be beneficial for children's vegetable intake, whereas this is not true for fruit. However, providing the child with choice has a much greater potential to stimulate fruit and vegetable intake and deserves more attention. To encourage children's fruit and vegetable intake in the long term, a positive eating atmosphere where children have some autonomy over their food choices will be most advantageous.

Authorship responsibilities

All authors were involved in the design of the study. GZ and NvdL collected the data. GZ was responsible for the data analysis with assistance and input from the other authors. All authors contributed to the discussion of the results. GZ wrote the manuscript with critical input from all authors.

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Appendix 3.1 Factor structure for parent-reported parental child-feeding strategies for vegetables (V)

	F1	F2	F3	F4	F5	F6	F7	F8
Factor 1: Positive information								
Do you tell your child V are healthy?	0.81							
Do you tell your child V are tasty?	0.81							
Do you tell your child V are good for them?	0.79							
When you eat V, do you show your child that you like them?	0.71							
Factor 2: Distraction								
Do you promise your child something tasty or nice, if he/she eats the V?		0.72						
Do you stimulate V consumption by presenting V in an unrecognizable state?		0.60						
Do you stimulate V consumption by making a game of eating V or telling a story around eating V?		0.60						
Do you tell your child that he/she won't get something tasty or nice, if he/she doesn't eat the V?		0.59						
Factor 3: Choice								
Do you give your child V when he/she gets back from school?			0.72					
Do you have a bowl with V at home from which the child is allowed to take?			0.69					
Do you give your child V to take with him/her to school?			0.63					
Do you try to convince your child to eat V instead of cake or candy?			0.57					
Do you let your child co-decide what V are eaten?			0.51					
Factor 4: Negative atmosphere								
Do you get frustrated when your child doesn't want to eat V?				0.80				
Do you get angry when your child doesn't want to eat V?				0.79				
Do you start a discussion when your child doesn't want to eat V?				0.66				
Do you show your disapproval when your child doesn't want to eat V?				0.61				
Factor 5: Pressure								
When you give your child V, does he/she have to eat the whole portion?					0.79			
Are you strict with your child concerning eating of V?					0.74			
Do you make your child eat V when he/she doesn't want to?					0.72			

	F1	F2	F3	F4	F5	F6	F7	F8
F6: Taste masking								
Do you let your child add something else over the V?						0.68		
Do you let your child add apple sauce over the V?						0.67		
Do you let your child add warm sauce over the V?						0.65		
Do you let your child add ketchup over the V?						0.63		
F7: Habit								
Do you habitually have V available at home?							0.59	
Do you eat V in the presence of your child?							0.54	
F8: Extra vegetables								
Do you habitually serve different kinds of V at supper?								0.81
Do you prepare an extra type of V, if your child doesn't like the offered V?								0.67
Do you take a second serving of V at dinner, in the presence of your child?								0.55
Parental practices not included in the factor structure								
Do you compliment your child after eating V?								
Do you offer V as reward for good behaviour?								
Do you serve V during celebration moments?								
Do you tell your child that he/she should taste at least one bite, if he/she doesn't want to eat V at that moment?								
Do you offer V that your child does not like, later on again?								
Do you set limits to the amount of V your child is allowed to eat?								
Do you monitor the amount of V your child eats?								
Do you let your child assist in preparing V?								
Do you stimulate V consumption by preparing the V in alternative ways?								
Do you stimulate V consumption by serving V in an attractive way?								
Do you stimulate V consumption by tricking the child?								

Appendix 3.2 Factor structure for parent-reported parental child-feeding strategies for fruit (F)

	F1	F2	F3	F4	F5
Factor 1: Negative Atmosphere and Pressure					
Do you start a discussion when your child doesn't want to eat F?	0.77				
Do you show your disapproval when your child doesn't want to eat F?	0.75				
Do you get angry when your child doesn't want to eat F?	0.72				
Do you get frustrated when your child doesn't want to eat F?	0.66				
Are you strict with your child concerning eating of F?	0.65				
Do you make your child eat F when he/she doesn't want to?	0.62				
Do you tell your child that he/she won't get something tasty or nice if he/she doesn't eat F?	0.62				
Do you promise your child something tasty or nice if he/she eats F?	0.55				
Factor 2: Positive information*					
Do you tell your child F is healthy?		0.80			
Do you tell your child F is tasty?		0.82			
Do you tell your child F is good for them?		0.75			
When you eat F, do you show your child that you like it?		0.60			
F3: Distraction					
Do you stimulate F consumption by making a game of eating F or telling a story around eating F?			0.67		
Do you stimulate F consumption by presenting F in an unrecognizable manner?			0.63		
Do you stimulate F consumption by tricking your child?			0.58		
Factor 4: Choice*					
Do you have a bowl with F at home from which the child is allowed to take?				0.66	
Do you let your child co-decide what F are bought?				0.59	
If you have different types of F at home, is your child allowed to choose what kind of fruit he/she wants to eat?				0.60	
Do you serve fruit during celebration moments?				0.50	
Do you let your child assist in preparing F?				0.49	
Factor 5: Availability					
Do you habitually have F available at home?					0.73
Do you habitually have different types of F at home?					0.71
Parental practices not included in the factor structure					
Do you compliment your child after eating F?					
Do you offer F as reward for good behaviour?					
Do you eat F in presence of your child?					
When you offer your child F, should he/she eat the whole portion?					
Do you tell your child that he/she should taste at least one bite, if he/she doesn't want to eat F at that moment?					

	F1	F2	F3	F4	F5
Do you offer F that your child does not like, later on again?					
Do you set limits to the amount of F your child is allowed to eat?					
Do you give your child F to take with him/her to school?					
Do you give your child F when he/she gets back from school?					
Do you try to convince your child to eat F instead of cake or candy?					
Do you monitor the amount of F your child eats?					
Do you prepare F for your child, so he/she can eat it immediately?					
Do you stimulate F consumption by serving F in an attractive way?					

* For reasons of comparison, the items for this factor have been listed in the same order as for vegetables

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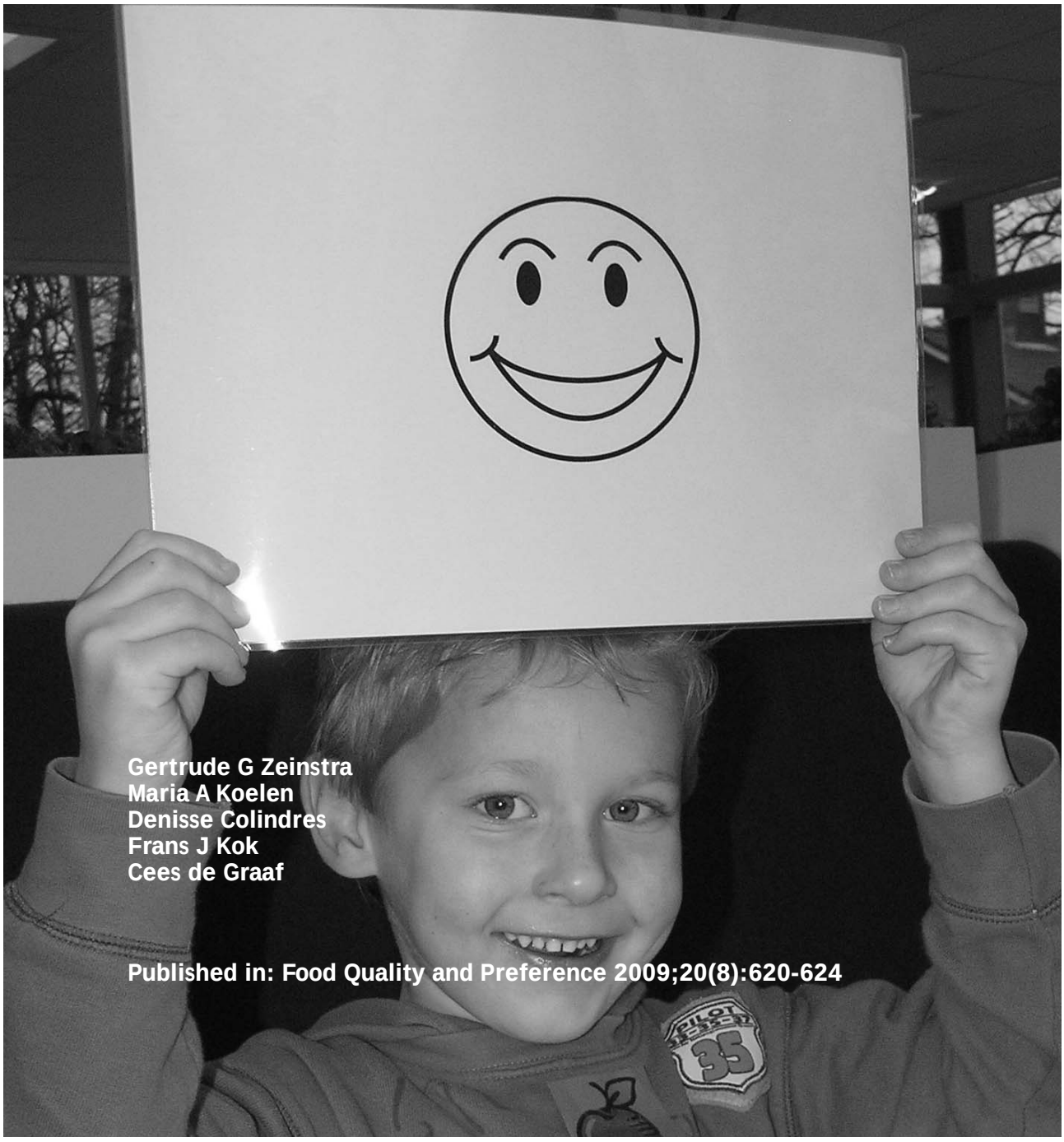
Facial expressions in school-aged children are a good indicator of ‘dislikes’, but not of ‘likes’



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ABSTRACT

Our pilot study sought to investigate whether facial expressions are a suitable and accurate method to assess food preferences in school-aged children. Six children, aged 5 to 13 years, tasted seven stimuli in randomized order: apple, sauerkraut, and beetroot juice, skimmed milk, asparagus solution, a bitter and a sweet solution. Their preferences were assessed using a traditional rank-order procedure. Each tasting was video-recorded to capture facial expressions. The first six seconds after tasting were coded using a selection of FACS-system Action Units (AUs). Data were analysed by frequency count, Pearson correlations and Chi-Square test. For disliked liquids, the majority of the AUs displayed were negative, whereas for neutral and liked liquids the number of positive and negative AUs was similar. On the basis of our results, we conclude that facial expressions are suitable to measure dislike, but not suitable to measure various gradients of food acceptance in children aged 5 to 13 years.

INTRODUCTION

To understand how food preferences develop in children, an accurate and valid measurement to assess children's food preferences is needed. In previous studies, a 5-point smiley scale has been successfully applied in children of various ages [1, 2]. Birch's two-stage method with three smiley faces and resulting in a complete preference rank-order, is considered an appropriate and well-accepted method for younger children [3].

However, there are still some difficulties in research with children. As children are very eager to please an adult [2], they will be more inclined to give confirmative or socially desirable answers. Other difficulties that may be encountered in research with young children is their shorter attention span and the fact that their cognitive capacities are not yet fully developed. Consequently, extreme answers, random answers, low repeatability and inconsistency may result [4-7]. In this context, facial expressions may be helpful in addition to the subjective measurements, since this method is independent of children's cognitive skills.

Facial expressions have been successfully used in infants. The application of facial expressions has revealed that infants can recognize and discriminate between various basic tastes and odours [8-12]. Newborn infants show differentiated facial responses to various basic solutions: a sweet taste elicits facial relaxation, sucking, tongue protrusions and may lead to a smile; a sour taste elicits lip pursing; a bitter taste gives rise to head turns, mouth gaping, nose wrinkling and lowered mouth corners; and a salty taste has a less distinctive pattern [9-13]. Although many variations of these expressions are displayed by infants [10], the system is quite robust at that age, since infants with head abnormalities also reveal this pattern of facial expressions towards basic tastes [11].

Facial expressions are thought of as biologically based adaptations crucial for the survival and normal development of the child. One function may be to prevent ingestion of a potentially harmful substance or to facilitate ingestion of nutritious liquids [10, 13]. In this way, facial actions support the two basic reactions to stimuli: approach/acceptance or avoidance [11, 12, 14]. This is probably the reason why facial expressions are usually interpreted in a dichotomous way: positive or negative affect [13]. A negative affective reaction in infants consists of gaping, nose wrinkling and head shake with a cry-face as the maximum [8, 9, 11]. A positive affective reaction is characterized by tongue protrusions, sucking, lip smacking and a relaxed face with sometimes a smile as ultimate extreme [8, 9, 11].

Less is known about the use of facial expressions in children. One study investigated facial responsiveness to pleasant and unpleasant odours in children aged 5 to 12 years [15]. The facial configuration varied according to odour valence and social condition. It would be interesting to investigate whether children's facial

expressions could be used in relation to food stimuli. Therefore, the aim of our pilot study was to investigate whether the facial-expressions method is suitable to measure primary school-aged children's food preferences. We hypothesized that for liked stimuli, the positive expressions would predominate over the negative expressions, whereas for disliked stimuli, the negative expressions would outweigh the positive ones. For neutral stimuli, a similar amount of negative and positive expressions may be seen, or neutral expressions may predominate. To examine whether facial expressions would be applicable over the whole age range of primary school, we investigated children from various ages.

METHODS

Participants

Six normal-weight children participated in the pilot study: one girl and one boy aged 5 years, two boys aged 8 years, one boy aged 12 years and one boy aged 13 years. The children were recruited in Wageningen (The Netherlands) and the surrounding area. The Medical Ethical Committee of Wageningen University approved the protocol for this pilot study.

Procedures

Each child was invited to visit our research facility once to participate in a taste test. The child performed the two-stage preference rank-order procedure [3] with assistance from the researcher without a parent present. First, the child was put at ease and the meaning of the three smiley faces was practiced. Next, seven liquids (100 ml each) were randomly presented in brightly coloured cups with a lid to prevent visual cues. After tasting a sip, the child placed the liquid on the smiley that indicated his or her preference (like, neutral or dislike = stage 1). When all liquids were tasted and placed into a liking category, the children tasted the liquids within one liking category again, and indicated the best liked one. This procedure was repeated for all samples in a category and for all categories until a complete preference rank-order was established (=stage 2). The whole procedure took about 15 minutes and the tasting session was video-taped (Dome camera on ceiling: Observer TM software Noldus, Wageningen).

Stimuli

Liquids were chosen because chewing and eating movements would disturb the measurement of facial expressions. Additionally, the use of liquids made our results comparable to the infant studies. We wanted to have a broad spectrum of tastes, which would vary in liking. Therefore, we selected basic tastes as well as non-basic tastes for ecological validity. The basic tastes were intense to elicit clear reactions. Because the number of stimuli should also be feasible

for younger children, we chose seven liquids: apple juice (PLUS supermarket, The Netherlands), skimmed milk (Melkan, The Netherlands), sauerkraut juice (Loverendal, bevtelsbachler Fruchtsaftkelterei, Germany), asparagus solution (Quest International, The Netherlands), beetroot juice (Luna e Terra, Natudis BV Harderwijk, The Netherlands), a bitter solution (0.003 M quinine hydrochloride ~0.25%) and a sweet solution (0.73 M sucrose ~25%).

Data analysis

The preference rank-order data were recorded in two ways. The absolute level of liking, like, neutral or dislike, was recorded (=stage 1) as well as the relative level of liking (preference rank-order 1-7 = stage 2).

The facial expressions were analysed using the Facial Action Coding System (FACS) [16]. FACS is an anatomically based coding system used to describe facial activity. The minimally distinguishable action of the facial muscle is called an Action Unit: AU [13, 16]. The FACS system consists of 58 units, consisting of AUs, action descriptors (AD) and gross behaviour codes. FACS coding indicates which facial muscles are active but gives no judgement about the meaning of the response [14].

In this pilot study, we used a selection of the AUs from the FACS system, namely, the AUs that show most consistency in the literature with regard to the positive or negative affective value [9, 11, 14, 15, 17]. Neutral, yet unknown regarding affective value, AUs were included to find out what affective value they indicate. The following negative AUs from the upper face were included: inner eyebrows raised (AU1), outer eyebrows raised (AU2), brows pulled together and lowered (AU4), nose wrinkle (AU9), eyes closed (AU43E), blink (AU45). In addition, smile with cheeks raised (AU6+12; positive) and cheek raiser (AU6; neutral) were included. From the lower face were included: upper lip raiser (AU10), lip corner depressor (AU15), lower lip depressor (AU16), lip stretch (AU20), lips pressed (AU24), lips part (AU25) and gape (AU27E+26), which are negative. Furthermore, the positive AUs lip corner puller (AU12), smile with open mouth (AU12+25) and lip smack (AU24+25) were included and chin raiser (AU17) and lip pucker (AU18) as neutral ones. For gross behaviour, we included: neutral face (AU0), lip bite (AU32; neutral), head shake (AU84; negative), head nod (AU81; positive), tongue protrusion (AD19; positive) and cheek sucking (AD35; positive).

The first six seconds after tasting were coded [15] in order to include first reactions and more delayed reactions to the stimuli. Each subject's video was coded twice on separate days to verify scoring. The coder was blinded to the order of the stimuli, but not to the test conditions. Actions were counted as frequency occurrences. Data were analysed by frequency count, Pearson correlations and Chi-Square test.

RESULTS

On the basis of the complete preference rank-order, apple juice was the most preferred stimulus, with a mean rank of 2.0 (range 1-4), followed by the sweet solution, with a mean rank of 3.0 (range 2-5). Least liked was the bitter solution, with a mean rank of 6.0 (range 3-7) and sauerkraut juice with a mean rank of 5.4 (range 3-7). Table 4.1 shows the absolute and relative liking scores for all stimuli for each participant separately.

A total of 74 negative, 31 positive and 16 neutral AUs (total 121) were displayed by the children. A significant correlation was found between rank-order preference and the sum of negative facial AUs (r=-0.44; p=0.009). The more the stimulus was disliked, the more negative AUs were displayed (see Figure 4.1). The relationship was not significant for positive AUs (r=-0.27; p=0.11) or neutral AUs (r=-0.12; p=0.50).

The stimuli were categorized into three categories of liking based on the individual evaluation of each subject: like, neutral or dislike (stage 1 rank-order procedure). For disliked stimuli, brows pulled together and lowered (AU4; 7x), lips pressed (AU24; 9x) and lips part (AU25; 6x) were most frequently shown. Two AUs were seen for disliked liquids and not for liked or neutral liquids: upper lip raiser (AU10; 3x) and head shake (AU84; 5x). For neutral stimuli, there was no AU that was specific for this liking category. Various AUs were shown 3x: inner brows raised (AU1), outer brows raised (AU2), lip corner puller (AU12), lip pucker (AU18), lips pressed (AU24), smile with cheeks raised (AU6+12) and smile with open mouth (AU12+25). For liked stimuli, the AUs most frequently expressed were: smile with cheek raised (6+12; 4x), lip pucker (AU18; 3x), lip stretch (AU20; 3x) and lip bite (AU32; 3x). Lip bite was only seen for liked liquids, not for the other liking categories.

Table 4.1 Liking scores of the six subjects for the seven taste stimuli, separated for stage 1 (absolute liking) and stage 2 (relative liking) of the preference rank-order

	Absolute level of liking (1 = like; 2 = neutral; 3 = dislike)						Rank-order preference (1 = best liked; 7 = least liked)					
Subjects →	S1	S2	S3	S4	S5	S6	S1	S2	S3	S4	S5	S6
Beet juice	3	1	3	1	2	3	.	1	7	1	4	4
Sauerkraut juice	3	3	3	3	2	3	.	6	6	7	3	5
Asparagus	3	2	2	2	3	3	.	5	4	5	5	6
Sweet solution	1	1	3	1	2	2	.	2	5	3	2	3
Apple juice	.	2	1	2	1	1	.	3	1	4	1	1
Milk	.	2	1	1	3	2	.	4	2	2	6	2
Bitter	3	3	1	3	3	3	.	7	3	6	7	7

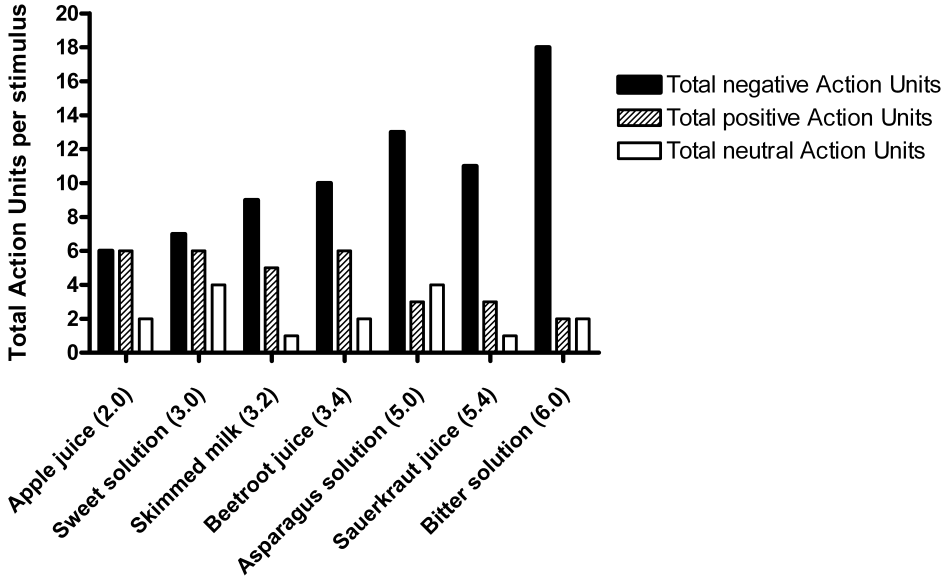

Figure 4.1 The total number of negative, neutral and positive Action Units that the six children expressed after tasting each of the seven liquids ordered from left to right based on their mean rank score (left = most liked, right = least liked).

For each category of liking, the number of AUs was calculated across the subjects. The total number of positive, neutral and negative AUs per liking category of the stimulus were cross tabulated (see Table 4.2). For disliked liquids, the negative AUs occurred more frequently (49x) than positive (7x) or neutral (4x) AUs. For the neutrally liked liquids, a similar number of positive (13x) and negative (16x) AUs were shown, with a few neutral ones (4x). Liked liquids evoked 11 positive AUs, 9 negative AUs and 8 neutral ones.

When these three categories of liking and the sum of total positive, negative and neutral AUs were tested for independence, a significant association was found (χ^2=24.13; $p<0.05$). The number of positive, neutral and negative AUs was

Table 4.2 The total number of positive, neutral and negative Action Units per liking category, expressed by the six children after tasting seven liquid stimuli

	Sum of Action Units per category of affectiveness		
Evaluation of stimuli	Positive	Neutral	Negative
Like	11	8	9
Neutral	13	4	16
Dislike	7	4	49
Total	31	16	74

significantly different across the liking categories of the stimuli. For disliked liquids, the majority of the displayed AUs were negative, whereas for neutral and liked liquids the children displayed a similar number of positive and negative AUs.

DISCUSSION

This pilot study focused on facial expressions in children in response to food stimuli. The aim was to investigate whether facial expressions are a suitable and accurate method to measure food preferences in primary school-aged children. Although we should be careful with interpretation because of the small number of subjects, this study provides certain insights that are valuable for researchers who are studying children's food preferences.

The results indicate that negative facial expressions for disliked food stimuli are easily recognized. Our hypothesis that negative expressions will predominate over positive expressions for disliked stimuli, is confirmed. However, the distinction between a positive or a neutral expression is less clear. For liked stimuli, the number of positive AUs does not predominate over the number of negative AUs.

Our finding is in agreement with other sensory studies demonstrating that negative reactions are more intense, quicker to appear, easier to recognize and less influenced by other factors than positive facial expressions. Horio [17] found that the facial muscles of adults showed greater responses to disliked tastes than to liked tastes. In infants, the bitter response is most easy to distinguish [10]. Furthermore, naive observers scored negative reactions in infants with more confidence than positive ones; the observers found it difficult to distinguish liking [11]. In addition, negative reactions occur more quickly in adults and children [11,14]. Greimel et al. [14] showed as well that emotional state modulates affective reactions to a liked, sweet taste, but emotional state did not influence affective reactions to an aversive, bitter taste. Thus, negative expressions seem to be more robust and easier to identify.

The robustness of the negative expressions may be related to the communication value of facial expressions. Although different opinions exist with regard to the origin of facial expressions, most researchers agree that facial expressions function as a communication signal directed at the caregiver, to other species members or at the environment [10-14, 18]. Communicating expressions of fear, disgust and threat to others is meaningful to the other [18], to prevent, for instance, the ingestion of potential poisoning (bitter) substances [10]. The Bayens' et al. [19] conditioning study supports this strong communication value of negative expressions. The consumption of a drink by a model was repeatedly paired with a negative facial expression of that model. As a result, the observing children aged 8 to 12 years decreased their liking for this drink. Negative expressions seem to serve as a warning sign.

The communication value of positive expressions seems to have another social function. Soussignan and Schaal [15] showed that the presence of a researcher made positive expressions towards pleasant odour stimuli more pronounced in children. During our study also, a researcher was present to assist the children with the procedures, but we did not see this social facilitation process for liked liquids, as it was difficult to distinguish liking from a neutral evaluation.

Another point that is specific to our study, relates to expressions in relation to food. Which expressions are evoked by foods? One emotion that is clearly food related, is the expression of disgust [20]. Certain food combinations may induce an expression of surprise. When a stimulus is liked (i.e. sweet solution), infants will smile, which is a sign of happiness. However, the liked stimuli in our pilot study did not evoke a clear expression of happiness in the children. The children in our study showed a similar amount of smiling and tongue protrusions for neutral liquids and liked liquids, whereas lip smacking was expressed more often for neutral liquids compared to liked liquids. Furthermore, not all children expressed these positive AUs. So, it seems that food may not evoke strong positive reactions. The foods that humans consume and accept may result in mild positive reactions [21]; this makes it more difficult to distinguish the gradations of liking (food acceptance) based on facial expressions. There are some studies indicating that the face is less expressive for pleasant stimuli in infants [10, 22] or regarding odours [15]. Our study with children consuming liquids confirms these findings.

An alternative explanation is that the liked liquids in our study were not as positive as the disliked liquids were negative. We expected that apple juice and the sweet solution would be liked by the children, whereas the bitter solution and sauerkraut juice would be disliked [11]. Looking at the absolute level of liking (stage 1), a similar number of liquids were evaluated as liked and neutral (both 11), whereas the number of disliked liquids was a bit higher (i.e. 18). Future studies should include drinks that are even better liked (perhaps milkshakes), although additional ones may be difficult to find. Nevertheless, other studies indicate as well that the human system is more responsive to potentially dangerous (disliked) substances than for safe, liked stimuli [19, 23].

A limitation of our pilot study is that we had one coder. As a reliability check, this coder scored the FACS test videos and calculated inter coder agreement for these videos with the expert in the FACS manual [10, 16]. Reliability was 72-75%, which is reasonable. However, future studies should repeat and extend our work with two independent coders.

Further research is needed about facial expressions in regard to food in children. We need more information about the interpretation of the AUs. How are they related to like and dislike? Perhaps, certain AUs are more significant

than others. In our study, lip bite appeared only with liked liquids, and upper lip raiser and head shake were expressed only for disliked liquids. We should be careful with conclusions, but specific AUs may be more sensitive than others. Since learning FACS and analysing the data is time-consuming (1-2 hours per 7x6 seconds film), it would be valuable to learn more about the most sensitive AUs with regard to food preferences.

In our study, we observed large variations in the expressiveness of the six children. Some were very expressive and others hardly showed any facial responses. To capture the more subtle changes in the face as well, it may be useful to apply electromyogram (EMG) measurements in future studies. EMG measurements or an automated scoring system can capture more subtle or invisible changes in the face and would make the measurement of facial expressions more objective and more widely accessible as a research tool [14, 24].

It should be taken into account that control of facial expressions and the ability to intentionally make faces develops gradually in the growing child [25, 26]. Although 5 and 12-year-old children appear equally capable in masking their facial expressions in response to unpleasant odours [15], it is unclear how much masking and control happens in response to food stimuli. Since masking and control influence the objectivity of facial expressions as a tool for measuring food preferences, future research should examine how much masking and control is present at various ages and how much between-subject variation is present concerning masking and controlling expressions.

Although the rank-order procedure discriminated well among the samples in our study, ranking may become unmanageable when more products are involved [27], because multiple tasting is necessary for a complete rank-order. To reduce the burden for children, facial expressions would be a valuable tool for assessing preferences as tasting once is sufficient. Since younger children (below 4-5 years) can have difficulties in understanding tasks and symbols that are used in research with children [7, 28], facial expressions may give more reliable information in this age group. Finally, when interaction with the child disturbs the research, observation of facial expressions can be a valuable tool to collect information about likes and dislikes.

On the basis of the results of our pilot study, we conclude that facial expressions are suitable to measure dislike, but not suitable to measure various gradients of food acceptance in children aged 5 to 13 years. Future studies with a larger number of children should be performed to confirm these results.

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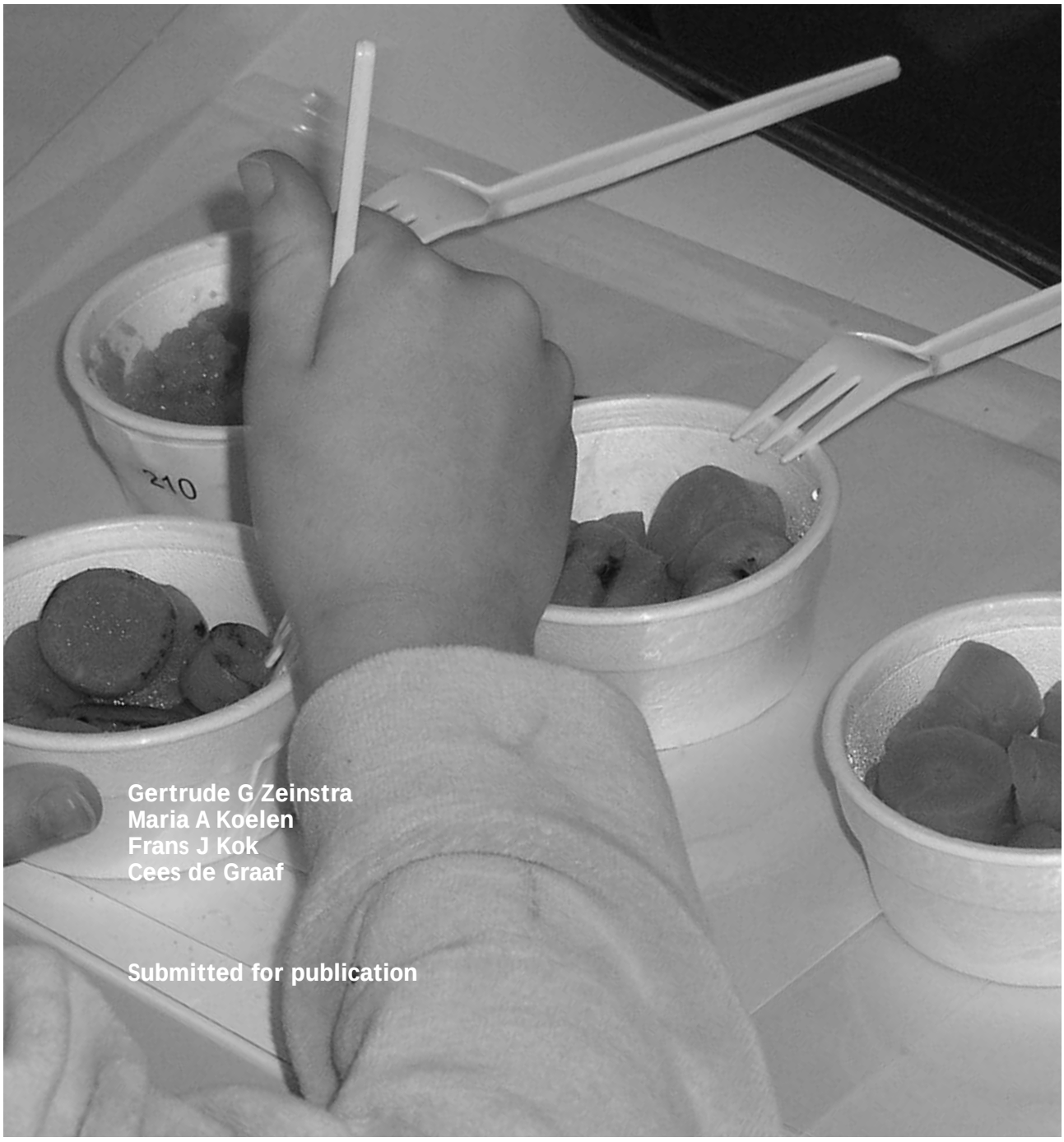
The influence of preparation method on children's liking for vegetables



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ABSTRACT

This study aimed to investigate how different preparation methods influence children's liking for vegetables. Participants were children from three age groups (4-6y N=46; 7-8y N=25; 11-12y N=23) and young adults (18-25y N=22). The participants tasted and ranked six preparation methods for carrots and French beans: mashed, steamed, boiled, stir-fried, grilled and deep-fried. In addition, the different vegetable preparations were rated on fifteen attributes. All participants preferred boiled and steamed vegetables over the other preparations ($p<0.05$). Boiled and stir-fried were the most familiar preparation methods for both vegetables. Vegetable liking was positively related to a uniform surface and the typical vegetable taste, and moderately related to crunchiness, whereas brown colouring and a granular texture were negatively related to vegetable liking. On the basis of these results, we conclude that children's vegetable liking is influenced by a complex mixture of a uniform appearance, easily controllable textures and a typical, familiar vegetable taste.

INTRODUCTION

In many countries, children's vegetable consumption is below that recommended [1-4]. One of the most important reasons for this low consumption is children's low preference for vegetables [5, 6]. This low preference has been attributed to our innate aversion to bitter tastes [7, 8], and probably also relates to the low energy content of vegetables. Humans are predisposed to learn to like high-energy foods through flavour-nutrient learning [9, 10], but this is less likely to occur with plain vegetables. Another sensory attribute that seems relevant for vegetable liking is texture, which can be an important reason for enjoying and accepting foods, or for rejecting foods [1, 11-14].

Texture may be especially important for children, because their teeth, jaws and surrounding muscles go through several physical developments from infancy to adolescence [14-17]. Humans want to be in full control of the foods that they place in their mouth, and therefore children reject textures that are difficult to manipulate in the mouth [18]. This seems also true for vegetables. Crunchy vegetables such as cucumber, carrot and tomatoes are often liked, whereas slippery and slimy vegetables, such as mushrooms and asparagus, are often disliked by children [1, 6, 14, 19, 20].

Research shows that the method of preparation can influence children's vegetable acceptance to a large extent [21-23]. Various studies indicate that raw vegetables and salads are better accepted than cooked vegetables [1, 14, 24-26]. This may be due to texture changes, but also due to changes in the appearance and taste of the product. To our knowledge, the effect of varying the vegetable preparation method on children's liking has not previously been studied in an experimental setting.

The primary objective of this study was to investigate how vegetable liking is influenced by the preparation method in different age groups. Identification of children's most preferred vegetable preparation per age group can be helpful in developing and recommending age-specific vegetable recipes, and thereby encouraging vegetable consumption. A second objective was to get more insight into the drivers of vegetable acceptance: which sensory attributes predict liking? We expected that the different preparation methods would influence vegetable liking, with the crunchiest preparations most preferred. Furthermore, age differences were expected because there is evidence that texture plays a more important role regarding liking and disliking in children below eight years than in children older than ten [17, 23]. We therefore hypothesized larger liking differences among the various preparation methods for the younger children than among older children and adults.

MATERIALS AND METHODS

Design

Carrots and French beans were prepared in six different ways: mashed (pureed), steamed, boiled, stir-fried, grilled and deep-fried. Three age groups of primary school children and a group of young adults made a preference rank-order for the six preparations of each vegetable during a taste test. Another group of young adults generated attributes for the six samples. In order to characterize the six vegetable preparations, the young adults that participated in the taste test also judged the six samples of both vegetables on the generated attributes in a later session. The characteristics of the preparations were related to vegetable liking to get more insight into the attributes that explain liking or disliking. The study protocol was approved by the Medical Ethical Committee of Wageningen University.

Participants

The children were recruited via primary schools in Wageningen and Bennekom, The Netherlands. Children aged 4-6 years, 7-8 years and 11-12 years were invited to participate. Healthy children whose parents signed an informed consent, and did not have an aversion to carrots or French beans, were included in the study. The young adults, aged 18-25 years, were recruited at Wageningen University via flyers and posters. They were included for comparison reasons. For the attribute generation, 15 MSc students [27] also aged 18-25 years were recruited via two MSc programs, Food Technology and Nutrition & Health. Participants were healthy and signed an informed consent. The children received a present for their participation, whereas the young adults received a small financial incentive.

Products and preparation methods

The choice of carrots and French beans was based on a list of Dutch children's most frequently consumed vegetables [28] and on practical preparation considerations. The vegetables were obtained from a wholesaler (Greenery, The Netherlands) and were from the same batch throughout the study to ensure similar vegetables during the study. The vegetables were delivered one day before the test day and stored in the fridge (< 7^0C).

The carrots were cut into pieces of about 0.5 cm in thickness, whereas the French beans were cut into pieces of about 2 cm in length. Standardized procedures were applied for preparation of the six vegetable samples (see Table 5.1). These procedures were based on current boiling times, the knowledge of an experienced chef and a pre-test that was done to assess proper cooking times for all preparations (vegetables not raw, not overcooked). No seasonings were added in order to have the six preparations as comparable as possible, preventing any

Table 5.1 Characteristics of the six preparation methods for carrots and French beans, including the energy value per preparation in kJ/100 grams

Sample	Pre-treatment (min)		Equipment	Oil	Treatment (min)		Energy content	
	Carrots	Beans			Carrots	Beans	Carrots	Beans
Mashed	Boil: 6	Boil: 8	Blender	No	3	3	62	80
Steamed	-	-	Steam oven	No	6	8	73	104
Boiled	-	-	Pan + water	No	6	8	91	110
Stir-fried	-	-	Wok pan	Yes	8	8	202	219
Grilled	Steam: 6	Steam: 6	Grill	No	5	3	142	168
Deep-fried	-	-	Deep-fat fryer	Yes	2½	2½	407	683

flavour-enhancing or any flavour-masking effects. Small portions (~ 50 grams) were put into isolating foam cups with a lid to ensure that the vegetables would stay warm for about 20 minutes.

Fifteen students came twice to our university to generate sensory attributes for the vegetables, once for carrots and once for French beans. The students received all six different preparation methods at the same time. A written guide was provided, which prompted separate focus on appearance, texture and taste. The students were asked to describe as many differences and similarities as possible between the vegetable samples regarding appearance, texture and taste [27, 29]. Water and crackers were provided for palate cleansing.

The attribute generation resulted in almost 50 different attributes for each vegetable, almost equally distributed over appearance, texture and taste. Fifteen attributes, five for each modality, were selected for inclusion in the analytical questionnaire. This selection was based on the most frequently mentioned attributes and on expected discrimination among the preparation methods.

Procedures

Baseline questionnaire

Before the start of the study, participants received a questionnaire at home with questions regarding age, gender, general liking for, and habitual intake of, carrots and French beans. Familiarity with the different preparation methods was assessed via the question: How are the carrots (French beans) usually prepared? Participants could mark one or more options from the six preparation methods (seven for carrots because raw was included as well). For the young adults, food neophobia was assessed with the 10-item Food Neophobia Scale [30], whereas the 6-item version was used for the children [31, 32]. Parents completed the questionnaire for their children; the young adults completed the questionnaire themselves.

Taste session

The children were familiarized with the researchers and Birch's rank-order procedure [33] during an introductory visit at their school. The taste sessions took place in a restaurant setting (Restaurant of the Future, Wageningen), where some cuddle animals and toys were placed to encourage a child-friendly atmosphere. To offer an age-appropriate program that would suit children's shorter attention span [34], the tasting was embedded in a school excursion. During this excursion, the children tasted carrots and French beans in two separate rounds that were alternated with physical activity games and nutrition-related educational activities.

During the taste session, the children were seated separately at tables and were guided individually by a research assistant trained for this purpose. The research assistant explained the rank-order procedure and practiced with the child. Then, the six foam cups with the six preparations of one vegetable were placed on the child's table. The child randomly tasted a sample and indicated to which smiley face the sample belonged (like, neutral, dislike). Water and crackers were provided for palate cleansing between the samples. After all six samples were categorized, each smiley face was inspected again. The child tasted the samples in the like category again and indicated the best liked sample, which was then removed. This was repeated for all samples in the like category and the two other categories, with a complete preference rank-order resulting (1=*best liked preparation*; 6=*least liked preparation*). No ties were allowed.

The young adults performed a similar ranking procedure for both vegetables, on two separate days with the vegetable order balanced. They received oral and written instructions and performed the taste session individually.

Analytical session

The young adults that participated in the taste session visited the restaurant a third time for the analytical test. The participants received oral and written instructions and were provided with water and crackers for palate cleansing. Each participant tasted the six samples for both vegetables in randomized order and rated the 15 attributes that were derived from the attribute generation concerning: *appearance* (orange/green; shiny; brown colouring; uniform surface; dry), *texture* (hard; crunchy; granular; well-done; falls apart easily) and *taste* (carrot/bean; fatty; watery; sweet; bitter). The 9-point scale ranged from 1=*not at all* to 9=*very*. The analytical session took about 30 minutes.

Statistical analyses

The statistical analyses were done using SPPS 15.0 and SAS 9.1, with a significance level of 0.05. Per age group, the mean ranks for the six preparation methods were

compared by Friedman's rank order test. The least significant ranked difference (LSRD) was calculated to assess significant differences for each pair of preference ranks [27]. Per preparation method, comparisons between the age groups were made using Kruskall Wallis. If significant, the age groups were pair-wise analysed with Mann Whitney tests.

Per vegetable, principal component analysis (PCA) was performed to examine the relationships between the six preparations and the fifteen attributes with the aim of exploring which attributes drive liking. In addition, partial least square (PLS) regression analyses were run with the rank-order scores as dependent variable and the mean attribute scores per preparation as the predictors, with the aim of exploring the attributes that predicted liking for each age group separately [35, 36]. The PLS models were based on a similar amount of explained variance in each age group ($R^2 \sim 93\%$) to justify comparison among the different age groups. Attributes with a VIP-coefficient (Variable Importance in Projection) above 0.80 were considered relevant [37]. For these PLS analyses, the rank-order scores were reversed so that higher scores indicated higher liking. Both PCA and PLS were performed, as consistency in both approaches would strengthen the findings.

Participant characteristics and attribute ratings were analysed using one-way ANOVA with Bonferroni as post-hoc test. For the attribute ratings, participant was included as random factor. Percentages were analysed by Chi-square.

RESULTS

Participant characteristics

Table 5.2 shows the participant characteristics. The age groups differed significantly in age ($p<0.0001$), BMI ($p<0.0001$), bean liking ($p=0.004$), carrot liking ($p=0.002$) and food neophobia ($p=0.002$). Carrot and French bean liking was lowest in the youngest children and highest in the young adults. Consumption frequency patterns did not differ according to age group (carrots: $p=0.41$; beans: $p=0.95$). The majority (50-60%) of the participants consumed the vegetables 1-3 times per month, whereas 25-30% consumed carrots and beans at least once a week.

Liking for the preparations

Mean rank-order scores for the different preparations of *carrots* are shown in Figure 5.1a. There was a main effect for preparation method in the youngest children ($p<0.001$), the 7-8-year olds ($p<0.001$) and the young adults ($p<0.001$), but not for the 11-12-year olds ($p=0.47$). Steamed and boiled were significantly preferred (lower ranks) over the other four preparations in the two youngest age groups. For the young adults, steamed was best liked of all preparations ($p<0.05$).

Table 5.2 Characteristics of the four age groups that evaluated the six vegetable preparations: mean ± SD

	4-6y	7-8y	11-12y	18-25y
N *	46	25	23	22
Boys/ girls	27/ 19	14/ 11	10/ 13	5/ 17
Age (years)	4.4 ± 0.7 [a]	7.3 ± 0.5 [b]	11.0 ± 0.3 [c]	21.2 ± 1.9 [d]
BMI (kg/m^2)	15.6 ± 2.5 [a]	16.2 ± 1.5 [a]	18.3 ± 2.9 [b]	21.1 ± 1.8 [c]
Neophobia score [s]	3.2 ± 1.0 [a]	2.8 ± 1.0 [ab]	2.7 ± 1.0 [ab]	2.2 ± 0.6 [b]
Carrot liking [s]	3.2 ± 1.4 [a]	4.0 ± 1.4 [b]	3.8 ± 1.2 [ab]	4.4 ± 0.7 [b]
Bean liking [s]	3.4 ± 1.3 [a]	3.8 ± 1.2 [ab]	3.5 ± 1.3 [a]	4.6 ± 0.8 [b]
Habitual carrot consumption				
Less than once a month	30%	20%	17%	9%
1-3 times a month	47%	48%	61%	50%
Once a week or more	23%	32%	22%	41%
Habitual bean consumption				
Less than once a month	13%	12%	17%	9%
1-3 times a month	56%	60%	52%	68%
Once a week or more	31%	28%	30%	23%

* N may be lower due to missing data (4-6y: N=35-46; 7-8y: N=21-25; 11-12y: N=14-23; 18-25y: N=22)

[abcd] Within rows, different superscripts indicate significant differences ($p<0.05$)

[s] Answer categories were on a 5-point scale from 1=*totally disagree* to 5=*totally agree*

Mashed and grilled were least liked (highest ranks) and differed significantly from steamed and boiled ($p<0.05$).

There was a main age effect for steamed ($p=0.04$) and grilled carrots ($p=0.009$). The young adults liked steamed carrots relatively more than the other three age groups (4-6y: $p=0.02$; 7-8y: $p=0.04$ and 11-12y: $p=0.009$). The young adults showed relatively lower liking for grilled carrots than the 4-6-year olds ($p=0.004$) and the 11-12-year olds ($p=0.008$).

Concerning the rank-order scores for *French beans* (Figure 5.1b), there was a main effect of preparation for all four age groups ($p<0.001$). Steamed and boiled beans were preferred in all four groups.

There was a main effect of age for grilled beans ($p=0.02$). The 7-8-year-old children showed relatively lower liking for the grilled beans than the 4-6-year olds ($p=0.009$) and the 11-12-year olds ($p=0.02$).

Characteristics of the preparations

For *carrots*, there were significant differences among the six preparations for all attributes (all $p<0.001$; sweetness $p=0.03$), except for bitterness ($p=0.27$; see Appendix 5.1). Steamed and boiled had comparable sensory profiles: an intense orange colour, hardly any brown colouring and highest score for uniform surface. They were medium hard, medium crunchy, scored high on carrot taste

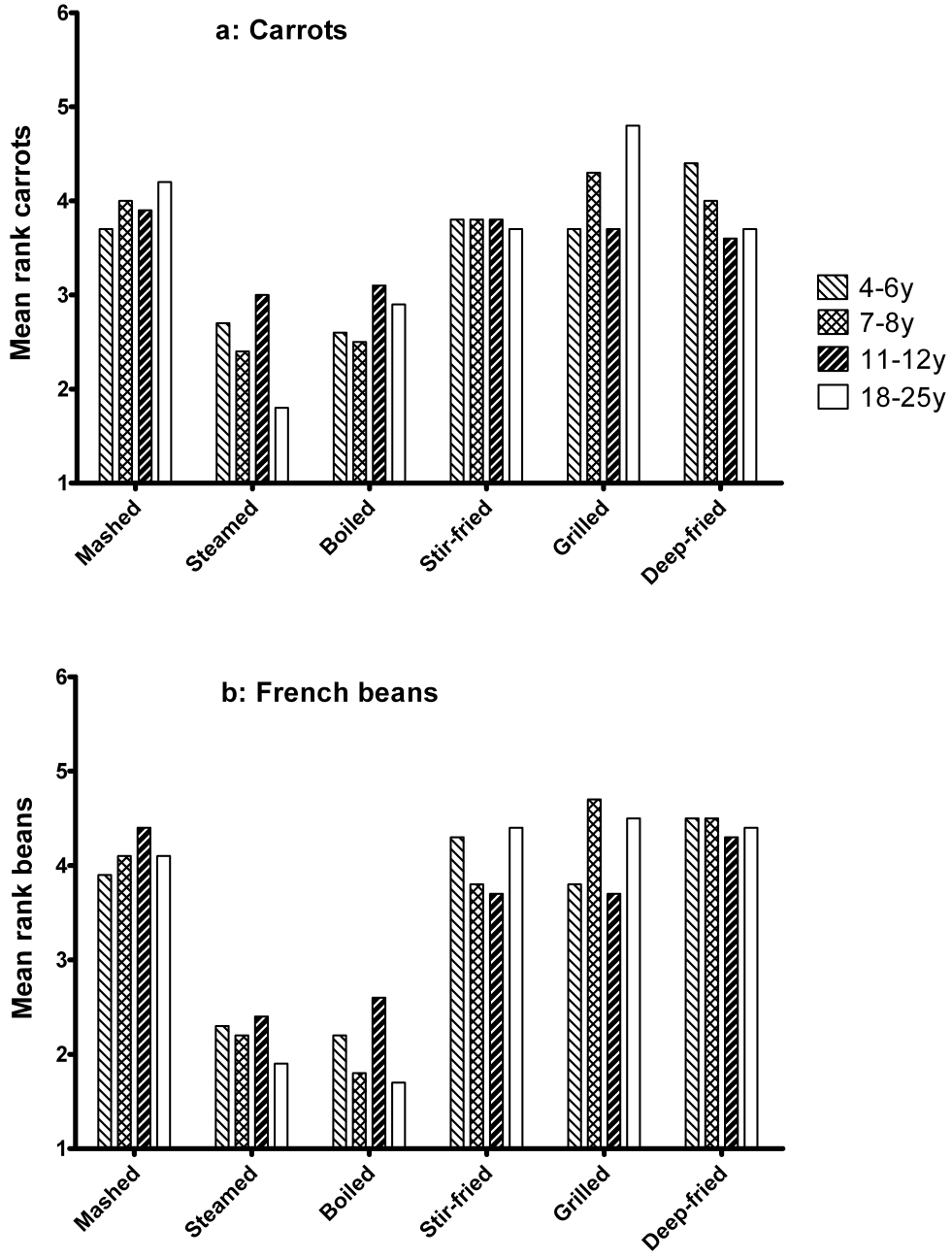

Figure 5.1 Mean rank-order scores (1=*best liked*; 6=*least liked*) for the six preparation methods for carrots (a) and French beans (b), separately for the four different age groups.

and low on fatty taste. Mashed was similar to boiled and steamed regarding the intense orange colour, no brown colouring, real carrot taste and no fatty taste. Compared with other preparations, mashed carrots scored highest on granular, well-done and falls apart easily, and lowest on hardness, crunchiness and dry appearance.

Stir-fried, grilled and deep-fried carrots scored relatively high on brown colouring. Stir-fried was perceived as hardest and most crunchy, with a medium fatty taste. Grilled and deep-fried carrots had highest scores for dry appearance, and lowest scores for uniform surface. Grilled was not shiny, relatively hard and scored medium on crunchiness. Deep-fried carrots scored highest on shiny and lowest on orange colour. They were not crunchy, but well-done and fell apart easily, with a fatty taste and sweeter than stir-fried carrots.

For *French beans*, the six preparation methods differed significantly for all attributes ($p<0.001$), except for sweetness ($p=0.49$) and bitterness ($p=0.15$; see Appendix 5.2). Steamed and boiled beans had comparable sensory profiles: a relatively intense green colour, hardly any brown colouring and highest scores for uniform surface. They were medium hard, medium crunchy, scored high on bean taste and low on fatty taste. Mashed had also a relatively intense green colour, hardly any brown colouring and no fatty taste. Compared with other preparations, mashed beans scored highest on granular and falls apart easily, and lowest on hardness and crunchiness.

Stir-fried beans were very shiny, brown coloured, with a relatively fatty taste. Grilled French beans were least shiny, brown coloured, and had the driest appearance together with deep-fried beans. Deep-fried beans were shiny and scored lowest on green colour and uniform surface, but highest on brown colouring. They were neither hard nor crunchy, but had the highest score for well-done. They scored lowest on bean taste and watery taste, and highest on fatty taste.

Familiarity with different preparations

Boiling was the most familiar preparation method for all age groups, followed by stir-frying. For carrots, 77-87% of the participants were familiar with boiled and 29-50% with stir-fried, whereas, for beans, 84-96% were familiar with boiled and 47-64% with stir-fried. It was also common to eat carrots raw, although this was less familiar in the younger groups (4-6y: 53%; 7-8y: 52%; 11-12y: 70%; young adults: 82%). A few participants were familiar with steamed carrots and beans (8-20%). Mashed carrots were most familiar to the youngest subjects (18%) and decreased with age (7-8y: 12%; 11-12y: 9%; young adults: 0%). Grilling and deep-frying were unfamiliar for both vegetables, and for beans, mashing was unfamiliar.

Attributes driving vegetable liking

PCA plots

In Figure 5.2, the relationships between the 15 attributes and the six preparations of *carrots* are depicted. The two dimensions explain 83% of the variance. The first dimension (R^2=45%) seems to relate to texture and the second dimension (R^2=38%) to appearance. The preferred preparations, boiled and steamed carrots, are relatively close in the plot, indicating that they are quite similar regarding their sensory characteristics. Both closely relate to uniform surface, carrot taste and orange colour. The textural attribute closest to these preparations is crunchiness. Stir-fried and grilled are also relatively close to each other, indicating sensory similarity. Mashed and deep-fried carrots are both different from all other preparation methods, as they are far away from other preparations in the plot.

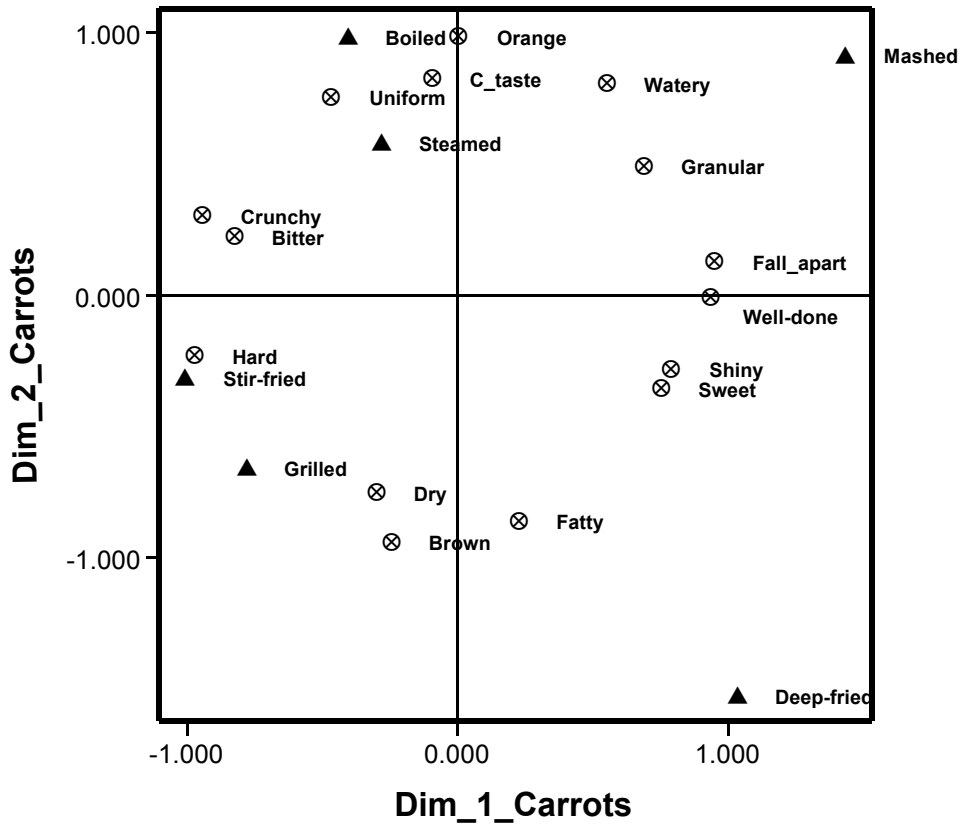

Figure 5.2 PCA plot of the 15 attributes (circles) and the six carrot preparations (triangles) with labels at right side of the symbols. For the attribute well-done, the label is at the lower right corner of the symbol.

Figure 5.3 shows the relationships between the 15 attributes and the six preparations for *French beans*. The two dimensions explain 79% of the variance. The first dimension (R^2=48%) seems to relate to appearance and the second dimension (R^2=31%) to texture. The preferred preparations, steamed and boiled, are a bit further away from each other in the plot compared with carrots. They are related to green colour, bean taste and uniform surface. Sweet taste seems to be more related to steamed beans. Crunchy and hard are the closest texture attributes and are more closely related to steamed than to boiled. Stir-fried and grilled are also further away from each other than in the carrot plot. Similar to carrots, deep-fried and mashed beans are both far from all other preparations, meaning that they are quite different in their sensory profile.

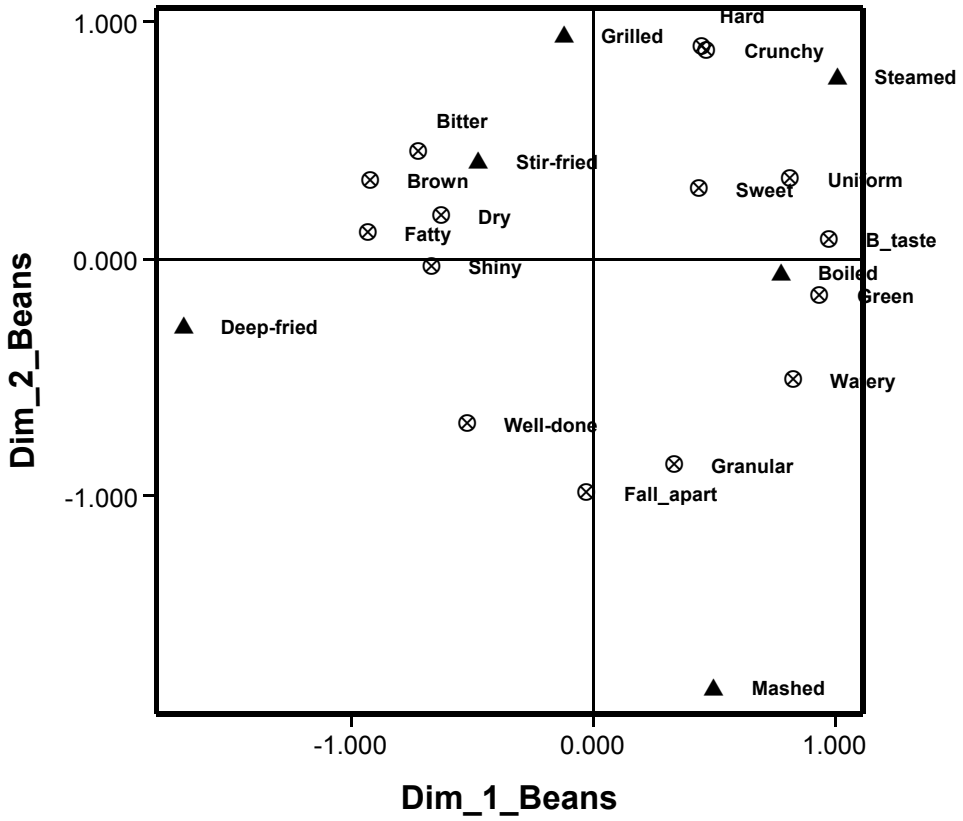

Figure 5.3 PCA plot of the 15 attributes (circles) and the six French bean preparations (triangles) with labels at right side of the symbols. For the attributes bitter and hard, the labels are at the upper right corner of the symbols.

Drivers of liking per age group

The predictors of *carrot* liking (Betas) for each age group are shown in Figure 5.4. For all age groups, a uniform surface and carrot taste were positive predictors of carrot liking, whereas brown colouring and falls apart easily were negative predictors. For the three oldest age groups, a granular texture predicted carrot liking negatively, whereas for the 4-6-year-old children, a fatty taste was a negative predictor. Shininess influenced liking positively in the 7-8-year olds and the young adults. In the 11-12-year olds, well-done was an additional positive predictor for carrot liking.

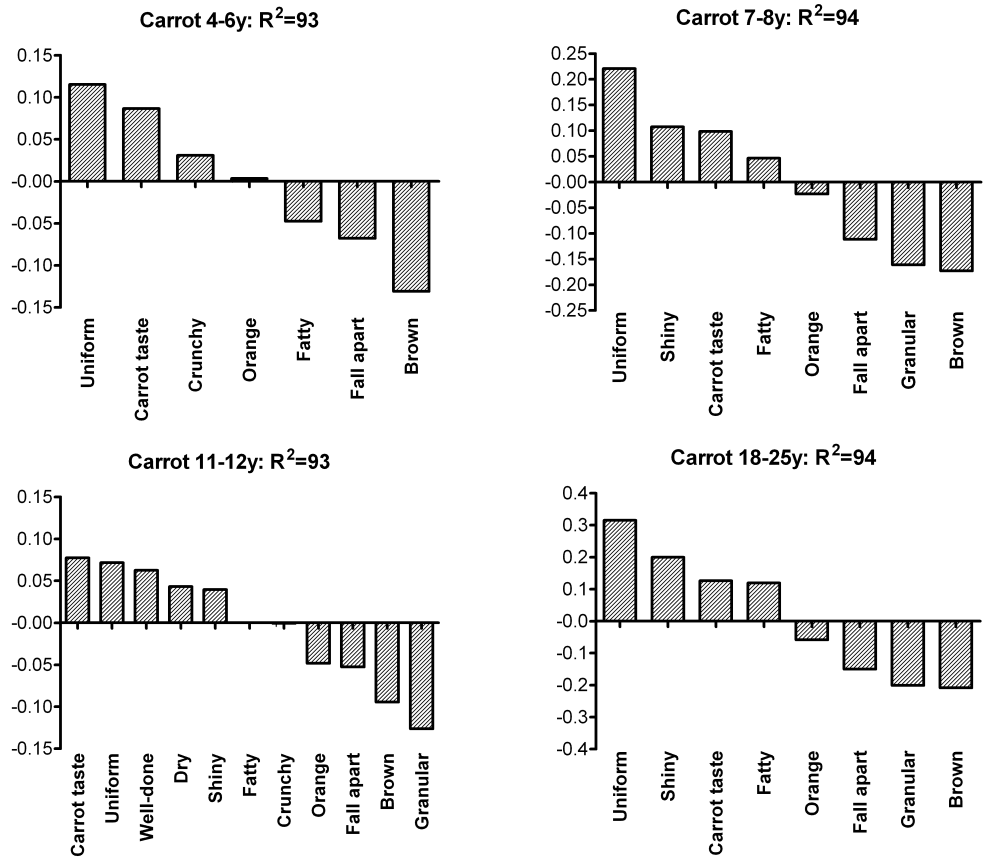

Figure 5.4 Predictors of carrot liking (Beta coefficients) based on partial least square regression analyses with the 15 sensory attributes as independent variables and the rank-order scores (1-6) as dependent variable for the four age groups separately. Rank-order scores reversed for analyses, so that higher scores indicate higher liking (1=*least liking*; 6=*best liking*).

The predictors of *French bean* liking (Betas) for each age group are shown in Figure 5.5. Brown colouring and granular texture negatively predicted bean liking, whereas a uniform surface positively influenced bean liking. Bean taste was a positive predictor in all age groups, but had relatively low Betas. Green colour was a negative predictor in 4-6-year olds and young adults. In the 7-8-year olds, shininess was an additional positive predictor, whereas dry appearance negatively predicted bean liking.

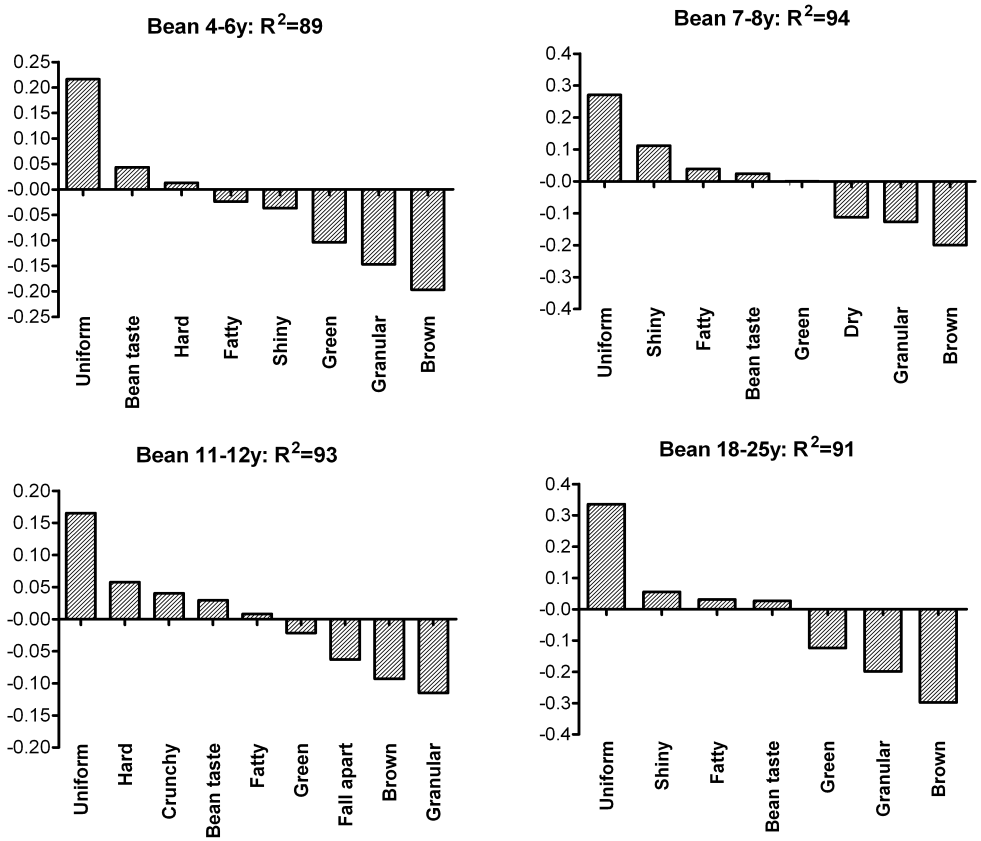

Figure 5.5 Predictors of French bean liking (Beta coefficients) based on partial least square regression analyses with the 15 sensory attributes as independent variables and the rank-order scores (1-6) as dependent variable for the four age groups separately. Rank-order scores reversed for analyses, so that higher scores indicate higher liking (1=*least liking*; 6=*best liking*).

DISCUSSION

The aim of our study was to investigate the effect of preparation method on children's liking for vegetables in different age groups. The study showed that the type of preparation influenced the liking of the vegetables, as steamed and boiled were preferred over mashed, grilled, stir-fried or deep-fried. This pattern of liking was similar for all age groups. The most preferred preparations, boiled and steamed, were related to a uniform surface, the typical vegetable taste and colour, and crunchiness. PLS regression analyses confirmed that a uniform surface without brown colouring was a positive predictor of vegetable liking.

It has been suggested that the type of preparation has a large impact on children's vegetable acceptance [1, 21, 22, 24, 26], but this has not previously been studied systematically in an experimental setting. Our study confirms this suggestion, as boiled and steamed were preferred above the other preparations. An explanation for this finding is that boiling was the most familiar preparation method [38, 39]. Steaming was less familiar, but had similar sensory characteristics as boiling. The importance of familiarity is also reflected in the appreciation of the typical vegetable taste.

Our hypothesis of larger liking differences among the preparations for the younger children compared with older participants could not be supported. Although the two youngest age groups showed larger liking differences than the 11-12-year olds for carrots, the carrot liking pattern for the young adults seemed more distinctive than for the children. In addition, the liking pattern for French beans was similar for all four age groups.

Our study showed that the presence of a uniform surface and the absence of brown colouring were important predictors of vegetable liking in all age groups. Other authors have confirmed that appearance plays an important role in children's expectations about vegetable acceptance [7, 18]. Various children, especially the young ones, mentioned during tasting that they did not like the brown colouring that was present on some of the vegetable preparations. Some of them selected the vegetable piece with least brown colouring for tasting.

The importance of a uniform surface and the undesirability of brown colouring may be explained by the desirability to have control over food placed in our mouth [18]. On the basis of a uniform surface, one may expect a homogenous food product, which may be easy to control in the mouth. In contrast, brown colouring and an irregular surface may indicate a less homogenous product, which may be more difficult to handle in the mouth.

Crunchiness appears to be a desired characteristic for vegetables in young children [1, 14], as confirmed by our PCA plots, where crunchiness was moderately related to the most preferred preparations. We had expected that deep-frying

would have resulted in crunchy vegetables, encouraging liking. However, this was not the case. The deep-fried carrots and deep-fried beans in our study scored low on crunchiness and hardness, and high on well-done. Although stir-frying has been suggested as an appealing and crunchy preparation for children's vegetables [7], stir-fried vegetables in our study were not crunchier than steamed and boiled. Perhaps shorter boiling times, which are common nowadays, have resulted in the vegetables retaining their crunch. In addition, the undesirable brown colouring on the stir-fried and deep-fried vegetables did not favour liking.

In contrast to the PCA plot, the PLS regression did not show the importance of crunchiness, but indicated that a granular texture and falls apart easily were negatively related to liking. Although a granular texture was not expected for mashed, mashed vegetables in our study scored high on both granular and falls apart easily, and were indeed not preferred. Falls apart easily appeared more important for carrots than for French beans and warrants further research. The importance of granular texture again offers support for the desirability to have control over food in our mouth [18], as a granular texture can induce choking. The difference between the PCA plot and PLS regression suggests that vegetable liking is not easy to clarify, since it is influenced by a complex mixture of various attributes that may not be independent.

Our study has limitations that should be considered for further research. First, we had no trained panel in our study, as trained panels for vegetables are scarce. Future research should work with trained panels, since their descriptions can be more precise [29]. In addition, the young adults that evaluated the vegetables on liking also participated in the analytical session. Although it would have been better to have different subjects, the taste session made the participants familiar with the different preparations. Moreover, the preference sessions were planned before the analytical sessions in order to have unbiased preference data.

Another limitation relates to the test situation. The vegetables were eaten in the morning; this is a bit unnatural and may have influenced liking [40]. On the other hand, the situation was similar for all participants and for all preparations, and we compared liking of the preparations within a vegetable. Therefore, we expect that testing in the afternoon or evening would not have changed the findings.

Finally, the preparations were tasted once. Because the stir-fried and deep-fried vegetables contained fat, these preparations could have induced flavour-nutrient learning when tasted repeatedly in larger amounts [9, 10]. In addition, some preparations were new for the children and may have been less liked due to their newness [21]. Longer exposure to the new preparations may have increased liking due to increased familiarity [38, 39]. On the other hand, familiarity was not completely in line with liking in our study, as stir-fried was relatively well-

known but was not preferred above grilled, deep-fried and mashed. Additionally, steamed was not familiar, but well-liked. It would have been interesting to include familiarity in the analyses, but because we measured familiarity with a relatively simple yes-no question, we could not include familiarity in the PCA or PLS analyses.

This is the first study to explore how different sensory characteristics of vegetables are related to liking among different age groups. Future research should confirm and extend our findings. It would be interesting to have raw vegetables included as a reference regarding liking and the sensory profile. In addition, familiarity should be measured at a more sophisticated level to be able to include it in the analyses. Food science could develop specific preparations or dishes that accentuate the perception of crunchiness in vegetables, that maintain the typical vegetable taste, while avoiding brown colouring and a granular texture. Adding seasonings or sauces, using different vegetable varieties or different harvest times may also be used to optimize the sensory characteristics of vegetables for children. Furthermore, it would be valuable to investigate whether better liked vegetable preparations also lead to higher vegetable intakes.

In conclusion, boiled and steamed vegetables were most preferred in all age groups. Vegetable liking was determined by a complex mixture of a uniform appearance, textures that are easily controllable in the mouth and the typical, familiar vegetable taste. Although future research should confirm our findings, our study indicated that it is promising to offer children vegetables that are as crunchy as possible, with the typical vegetable taste and a uniform surface without brown colouring and without a granular texture. Future research should statistically control for familiarity and should investigate whether better liked vegetable preparations lead to higher vegetable intakes.

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Appendix 5.1 Mean scores (± SD) for the 15 sensory attributes of the six preparation methods for carrots on a 9-point scale ranging from 1=*not at all* to 9=*very* (N=20)

	Mashed	Steamed	Boiled	Stir-fried	Grilled	Deep-fried
Appearance						
Orange colour	8.1 ± 1.4 ^{a}	7.0 ± 1.3 ^{ab}	7.5 ± 1.5 ^{a}	5.6 ± 2.0 ^{bc}	5.0 ± 1.9 ^{c}	2.8 ± 1.6 ^{d}
Shiny	4.8 ± 1.8 ^{ab}	3.4 ± 2.1 ^{bc}	3.3 ± 2.0 ^{bc}	3.7 ± 2.1 ^{b}	1.8 ± 1.5 ^{c}	6.1 ± 2.3 ^{a}
Brown colouring	1.3 ± 1.1 ^{a}	1.9 ± 1.9 ^{a}	1.3 ± 0.4 ^{a}	6.1 ± 1.9 ^{b}	6.0 ± 1.8 ^{b}	6.5 ± 1.9 ^{b}
Uniform surface	3.9 ± 2.6 ^{ab}	6.5 ± 1.2 ^{cd}	6.7 ± 1.7 ^{cd}	5.4 ± 2.0 ^{ad}	2.9 ± 1.7 ^{be}	2.1 ± 1.8 ^{e}
Dry appearance	2.9 ± 1.8 ^{a}	4.5 ± 1.5 ^{ab}	3.7 ± 1.8 ^{ab}	3.9 ± 2.0 ^{ab}	6.4 ± 2.3 ^{c}	5.4 ± 2.3 ^{bc}
Texture						
Hard	2.0 ± 2.0 ^{a}	5.4 ± 2.2 ^{bd}	5.4 ± 1.9 ^{bd}	7.4 ± 1.6 ^{c}	6.7 ± 1.9 ^{bc}	3.9 ± 2.1 ^{d}
Crunchy	3.1 ± 2.4 ^{a}	5.8 ± 2.3 ^{b}	5.8 ± 1.7 ^{b}	5.9 ± 2.0 ^{b}	5.8 ± 2.2 ^{b}	2.6 ± 1.5 ^{a}
Granular	7.2 ± 2.7 ^{a}	3.2 ± 2.4 ^{b}	3.3 ± 1.9 ^{b}	3.4 ± 2.0 ^{b}	2.8 ± 1.8 ^{b}	3.1 ± 2.4 ^{b}
Well-done	7.1 ± 1.7 ^{ab}	5.9 ± 1.4 ^{bc}	6.2 ± 1.8 ^{acd}	4.8 ± 2.1 ^{cd}	5.0 ± 1.7 ^{cd}	7.5 ± 1.6 ^{a}
Falls apart easily	8.3 ± 1.4 ^{a}	4.1 ± 1.9 ^{b}	4.3 ± 1.8 ^{b}	3.4 ± 1.9 ^{b}	4.2 ± 2.0 ^{b}	6.1 ± 2.1 ^{c}
Taste						
Carrot taste	6.5 ± 1.9 ^{ab}	7.6 ± 0.9 ^{a}	7.4 ± 1.2 ^{ab}	5.0 ± 1.9 ^{c}	6.0 ± 2.0 ^{bc}	4.9 ± 1.9 ^{c}
Fatty	2.0 ± 1.4 ^{a}	1.5 ± 0.6 ^{a}	1.5 ± 0.5 ^{a}	5.0 ± 2.9 ^{b}	2.5 ± 1.7 ^{a}	7.6 ± 1.7 ^{c}
Watery	5.7 ± 1.8 ^{a}	4.2 ± 2.0 ^{ab}	5.0 ± 2.4 ^{ac}	3.6 ± 1.9 ^{bcd}	3.3 ± 1.7 ^{bd}	3.7 ± 1.9 ^{bcd}
Sweet	5.6 ± 2.4 ^{ab}	5.5 ± 1.9 ^{ab}	4.7 ± 1.8 ^{ab}	4.5 ± 2.3 ^{a}	5.3 ± 2.2 ^{ab}	6.0 ± 2.1 ^{b}
Bitter	2.5 ± 2.0	2.6 ± 1.7	2.9 ± 2.0	3.2 ± 2.0	2.7 ± 1.9	2.3 ± 1.8

^{abcde} Within rows, different superscripts indicate significant differences ($p<0.05$)

Appendix 5.2 Mean scores (± SD) for the 15 sensory attributes of the six preparation methods for French beans on a 9-point scale ranging from 1=*not at all* to 9=*very* (N=21)

	Mashed	Steamed	Boiled	Stir-fried	Grilled	Deep-fried
Appearance						
Green colour	7.1 ± 1.7 [a]	6.9 ± 0.8 [a]	6.7 ± 1.7 [ab]	5.5 ± 1.9 [bc]	4.4 ± 2.0 [c]	1.4 ± 0.7 [d]
Shiny	4.0 ± 2.1 [a]	4.1 ± 1.9 [a]	3.6 ± 1.7 [ab]	8.3 ± 1.1 [c]	2.5 ± 1.5 [b]	7.3 ± 1.5 [c]
Brown colouring	1.4 ± 1.2 [a]	1.6 ± 1.2 [a]	1.8 ± 1.5 [a]	7.1 ± 1.4 [b]	6.7 ± 1.5 [b]	8.7 ± 0.7 [c]
Uniform surface	3.3 ± 2.5 [ab]	7.4 ± 1.3 [c]	7.5 ± 1.8 [c]	4.6 ± 2.4 [a]	3.4 ± 1.7 [a]	1.6 ± 0.9 [b]
Dry appearance	3.3 ± 2.0 [a]	3.1 ± 1.5 [a]	3.1 ± 1.4 [a]	2.6 ± 1.7 [a]	6.1 ± 1.9 [b]	6.1 ± 2.2 [b]
Texture						
Hard	2.2 ± 2.0 [a]	6.6 ± 1.7 [b]	5.2 ± 1.8 [bc]	5.0 ± 1.9 [cd]	5.9 ± 2.2 [bc]	2.9 ± 1.8 [a]
Crunchy	3.2 ± 2.5 [a]	6.5 ± 1.9 [b]	5.5 ± 1.9 [b]	5.4 ± 1.7 [b]	6.0 ± 1.8 [b]	3.6 ± 2.1 [a]
Granular	7.3 ± 2.0 [a]	2.9 ± 2.0 [b]	2.7 ± 1.5 [b]	2.4 ± 1.4 [b]	2.5 ± 1.3 [b]	2.3 ± 1.7 [b]
Well-done	6.8 ± 1.4 [ab]	5.4 ± 1.6 [c]	6.5 ± 1.5 [acd]	5.8 ± 1.9 [ac]	5.4 ± 1.7 [c]	7.5 ± 1.7 [bd]
Falls apart easily	8.5 ± 0.9 [a]	4.0 ± 1.9 [b]	5.2 ± 1.9 [bc]	4.2 ± 2.1 [b]	4.2 ± 1.9 [b]	5.9 ± 2.0 [c]
Taste						
Bean taste	6.3 ± 1.6 [ab]	7.6 ± 0.9 [a]	7.5 ± 1.1 [a]	4.1 ± 2.1 [c]	6.1 ± 1.6 [b]	2.2 ± 1.3 [d]
Fatty	1.3 ± 0.5 [a]	1.4 ± 0.7 [a]	1.3 ± 0.7 [a]	6.5 ± 2.4 [b]	2.6 ± 1.8 [c]	8.0 ± 1.3 [d]
Watery	5.5 ± 2.0 [ab]	4.4 ± 2.2 [acd]	5.0 ± 1.9 [bde]	3.9 ± 2.2 [ce]	4.1 ± 2.1 [bc]	3.1 ± 2.1 [c]
Sweet	4.1 ± 1.9	4.6 ± 1.7	4.0 ± 1.7	3.7 ± 2.3	4.4 ± 1.9	4.0 ± 2.6
Bitter	3.7 ± 1.9	3.7 ± 2.1	3.7 ± 2.3	4.2 ± 1.6	4.8 ± 2.3	4.5 ± 2.4

[abcde] Within rows, different superscripts indicate significant differences ($p<0.05$)

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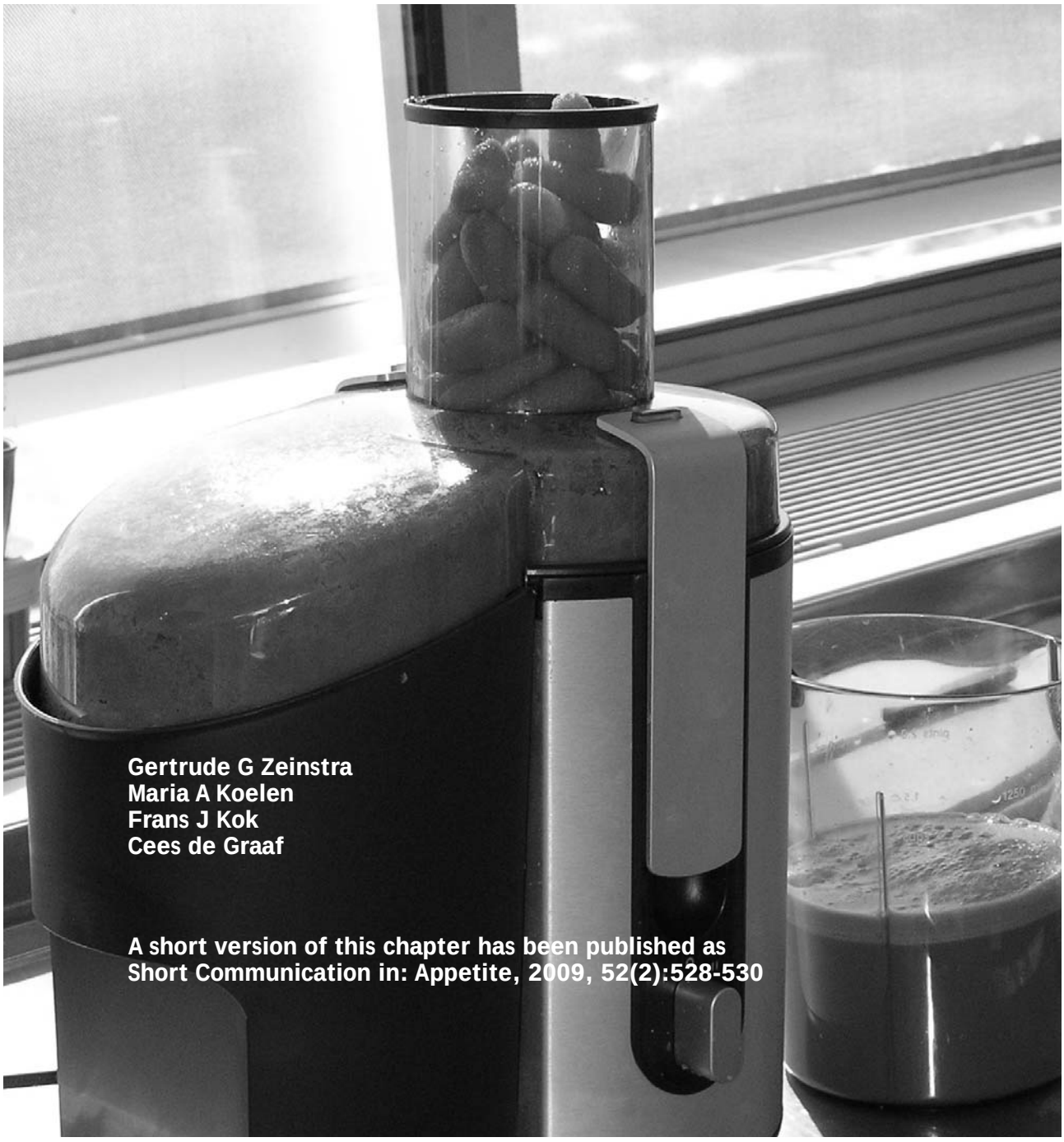
Children's hard-wired aversion to pure vegetable tastes: a 'failed' flavour-nutrient learning study



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6

ABSTRACT

Conditioning is an important mechanism for establishing food preferences. Although the basic principles for conditioning are well-known, less is known about the conditions under which this type of learning takes place. This paper aims to add to the knowledge of the essential conditions for flavour-nutrient learning with vegetable flavours. We describe a study which aimed to investigate whether flavour-nutrient learning is effective in increasing 7-8-year-old children's preference for vegetables (N=19). Their preference for, and consumption of, two different vegetable drinks was measured before and after a 14-day-conditioning period, using a within-subject design. Flavour-nutrient learning could not occur, due to insufficient consumption during the conditioning period: 2.4 grams (SD=5.6) for the high-energy drink and 3.0 grams (SD=9.3) for the low-energy drink. The high taste intensity, the perceived increase in bitterness, saltiness and thickness, and the unexpected combination of vegetables in juice form, may have caused the insufficient consumption. We hypothesize that the pure taste of a vegetable by itself is not acceptable. Mixing vegetables with other foods may lead to gradual acceptance of vegetables through flavour-flavour and flavour-nutrient learning. Future flavour-nutrient learning studies with children should use less intense vegetable flavours.

INTRODUCTION

Despite the health benefits, children's consumption of vegetables is below that recommended [1-3]. Dutch children aged 4 to 6 years consume on average 43 grams of vegetables per day, whereas the guidelines advise 100-150 grams per day for this age group [4]. Low vegetable consumption is probably due to a low preference for vegetables [2, 5-7]. Since preference is the most important determinant of children's food choice [3, 5, 8], we need to focus on increasing children's preference for vegetables in order to increase their consumption.

To facilitate this process, it is essential to understand how food preferences develop. Apart from the inborn preference for sweet and an aversion to sour and bitter [9], most food preferences are learned. Mere exposure is a relative simple learning process for establishing and altering food preferences. It is generally accepted that mere exposure can be effective in increasing children's preference for various foods, with 5 to 10 exposures needed [10, 11]. The food has to be tasted; merely looking is not sufficient [12]. Different experimental studies have shown that repeated exposure to a vegetable can increase liking and intake in infants and children aged 2 to 7 years. In these studies, the increase in vegetable intake ranged between 5 and 135 grams [13-16].

Conditioning is another important mechanism to acquire food preferences [17-21]. In the conditioning process, an association is established between the flavour of a food and the atmosphere of eating (social learning), a familiar and liked flavour (flavour-flavour conditioning) or the post-ingestive consequences (flavour-nutrient conditioning).

Social learning plays an important role in the formation of children's food preferences [22, 23]. This has been shown for vegetables as well. After three days of peer modelling, preschool children shifted their food choice from most preferred vegetable to least preferred vegetable and increased their preference for this least preferred vegetable [24].

Flavour-flavour conditioning with sucrose has been successfully applied to vegetables in children and in adults [25, 26]. In these studies, three or six pairings with sucrose were effective in increasing the preference for a target vegetable. However, the effect of flavour-flavour pairing on consumption was not measured in these studies. Some studies have shown that flavour-flavour learning is only effective in subjects that initially dislike the target food [25, 27], thus an initial dislike may be a prerequisite for successful flavour-flavour learning.

Flavour-nutrient conditioning is an important mechanism that predisposes children to prefer energy-dense foods [28]. This is confirmed by Gibson's analysis [29]: within the low-energy food category of fruit and vegetables, children prefer the fruits and vegetables with the highest energy densities. Various experimental

studies have shown that flavour-nutrient conditioning works well in children below the age of five years [30-32]. In these studies, fruity flavours and new tastes such as orange-chocolate, bubble-gum, maple-almond were associated with fat or carbohydrates in yoghurt drinks.

Flavour-nutrient conditioning has been successfully applied in adults as well [18, 33]. However, the evidence in adults is less convincing as some studies did not show an effect of flavour-nutrient conditioning [21, 34]. Reasons for not finding flavour-nutrient learning in adults may relate to prior experiences (pre-learned associations between a flavour and its energy content), awareness of the formation of an association or to the need state: flavour-nutrient learning with energy appears to be effective only in the hungry state [17, 18, 21, 32]. Additionally, there may be important, not yet understood factors, such as individual susceptibility or context effects, that influence the learning process [35].

Mere exposure, flavour-flavour learning and social learning are mechanisms that have been successfully applied to vegetable flavours among children. To our knowledge, flavour-nutrient conditioning has not been experimentally applied to vegetable flavours among children. Therefore, the aim of this study is to investigate whether flavour-nutrient learning is effective in increasing children's vegetable preference. We hypothesized that children's liking for the vegetable flavour paired with high energy would increase more over time than the vegetable flavour that was not paired with energy, but was repeatedly consumed.

If flavour-nutrient conditioning works for vegetables, then this may be a useful strategy that parents can apply at home to increase their children's vegetable preference and intake. It may be used as a bridge to overcome children's initial dislike for vegetables. After they have learned to like the vegetable flavour, the vegetables can be served in their low-energy version [30-32].

METHODS

Design

Before and after a 14-day conditioning period, ad libitum consumption of, and preference for, two vegetable drinks were compared, using a within-subject design (see Figure 6.1). After a first rank-order preference test with six vegetable drinks, two target flavours were selected per child. In seven conditioning trials, the children repeatedly received a fixed amount (150 grams) of the two different vegetable drinks. Per subject, one flavour was paired with high energy (HE) by adding maltodextrin, whereas the other flavour was paired with low energy (LE), where no maltodextrin was added. The children received the two drinks in random order (each drink 7x). The children were blind to the treatment, since they were not aware of which drink was high in energy and which drink was low

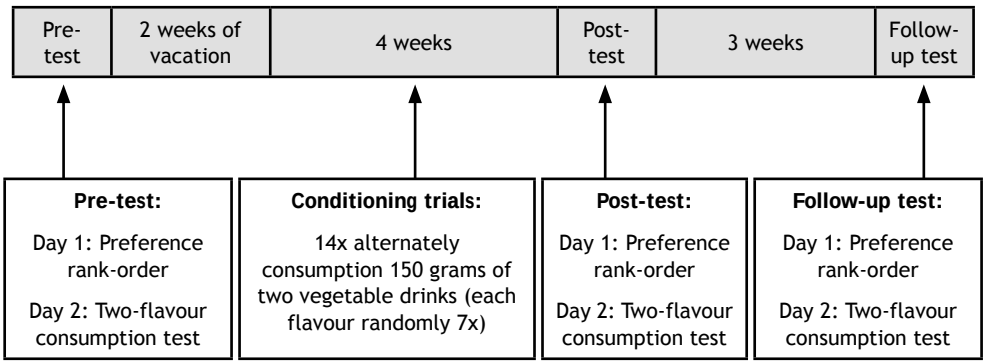

Figure 6.1 Design and timeline of the flavour-nutrient conditioning study in 7-8-year-old children.

in energy. Preference and consumption were measured again three weeks after the conditioning period to assess longer-term effects. The study protocol was approved by the Medical Ethical Committee of Wageningen University.

Subjects

Subjects were recruited via a primary school in Wageningen, The Netherlands. One class of 21 children aged 7-8 years participated in the study (N=21). The principal of the school and the teacher agreed to participate. Healthy children whose parents signed an informed consent, were allowed to join (N=19).

Vegetable drinks

For various reasons, we chose to use vegetables in juice form. Firstly, flavour-nutrient learning requires a novel flavour or a new flavour-product combination to be associable [21, 31, 32, 34], so vegetables in their regular consumption form were not suitable. Secondly, the flavour of the vegetable should serve as the conditioned stimulus, so it was essential to have a similar texture for all vegetables. Furthermore, neither the morning break nor the summer period was appropriate for a hot vegetable dish; and, finally, vegetable drinks could be prepared in advance and maltodextrin could easily be mixed into liquid products.

The vegetable drinks were prepared by squeezing fresh vegetables through a juicer (Philips hr 1861/00). Six flavours were used: cucumber, carrot, iceberg lettuce, red (bell) pepper, plum tomatoes and beetroot. The choice of these vegetables was based on practical preparation considerations and they are the most frequently consumed vegetable types among Dutch children [1].

To get a similar thickness for all drinks, water was added to the beetroot juice (juice: water = 2:1). Forty grams of maltodextrin (Fantomalt, Nutricia) were added

to 150 ml juice in order to get a HE version, resulting in an energy difference of 150 kcal between the HE and LE vegetable drink. Total energy content for the LE version of the six drinks ranged between 20 and 37 kcal per 150 ml. Aspartame was added to make the juices sweeter and, consequently, more acceptable to the children [36, 37]. To control for sweetness differences, the amounts were 0.087 grams/150 ml for the LE drink and 0.030 grams/150 ml for the HE drink.

Juices were prepared in the morning of the day of the test. After preparation, the juices were stored in labelled plastic bottles in the fridge (<7°C) and transported to the school in cool boxes.

Procedures

All testing with the children was done at school in the morning, during or around their habitual morning break (10h15), at which the children were used to eating and drinking something. On the test days, the children were asked not to bring their usual snack, as the vegetable drinks substituted their normal morning drink. Before the start of the study, the research team visited the school to introduce themselves, to teach the children about the basic tastes and to make the children familiar with the study procedures. No specific emphasis was given to the fact that vegetable drinks would be used.

Rank-order preference test

The children were tested individually in a room that was not their normal classroom. Birch's procedure with three grades of smiley faces was used to make a preference rank-order [38]. These three smiley faces, indicating *like*, *just ok* or *dislike*, were explained to the child and the procedure was practiced until the child understood it. The child was seated at a table and invited to taste the six vegetable drinks in random order. Each drink (60 ml) was offered in a white-blue-coloured cup with a lid and orange straw, to prevent visual cues. After tasting, the child had to place the drink on the smiley that indicated his liking for the drink. When all six drinks were placed in a liking category, the child was asked to taste the drinks within one category again, and indicate which one was best. This drink was removed and the child was asked which one was best then. This was repeated for each smiley face until all drinks were put into a complete rank-order.

Two-flavour consumption test

For each child, the drinks ranked three and four in the preference test were chosen as target drinks for that child. The middle ranks were chosen to ensure that the drinks could rise or drop in the preference rank-order. The two-flavour consumption test was applied in groups of six to seven children in a room where no teacher or other children were present. The children were offered an LE version of their two target drinks (150 grams each) and were invited to drink as

much as they wanted of each drink over a 20-minute period. The children could ask for more if they finished one of their drinks. To have a natural eat-and-drink situation, the children received something to eat: one piece of gingerbread (72 kcal; Albert Heijn) or, for the children who did not like gingerbread, soup dipper sticks (portion of 72 kcal; Star Grissini). The children were seated at a table and watched a movie in the meantime. Consumption of the drinks was measured by pre-weighing and post-weighing the cups.

Conditioning period

During the conditioning period, the research team visited the class room every morning at 10h15. When the children entered the class room after playing outside, each child's table was equipped with one cup of vegetable juice (150 grams), one cup of water for palate cleansing (150 grams) and one piece of gingerbread or soup dipper sticks (72 kcal). For each child, one of their two target flavours was randomly assigned to be the HE, on condition that within one vegetable flavour, there should be a HE version as well as an LE version in the study. The allocation of the HE and LE drink to each child was randomized across days, with the restriction that each flavour should be consumed at least once within a week.

The children were instructed to drink as much of the vegetable drink as they wanted, preferably the whole cup, while completing a questionnaire about different (sensory) characteristics of the drink: liking, sweetness, sourness, saltiness, bitterness and thickness. Liking was scored on a 5-point smiley scale including verbal descriptions ranging from *dislike a lot* to *like a lot*. The attributes were scored on a 5-point scale with the anchors *not at all* and *very*. A question on taste intensity was included as well. Because this question is more complex for children of this age, intensity was scored on a 3-point scale.

When the children had completed the questionnaire, they received an individual game task and were reminded to consume as much as they wanted from the vegetable drink. Since the piece of gingerbread was much less than the children usually consumed during the morning break, the children were also offered a healthy, popular snack each day, during the final five minutes of the procedure. This snack varied every day (fruit, a biscuit, skimmed yoghurt), but the energy content of the snack always ranged between 60 and 80 kcal. The whole daily procedure took about 20 minutes, after which the children received a sticker. The stickers served as encouragement and were converted into a diploma at the end of the study. Consumption of the vegetable drinks and water was calculated as the difference between post-weighing and pre-weighing the cups.

Parental questionnaire

Before the start of the study, parents completed a questionnaire about their child's age, weight, height, breastfeeding history, vegetable preference and food neophobia. Food neophobia was measured via six questions from the Food Neophobia Scale, as applied by Cooke, Carnell, and Wardle [39] and Wardle, Carnell, and Cooke [40]. As an indicator for vegetable preference, parents responded to the statement "In general, my child likes vegetables". Answer categories were on a 5-point scale where 1=*totally disagree* and 5=*totally agree*.

Statistics

Data were analysed with SAS 9.1, applying a significance level of $p<0.05$. A sum neophobia score was calculated by adding the scores for each neophobia question, with two questions reversed scored. A higher score indicates higher neophobia. During the first days of the conditioning period, three children had extremely high consumption values for the vegetable drink, and these were considered outliers. Their consumption value was replaced by the mean consumption value of that specific day.

A general linear model (GLM) with time, energy and the interaction of time*energy as fixed factors and subject as random factor was used to investigate the patterns of change in preference ranking and consumption. Preference ranking and consumption for the HE or LE drinks were compared between two measurement moments using a paired t-test. Time trends during the conditioning period for the dependent variables liking, consumption and the sensory attributes were tested using a GLM model (time, energy and the interaction time*energy as fixed factors, subject as random factor), as well as a model for the HE and LE condition separately. Tukey-Kramer was used as post-hoc test. Beta coefficients were calculated for those attributes showing a significant time effect for the seven conditioning days.

As a secondary analysis, a stepwise regression was performed with the data collected during the conditioning period: liking as the dependent variable and the sensory attributes as independent variables.

RESULTS

Subject characteristics

Seven boys and 12 girls participated in the study. Mean age was 7 years and 6 months (SD=4.6 months) and mean BMI was 16.7 kg/m^2 (SD=2.5), which is in line with a healthy weight [41]. Six children were exclusively breastfed at the age of three months, eight were exclusively formula fed and five children received breast and formula feeding at three months. Six parents agreed with the statement

that their child liked vegetables in general. Nine parents did not agree with the statement and four parents scored *neither agree nor disagree*. Children's mean neophobia sum score was 18 (SD=8; possible range 6-30).

Ranking of the vegetable juices at pre-test (1=*best liked*; 6=*least liked*)

During pre-testing, the best liked drink was cucumber with a mean rank of 1.7, followed by carrot (2.8) and iceberg lettuce (3.6). Plum tomato came fourth with a mean rank of 3.7 and the least liked juices were red pepper (4.1) and beetroot (5.0). One child did not finish the rank-order procedure, so these values are based on 18 children.

Liking and selection of target flavours

The flavours that came third and fourth in the preference rank order, were 2x cucumber, 6x carrot, 8x iceberg lettuce, 9x red pepper, 7x plum tomatoes and 6x beetroot. Mean liking during pre-test on the 3-point smiley scale was 2.2 (SD=0.8) for the flavour that was assigned HE, and 2.3 (SD=0.7) for the LE flavour, where 1=*like*, 2=*neutral* and 3=*dislike*. The distribution of liking scores for the two target drinks at pre-test on a 3-point scale are shown in Table 6.1. The majority of the children placed their target drinks in the neutral category of liking.

Consumption during the conditioning period

Figure 6.2 shows the vegetable drink and water consumption during the conditioning period. Mean consumption of the vegetable drink during the seven conditioning days was 2.4 grams (SD=5.6) for the HE drink and 3.0 grams (SD=9.3) for the LE drink. There was no interaction of time*energy and no main effect of energy or time in the combined GLM analysis. Consumption of the vegetable drink was far below 80% of 150 grams (=120 grams), a cut-off percentage that is typically used in flavour-nutrient learning studies with children [31, 32]. Because of this low consumption, it is not possible to have effects of flavour-nutrient learning. The remainder of the results section is focused on factors that may explain these low consumption levels.

Table 6.1 Frequencies per category of liking for the two target vegetable drinks during pre-test in Dutch children aged 7-8 years

	High-energy drink	Low-energy drink
Like (1)	4	2
Neutral (2)	7	10
Dislike (3)	7	7
Total	18 [a]	19

[a] One child did not complete the rank-order preference test during pre-test

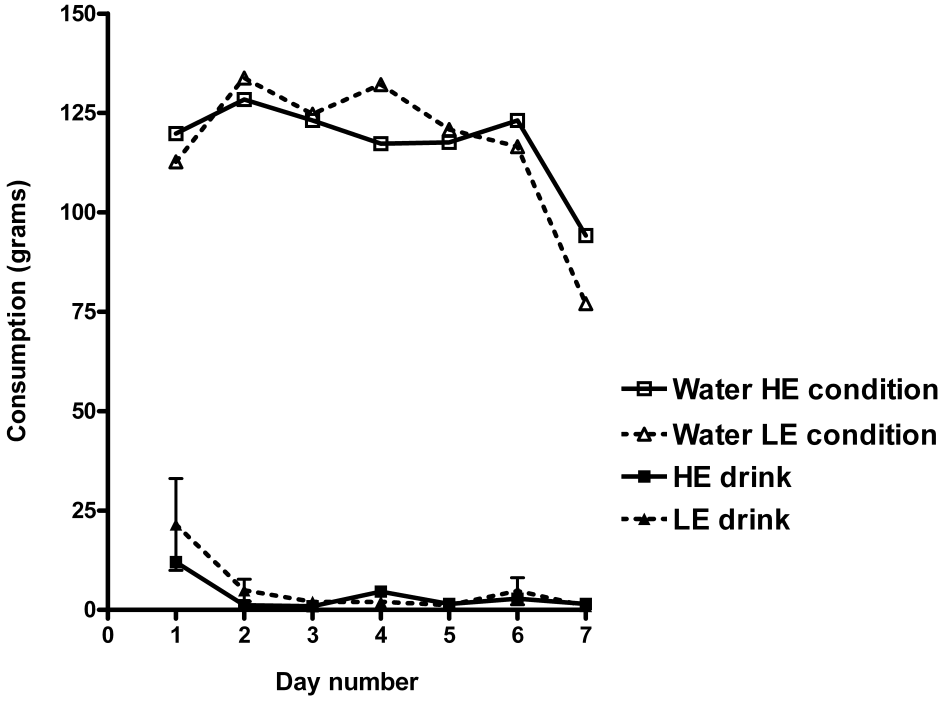

Figure 6.2 Consumption of the vegetable drink and water during the conditioning period in 7-8-year-old children, separately for the high-energy (HE) and low-energy (LE) condition.

During the conditioning period, mean water consumption was 118 grams (SD=49) for the HE condition and 117 grams (SD=51) for the LE condition. There was no interaction of time*energy and no main effect of energy in the combined GLM analysis. The time effect was significant: $F(6,31)=4.63$, $p=0.0002$. Water consumption was not significantly different on the seven conditioning days for the HE condition, whereas GLM showed a main effect of time for the LE condition: $F(6,24)=3.66$, $p<0.001$, due to lower water consumption on day 7.

Liking and consumption during pre-, post- and follow-up test

The mean preference ranks and consumption of the HE and LE drink before and after conditioning show no evidence for a mere exposure effect. Both drinks started intentionally at preference rank 3.5. There were no main effects, but the interaction effect of time*energy was significant: $F(2,23)=3.70$, $p=0.03$. For the HE drink, the changes in preference rank from pre-test to post-test and from post-test to follow-up were not significant. For the LE drink, the rank at follow-up

was significantly higher than at post-test (t=2.18, p=0.04), indicating a decrease in preference.

Consumption of the HE drink changed non-significantly from 4.5 grams (SD=8.6) to 1.9 grams (SD=3.8) to 2.6 grams (SD=3.5). For the LE drink, consumption varied non-significantly from 7.7 grams (SD=19.9) to 3.3 grams (SD=7.8) to 2.2 grams (SD=4.0). The main effects and the interaction effect of time*energy were not significant.

Liking and sensory attribute scores during the conditioning period

Mean liking of the vegetable drinks during the seven conditioning days was 2.2 (SD=1.4) for the HE drink and 1.9 (SD=1.3) for the LE drink (5-point scale: 1=*dislike a lot* and 5=*like a lot*). Children's liking for both drinks did not differ significantly among the seven conditioning days (see Figure 6.3a). GLM analyses showed that the HE drink was preferred above the LE drink (F(1,31)=4.87, p=0.03).

The children perceived the drinks as being very high in taste intensity. The mean score over the seven conditioning days was 2.7 on a 3-point scale (HE: 2.7±0.6; LE: 2.7±0.5). Taste intensity was high during all days (see Figure 6.3b). The other mean attribute scores over the seven days are shown in Table 6.2. The children perceived the drink as a little bit sour and salty. The scores for sweet, bitter and thickness are quite similar and indicate medium scores.

There were no significant interaction effects of time*energy for any of the attribute scores over the seven days. Neither were there any main effects for energy. Main effects for time were significant for saltiness: F(6,31)=3.21,

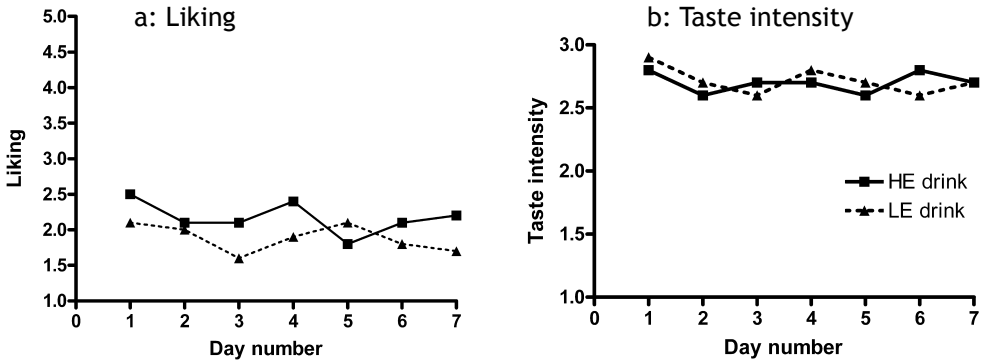

Figure 6.3 Liking (a) on 5-point scale, where 1=*dislike a lot* and 5=*like a lot* and taste intensity scores (b) on 3-point scale, where 1=*not at all intense* and 3=*very intense* over the 14-day conditioning period by high-energy (HE) and low-energy (LE) drink (N=19).

Table 6.2 Mean attribute scores (SD) over the seven exposure days in 7-8-year-old children by high-energy (HE) and low-energy (LE) drink, where 1=*not at all* and 5=*very* (N=19)

	Sweetness	Sourness	Saltiness	Bitterness	Thickness
HE	2.6 (1.6)	1.7 (1.1)	1.8 (1.1)	2.6 (1.6)	2.6 (1.5)
LE	2.6 (1.6)	1.7 (1.1)	2.0 (1.3)	2.9 (1.7)	2.7 (1.6)

p=0.048; for bitterness: F(6,31)=3.12, p=0.006; and for thickness: F(6,31)=5.26, p<0.0001.

For the HE drink, there were differences between the seven conditioning days for thickness: F(6,24)=3.30, p=0.005; and for saltiness: F(6,24)=2.74, p=0.02. Thickness (ß=0.16; p=0.02) and saltiness (ß=0.14; p=0.004) both became stronger with time. For the LE drink, there was a main effect of time for bitterness: F(6,24)=3.32, p=0.005; and for thickness: F(6,24)=2.58, p=0.02. Both bitterness (ß=0.19; p=0.009) and thickness (ß=0.17; p=0.01) intensified with exposure time. For all other attributes, there were no significant main effects of day for either the HE drink or the LE drink.

Predicting liking from the attribute scores

The final stepwise regression model explained 9.8% of the variance in liking and included three variables. Sweetness was a positive predictor, whereas saltiness and taste intensity were negative predictors of liking.

DISCUSSION

From our study, we cannot conclude that flavour-nutrient learning is not effective for vegetable flavours. Due to the low vegetable drink consumption during conditioning, it was not possible to have effects of flavour-nutrient learning. Consequently, both preference and consumption did not change from pre- to post-test. However, even though flavour-nutrient learning could not take place, we would have expected a mere exposure effect, which usually occurs after 5 to 10 exposures [10]. Contrary to exposure studies with vegetables that were effective in increasing intake and liking [13, 15, 16], there was no mere exposure effect in our study for either the HE drink or the LE drink. Below, we discuss the factors that should have favoured a successful implementation of the flavour-nutrient learning study, and the factors that may be additionally required when using vegetable flavours.

Firstly, the mean score for liking during pre-test for both the HE and LE drink was in the neutral category (2.2 and 2.3), indicating a fairly acceptable product. De Graaf et al. [42] have shown that an acceptability score of 4 or 5 on the

9-point hedonic scale (~neutral) related to a mean consumption level of 77% or 87% of served portions/dishes. In addition, during a pre-test with 25 children (not participants), where each child was asked to consume one cup of vegetable drink (150 gram), 50% of the children consumed at least 80% of the drink. This indicated reasonable acceptability, which was what we aimed for. It was not our aim to increase preference for already liked vegetables.

Secondly, the amount of 150 grams was less than most children normally consumed during their morning break, because a typical Dutch drinking carton contains 200 ml (~200 grams). Other flavour-nutrient learning studies, using nutty and fruity flavours, have successfully used amounts between 100 and 150 grams with younger children [30-32]. Both these aspects would suggest no problems in drinking 150 grams of vegetable drink.

Furthermore, we tested the children during their regular morning break in order to have children in a hungry state, which seems required for successful flavour-nutrient conditioning [18, 21, 32]. The high water intake and the consumption of the extra snack confirmed that the children were indeed hungry and thirsty. The children indicated on the study evaluation form that the context was very positive and that they enjoyed participating in the study, all of which argues for a positive shift in liking [22]. Finally, sweetening the drinks with aspartame should have made the drinks more acceptable, since sweetness is one of the most important determinants of liking in children [43].

There are a number of possible reasons why the children were not able to finish 150 grams of their vegetable drinks. The first reason relates to the high taste intensity. The children indicated that the pronounced vegetable taste was very intense. Children often like intense flavours [36, 44], but the intensity of these drinks may have been too high. This may also explain why children who stated that they liked the drink, were not able to finish 150 grams, as occurred six times (four children). Presumably, the flavour of the drinks became aversive after drinking more than a few sips. In other words, the drinks may have caused early sensory specific satiation, which occurs quicker with high intensities [45, 46].

This pronounced vegetable taste intensity may originate from two causes. To begin with, the juices were produced by squeezing vegetables through a juicer. This process partly destroys the cell structures leading to a higher flavour release, and the flavour may become more concentrated because the pulp mass is removed from the vegetable. In addition, the children took very small sips of the drinks, leading to a higher perceived oral sensory exposure [47].

A second potential reason for the low consumption relates to pre-learned associations. From experiences at home, the children may have developed associations between the vegetable flavours used in the study and the low reinforcement value

that is typical for vegetables, making it difficult to associate an even stronger vegetable flavour with positive post-ingestive consequences [17, 21, 30].

Thirdly, the children perceived a few attributes as becoming stronger with time: thickness of both the HE and the LE drink, saltiness of the HE drink and bitterness of the LE drink, although they consumed the same drink for seven days. Probably, the thickness and bitterness became gradually more aversive after repeated consumption and this prevented any increase in liking. Since saltiness was a negative predictor of liking in our regression model, the intensification of saltiness presumably hindered liking as well. These trends were unexpected.

A final reason for the low consumption relates to the use of a drink. In flavour-nutrient learning studies, it is common to use drinks [18, 30-32, 48] and a novel flavour combination is required. However, for our situation, drinks may have been inappropriate. Vegetable juices are consumed by a small number of the Dutch population [1]. Furthermore, it is the most unpopular juice among adults [49] and consumption is often related to dieting. So, for the children, consuming vegetables in juice form was a very new experience. In addition, the children may not have expected a drink to have a vegetable taste. For fruit, there are many common consumption forms and fruit flavours are used in many different foods: fruit juices, fruit purees (apple sauce), fruit biscuits, fruit yoghurts, candies or ice cream with fruity flavours. This is not the case with vegetables. So, the children in our study may have been surprised by this -for them- weird combination of vegetables as a drink. Together with the fact that the children in our study scored higher on neophobia compared to younger children in other studies [39, 50], this may explain the low acceptability of this novel vegetable form. Wrieden and Bürger [51] also found that new vegetable combinations, such as carrots with chocolate or pizza flavoured sweet corn, scored lower on acceptability than the plain vegetables.

Based on the results of this study, we hypothesize that the pure taste of a vegetable by itself is not acceptable. This is confirmed by the fact that vegetables are seldom eaten on their own. Usually, they are consumed in combination with staple foods such as rice and potatoes, sauces, cheese, butter or other seasonings [49]. Salads are often mixed dishes as well, with the addition of nuts, croutons, fruits and dressing. Vegetables are also consumed as ingredients in soup, where the vegetable flavour is diluted with bouillon. So, vegetables may only be well-accepted by humans when eaten in combination with other foods, the pure taste being too intense, especially for children.

Mixing vegetables with other foods in traditional meals may induce conditioning as well. Depending on the energy content of the foods that come with the vegetables, flavour-flavour or flavour-nutrient learning may occur. This may be one means of how humans slowly learn to accept vegetables.

Lessons learned for future research

For child conditioning studies with vegetable flavours, vegetables in concentrated juice form seem inappropriate as this combination is too novel and too intense for children. Using diluted or masked vegetable flavours, such as vegetable soups, vegetable pies or vegetable sauces, may be more suitable for children. Further research should investigate whether more diluted vegetable flavours can be associated with the positive post-ingestive consequences of energy and which age group is most responsive to flavour-nutrient learning with vegetables.

Another interesting research topic would be to study children's preferences for vegetables prepared with different seasonings or recipes. Certain vegetable combinations may be more attractive than others [27, 51] and this is worth investigating. In our study, we sweetened the vegetables, but it would also be appealing to use savoury flavourings, such as herbs, spices and sauces.

In conclusion, insufficient consumption during the conditioning period of this study prevented a flavour-nutrient learning effect for vegetable flavours, despite the fact that the prerequisites for an effective flavour-nutrient conditioning study were met. The high flavour intensity, the perceived increase in bitterness, saltiness and thickness, and the unexpected, novel combination of vegetables in juice form, were probably the causes of the low consumption. As the pure vegetable taste in itself is too intense for children, mixing vegetables with other foods is a good strategy that stimulates flavour-flavour and flavour-nutrient learning, which, in turn, may lead to a gradual acceptance of vegetables.

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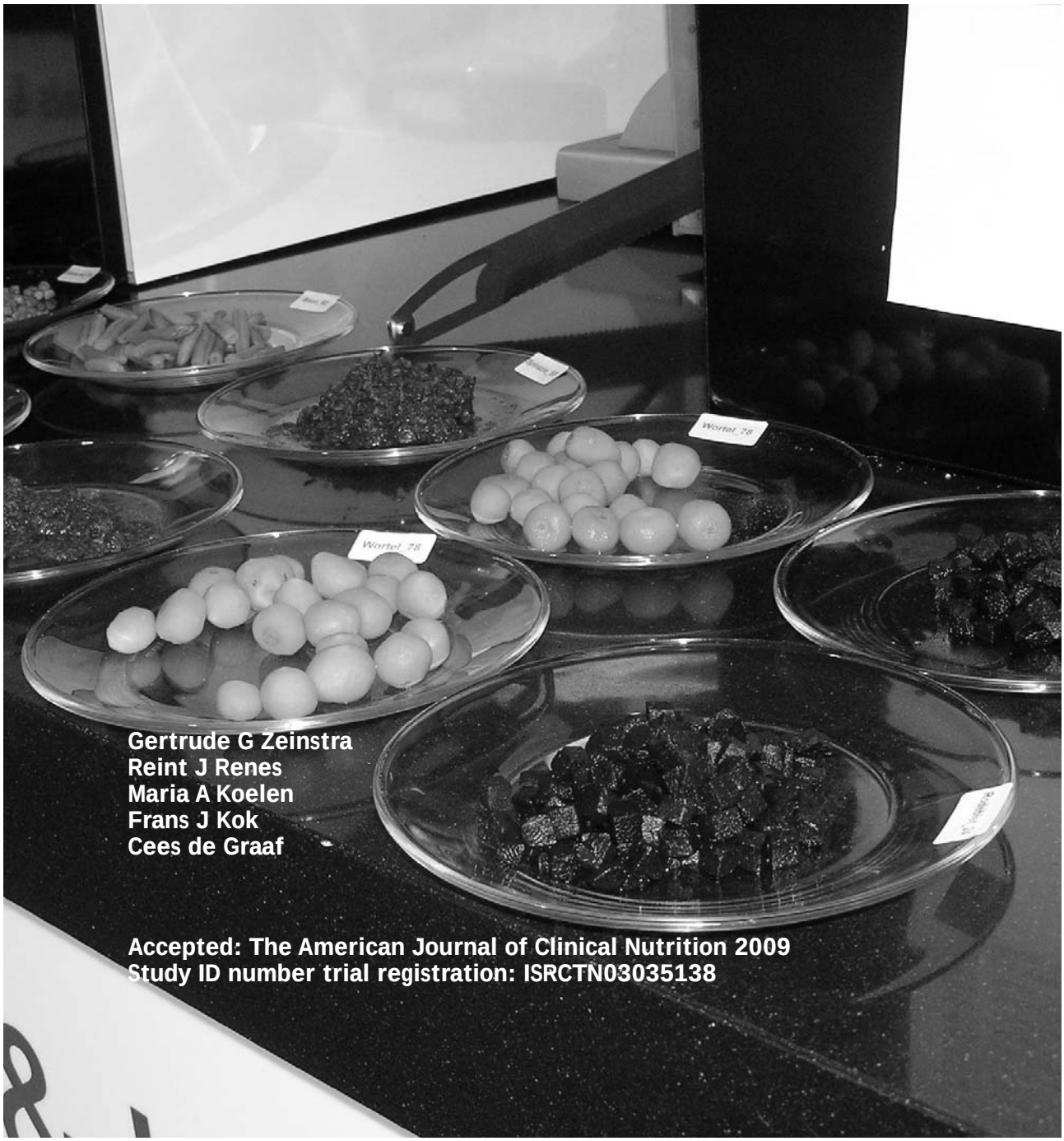
Offering choice and its effect on Dutch children's liking and consumption of vegetables: a randomized controlled trial



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ABSTRACT

Background: Children's vegetable consumption is below that recommended. Stimulating children's feelings of autonomy by offering a choice may be a valuable strategy to increase their vegetable liking and consumption, according to self-determination theory. The effect of choice-offering on children's vegetable liking and consumption has not yet been studied.

Objective: To investigate whether having a choice between two vegetables enhances children's vegetable liking and consumption.

Design: 303 children aged 4-6 years were randomly assigned to one of three dinner conditions. Two similarly liked vegetables were presented, after which the child had no choice, a pre-meal choice, or an at-meal choice. Subsequently, the dinner was consumed with one parent. Comparisons between the three conditions regarding children's meal experience, vegetable liking, and consumption were made using ANOVA and Kruskall Wallis.

Results: Children's vegetable consumption did not differ ($p=0.54$) among the conditions: 56±45 grams in the no-choice condition, 51±46 grams in the pre-meal-choice condition, and 49±47 grams in the at-meal-choice condition. In the no-choice condition, high reactant children consumed less vegetables (45±42 grams) than low reactant children (73±43 grams; $p=0.04$). Vegetable liking was similar in all three conditions ($p=0.43$). Children appreciated being able to choose in the pre-meal-choice condition.

Conclusion: A pre-meal choice between two vegetables was appreciated by the children, but did not increase their vegetable liking and consumption. No choice decreased vegetable consumption in high reactant children. Future research should investigate the effects of choice-offering in the long term and in more familiar eating settings.

INTRODUCTION

Since most children do not meet the recommendations for vegetable intake [1-3], it is necessary to find easily applicable and innovative strategies to encourage children's vegetable consumption. One such strategy may be to provide children with a choice during vegetable eating.

The provision of choice leads to feelings of autonomy and a sense of personal control, and this in turn increases intrinsic motivation, according to self-determination theory [4-7]. More intrinsic motivations have been related to multiple psychological and behavioral benefits, such as improved performance, higher interest, liking and enjoyment, more positive affect, greater satisfaction, and better health [5-11].

The absence of choice leads to a variety of detrimental outcomes on intrinsic motivation, life satisfaction, and health status [5, 6]. When people experience the environment as controlling, and perceive that choice is absent or removed, intrinsic motivation decreases. They experience feelings of reactance and feel a tendency to oppose in order to restore their freedom [12-15]. These effects may be stronger for high reactant persons who are more sensitive to the psychological pressure that results from attempts by others to influence them [12, 13].

Choice-offering has rarely been used to encourage children's vegetable consumption. In a previous survey study, the parental strategy 'Choice' was positively associated with children's vegetable consumption [16]. A few other studies indicate that choice may be beneficial for children's vegetable consumption [17, 18], but these studies were not specifically designed to study the effect of choice-offering as such.

Therefore, our study was designed to test the hypothesis that providing children with choice in a restaurant setting leads to a higher vegetable liking and intake compared to having no choice. We expected that children presented with a choice would experience feelings of autonomy, and that this would result in less reactance and higher intrinsic motivation. Together with a more pleasant eating atmosphere [19], their vegetable liking and intake may increase. Since variety may increase intake as well [20, 21], we included a third condition that included both choice and variety.

SUBJECTS AND METHODS

Design

Our study was a randomized controlled experiment in a restaurant setting with three conditions varying in the degree of choice concerning vegetable eating. In the no-choice condition, the child was randomly assigned one of two vegetables (N=96). In the pre-meal-choice condition, the child could choose one out of two

vegetables before the meal (N=110). In the at-meal-choice condition, the child had a choice between two vegetables during the meal as well as variety, since both vegetables were served on the child's plate (N=97). Parent-child couples visited our restaurant to have a typical Dutch dinner. To prevent a high drop-out rate and an unnatural situation for the children, a between-subject design was chosen.

Twelve weekdays spread over three weeks (4x3) were scheduled for the dinners. The three conditions were randomly assigned to the twelve days (one condition per evening), with the restriction that each week included all three conditions and each condition occurred once on every weekday. The study protocol was approved by the Medical Ethical Committee of Wageningen University.

Subjects

Four to six-year-old children and their parents were recruited via six primary schools in Wageningen (The Netherlands) and the surrounding area. This young age group was chosen because this age marks a transition phase in The Netherlands; from the age of four, children start attending primary school and have to become more independent than before. Furthermore, choosing within the vegetable-eating context is expected to be a more important freedom for younger than for older children [12]. Additionally, it is expected that the beneficial effect of choice will be greater in younger children who experience fewer opportunities to make choices than older children [6].

Our sample size calculation was based on a significance level of p=0.05, a power of 80% and an SD of children's vegetable consumption of 36 grams [2]. The expected difference between the conditions was set at 15 grams (=10% of recommended 150 grams). Ninety subjects were required per condition.

Four hundred seventeen parents received an information pack. They were informed that the study was about presenting vegetables in various ways and children's meal experience. Three hundred twenty six parents (78%) signed the informed consent for themselves and their child(ren).

It was not possible to make a dinner appointment with 14 of the parent-child couples. Nine parent-child couples had to cancel their appointment due to illness or other unexpected reasons. Consequently, 303 parent-child couples (73%) had dinner in our restaurant. The group consisted of 156 boys (51%) and 147 girls (49%) with a mean age of 5.2±0.7 years.

Procedures

Preference assessment

To determine target vegetables at an individual level, children's vegetable preferences were assessed at school using Birch's [22] preference rank-order method. After an explanation in the class room, the children were individually assisted by a trained research assistant to make their own preference rank-order in a separate, quiet room.

Each child was shown eight vegetable pictures in random order: carrots, peas, cauliflower, broccoli, red cabbage, beets (beetroot), French beans, and spinach. These vegetables were selected for two reasons: 1) most eaten vegetables by 4-6-year-old Dutch children [23] and 2) vegetables fitting into a typical Dutch meal consisting of potatoes, meat, and vegetables.

First, each child categorized the vegetable photos into three categories of liking (like, neutral, or dislike), represented by three smiley faces. Subsequently, the child indicated the best liked vegetable of the like category. This procedure was repeated for all vegetables in a category and for all categories until a complete preference rank-order was established (vegetable 1=*best liked* and 8=*least liked*). Uneaten or unknown vegetables were excluded from the preference data. This preference assessment was conducted again after the meal in the restaurant.

Selection of target foods

For each child, numbers three and four of the preference rank-order were selected as target vegetables because we aimed to include two vegetables that were approximately similarly liked and reasonably accepted by the child.

For each child, the type of staple food (starchy component), meat component, and dessert were selected on the basis of parental report of their child's acceptance. The standard was mashed potatoes (Henry, The Netherlands), canned sausages (Unox, The Netherlands), and chocolate-vanilla vla (a Dutch cold dessert comparable to custard; Boermarke, The Netherlands). If a child had dietary restrictions due to allergies, religion, or vegetarianism, or if the child really disliked the standard food, comparable alternatives were selected.

Parents received the same meal components as their child, except when parent and child had different dietary restrictions. Parents received larger portions of vegetables (200 vs 130 grams) and staple (250 vs 130 grams), whereas meat and dessert portions were kept similar for parent and child (60 grams meat; 150 grams dessert). In the at-meal-choice condition, participants received both vegetables on their plate, 65 grams of each for the children and 100 grams of each for the parents, making the served amount of vegetables similar in all three conditions (130 grams children; 200 grams parents). The served portion sizes were based on the recommended daily intakes in The Netherlands [24].

Meals at restaurant

Arrival times were 17h00, 17h30 or 18h00, comparable to children's regular dinner time. Parents had been asked not to feed their child one hour before the dinner session. Furthermore, they were asked to refrain from controlling the eating behavior of their child, from focusing on the vegetables, and from sharing food with their child during the meal. In this way, parental interference was kept as minimal as possible. To keep the situation natural, parents were advised to talk about topics other than eating, such as friends, school, and hobbies.

Trained research assistants guided a parent-child couple individually during the whole evening. Tables in the restaurant were nicely set, with placemats, cutlery, and napkins, and background music was playing softly. To minimize social interference, each parent-child couple was seated at their own table. Having provided a glass of water, the research assistant showed the child two plates with one of the child's target vegetables on each plate. While showing the plates, the research assistant said the phrase appropriate to the condition of that evening: *"Take a look [name child], today we have these two vegetables"*.

- **No-choice:** *"You are not allowed to choose, you'll get this vegetable".*
- **Pre-meal choice:** *"You are allowed to choose. Point out the vegetable you want to eat today. [child chooses] You want this one".*
- **At-meal choice:** *"You are allowed to eat them both".*

The final sentence for all conditions was: *"I will bring your plate in a second"*.

After that, the research assistant served the right potato-meat-vegetable plates to parent and child with the phrase *"Enjoy your meal"*. There was no pressure to clean the plate, and eating time was not restricted. No second servings were provided in order to have a similar situation for all children (parents were informed about this beforehand; none of the children asked for more food). Once the parent and child had finished eating, they turned over a notice (from the side which said "We are eating" to the other side which said "We have finished eating") at the edge of the table. The research assistant then picked up the plates and brought these to the weighing kitchen (out of view of participants).

Subsequently, the personal research assistant sat down at the parent-child couple's dinner table. While the parent filled in a questionnaire about the meal, the research assistant interviewed the child, using three smiley faces. The child-questioning ended by once again establishing the preference rank-order for the eight vegetable photos. When parent and child were both finished, the dessert was served. On finishing their dessert, they could leave the restaurant and received a small present to thank them for their participation.

Measurements

Parental home questionnaire

Before the study, parents completed a questionnaire at home about their child's acceptance of various types of dinner components (staple, meat, vegetables, desserts), parental and child dietary restrictions concerning allergies, religion, or vegetarianism, the regular dinner situation (time and number of persons present), their gender, and their own and partner's education level.

Besides age, gender, weight, and height, other child characteristics were included in the questionnaire, because vegetable intake is influenced by various factors and the study had a between-subject design. The personal characteristic of trait reactance was assessed via the Psychological Reactance Scale [25, 26]. The scale was adapted so that the parent was answering on behalf of the child ("My child finds …" rather than "I find …") and translated back-and-forward into Dutch through a translation agency (AVB Amstelveen, The Netherlands). Examples of scale items are: "My child becomes frustrated when he/she is unable to make free and independent decisions"; "My child becomes angry when his/her freedom of choice is restricted"; "Advice and recommendations usually induce my child to do just the opposite". The 6-item Child Neophobia Scale [27, 28] and the sections Restriction, Pressure, and Monitoring of the validated Child Feeding Questionnaire [29] were included, as well as a question about vegetable liking in general ("My child likes most vegetables"). Answer categories were on a 5-point scale ranging from either 1=*totally disagree* to 5=*totally agree* or 1=*never* to 5=*always*.

Intake

The amount of food – vegetables, staple, meat, and dessert – before and after the meal was weighed per component to the nearest 0.1 grams (Sartorius weighing scales MP1213/1203). Intake was calculated by subtracting the leftover weight from the weight served.

Liking

Liking was assessed via different ways. Parents reported their child's meal and vegetable liking on a 9-point hedonic scale (1=*dislike extremely*, 9=*like extremely*). The children indicated their liking for the three meal components using the three smiley faces (1=*dislike*, 2=*neutral*, 3=*like*). In addition, the children ranked the eight vegetable photos again in their order of preference, including their target vegetables (1=*best liked*, 8=*least liked*).

Parental questionnaire after dinner

Parents completed a questionnaire about their child's meal experience regarding meal atmosphere, situational reactance, motivation, and autonomy. The questions were derived from the interest/enjoyment, pressure/tension, and perception

of choice subscales of the Intrinsic Motivation Inventory [30] and the concepts regarding liking, motivation, task evaluation, autonomy, anger/frustration from the choice literature [6, 14, 31]. Answer categories were on a 5-point scale with 1=*totally disagree* and 5=*totally agree*.

Principal component analysis with varimax rotation confirmed the underlying meal experience concepts. The six identified factors (R^2=65%) are described in the next two sections in relation to the underlying concepts. The mean score was calculated of the items comprising the factor.

Meal atmosphere, situational reactance, and motivation

Meal atmosphere was measured via two concepts. The concept 'Pleasant atmosphere' consisted of four items (α=0.81): "My child enjoyed eating a meal in this restaurant"; "My child experienced the meal as pleasant"; "My child experienced sitting at this table as cozy"; "My child experienced eating in this restaurant as boring" (scores reversed). 'Tension' consisted of two items (α=0.72): "My child was nervous while he/she was eating" and "My child was relaxed tonight" (scores reversed). Situational reactance was operationalized [32] via 'Negative feelings', consisting of three items (α=0.59): "My child showed oppositional behavior during the meal"; "My child was frustrated due to tonight's situation"; "My child was restless due to tonight's situation". 'Motivation to eat vegetables' was assessed via two items (α=0.81): "My child was motivated to eat his/her vegetables" and "My child felt like eating his/her vegetables".

All children were asked about their experience regarding eating in our restaurant and the vegetable selection (choice) procedure. The three smiley faces were used, representing 1=*not enjoyable*, 2=*neutral*, and 3=*enjoyable*.

Autonomy and perception of choice

'Choice of type of food' was measured via two parent-reported items (α=0.54): "My child was allowed to choose which food he/she would eat during this meal" and "Before the meal, my child had influence on what he/she received to eat". The sixth concept was about autonomy concerning amount consumed: "My child had influence on the amount he/she ate during this meal".

Each child was asked who had chosen his or her meal. Children could give their own answer or were given the options: cook, parent, myself, assistant or somebody else. These parent and child-reported questions were used as a manipulation check.

Statistical analyses

All analyses were conducted using the statistical software SPSS 15.0 at a significance level of p=0.05. In the at-meal-choice condition, the average of both vegetables was calculated for liking and intake. Comparisons between the

three conditions regarding intake, liking, and meal experience were made by one-way ANOVA with Bonferroni as post-hoc test. The rank-order scores (rank 1-8) were analyzed non-parametrically with Kruskall Wallis and Mann-Whitney. Frequencies were analyzed with Chi-square. Pearson correlation coefficients were calculated between parent and child intake.

To examine moderator effects of baseline characteristics, children were divided into subgroups. These subgroups were included as a factor in the ANOVA model, or separate analyses per subgroup were conducted for the rank-order scores. On the basis of the children's trait reactance scores, the children were divided into three similar sized groups (high, medium, and low reactant). The same was done for age, neophobia, general vegetable liking, restriction, pressure, monitoring, and with two groups for gender. The effects of gender, restriction, pressure, and monitoring were not significant and are not reported.

RESULTS

Participant characteristics

Table 7.1 shows the characteristics of the children. There were no significant differences between the three conditions for age, anthropometry, neophobia, trait reactance, restriction, pressure, monitoring, and children's vegetable liking.

The majority of children in our study (78%) habitually consume dinner together with two parents and one or two siblings. The parents were relatively

Table 7.1 Characteristics of the children in the Dutch study about choice-offering and children's vegetable liking and intake: mean ± SD

	No choice	Pre-meal choice	At-meal choice	p-value
N total	96	110	97	
Boys/ girls (N)	46/ 50	66/ 44	44/ 53	0.08 [1]
Height (cm)	112.2 ± 6.4	113.5 ± 5.6	113.7 ± 7.2	0.67 [2]
Weight (kg)	19.6 ± 2.6	20.0 ± 2.9	19.7 ± 3.1	0.24 [2]
BMI (kg/m^2)	15.5 ± 1.7	15.3 ± 1.7	15.2 ± 1.7	0.59 [2]
Age (years)	5.1 ± 0.6	5.2 ± 0.6	5.2 ± 0.7	0.27 [2]
Vegetable liking [3]	3.3 ± 1.5	3.5 ± 1.5	3.4 ± 1.4	0.63 [2]
Neophobia [3]	2.8 ± 0.6	2.9 ± 0.6	2.9 ± 0.6	0.17 [2]
Trait reactance [3]	2.5 ± 0.7	2.4 ± 0.6	2.4 ± 0.7	0.75 [2]
Restriction [3]	3.1 ± 0.7	3.0 ± 0.6	3.0 ± 0.7	0.49 [2]
Pressure [3]	2.9 ± 1.0	3.1 ± 0.9	3.0 ± 1.0	0.53 [2]
Monitoring [4]	4.0 ± 0.9	4.0 ± 0.9	4.0 ± 1.0	0.92 [2]

[1] Chi-square
[2] One-way ANOVA
[3] Answers are on a 5-point scale, where 1=*totally disagree* and 5=*totally agree*
[4] Answers are on a 5-point scale, where 1=*never* and 5=*always*

highly educated: 5% had lower education (elementary/primary), 24% middle (high school/secondary) and 71% had high education (college/third level). The percentages were similar for the partners (6% low, 27% middle and 67% high). Mainly mothers completed the questionnaire (80%).

Manipulation check: autonomy and perception of choice

Parents reported a difference in autonomy among the conditions ($p<0.001$). The amount of autonomy (choice) was perceived highest in the pre-meal-choice condition (4.1±0.9), second in the at-meal-choice condition (3.3±1.3), and lowest in the no-choice condition (2.1±1.3).

The children recognized the choice manipulation as well. In the pre-meal-choice condition, the majority of the children responded that they themselves had chosen what they were going to eat tonight (77%), whereas this was 16% in the no-choice condition, and 8% in the at-meal-choice condition. These children answered most often that the assistant had chosen for them (no-choice: 46%; at-meal-choice: 35%). Chi-square was significant ($p<0.001$).

The manipulation of choice was experienced in relation to choice about what to eat; there were no differences in the experience of choosing how much to eat (parent-reported; $p=0.79$).

Intake

Table 7.2 shows the mean intake for the different meal components. There were no significant differences between the three conditions for child intake of vegetables ($p=0.54$), staple ($p=0.42$), meat ($p=0.54$), or dessert ($p=0.43$). Parental intake was not significantly different between the conditions either: vegetables ($p=0.55$), staple ($p=0.39$), meat ($p=0.14$), and dessert ($p=0.66$).

Parent and child intake was significantly correlated for vegetables ($r=0.22$; $p<0.001$), staple ($r=0.21$; $p<0.001$), and dessert ($r=0.20$; $p=0.01$), but not for meat ($p=0.30$).

Table 7.2 Mean intake of meal components in grams (± SD) for the 4-6-year-old children in the no-choice condition (N=96), the pre-meal-choice condition (N=110), and the at-meal-choice condition (N=97)

	No choice	Pre-meal choice	At-meal choice	p-value [2]
Vegetable	55.8 ± 45	51.3 ± 46	48.5 ± 47 [1]	0.54
Staple	47.4 ± 44	49.5 ± 47	41.3 ± 45	0.42
Meat	57.2 ± 14	59.0 ± 10	57.6 ± 13	0.54
Dessert	125.1 ± 34	123.2 ± 35	129.1 ± 27	0.43

[1] Mean of both vegetables: 25.1 + 23.4 grams
[2] One-way ANOVA

There was a main effect of age (p=0.001), neophobia (p=0.008) and general vegetable liking (p<0.001). Over all conditions, the youngest tertile of children ate less vegetables (41±39 grams) than the oldest children (65±47 grams; p=0.001). Children in the highest neophobia tertile ate less vegetables (41±42 grams) than children in the lowest neophobia tertile (60±47 grams; p=0.01). Vegetable dislikers ate less vegetables (31±37 grams) than medium vegetable likers (56±45 grams; p<0.001) and highest vegetable likers (69±46 grams; p<0.001).

In the no-choice condition, the three reactance groups differed significantly (p=0.03) in their vegetable intake. High reactant children consumed 45±42 grams of vegetables, whereas low reactant children consumed 73±43 grams (p=0.04).

Liking

There were no significant differences between the three conditions for children's liking of vegetables (p=0.43), staple (p=0.88), and meat (p=0.43), which was also true for the three reactant groups. There was a main effect of general vegetable liking (p<0.001). Vegetable dislikers appreciated the eaten vegetables less (1.9±0.9) than medium vegetable likers (2.3±0.8; p=0.004) and highest vegetable likers (2.4±0.8; p<0.001).

The rank-order score of the eaten vegetable was similar among the three conditions (p=0.10): no-choice 3.8±1.8, pre-meal-choice 3.5±1.8, and at-meal-choice 3.9±1.3. This was also true for high reactant children (p=0.07). The oldest tertile of children appreciated the eaten vegetable in the pre-meal-choice condition (rank: 3.1±1.6) more than in the at-meal-choice condition (4.0±1.3; p=0.02). For the vegetable dislikers, there was a main effect of condition (p=0.03). The eaten vegetable was least liked in the at-meal-choice condition.

Parents reported a significant difference among the conditions for the child's meal liking (p=0.05), measured on a 9-point scale. They reported a higher child-liking for the whole meal in the no-choice condition (mean=5.5±2.0) compared to the at-meal-choice condition (mean=4.8±2.1; p=0.045), with the pre-meal-choice condition in between (mean=5.2±2.1). The difference for vegetable liking was not significant (p=0.09).

Meal atmosphere, situational reactance, and motivation

Parent-reported mean scores for 'Pleasant atmosphere' were high in all three conditions (p=0.61): no-choice 4.2±0.7, pre-meal-choice 4.2±0.8, and at-meal-choice 4.1±0.8. Feelings of 'Tension' were low in all three conditions (p=0.57): no-choice 1.8±1.0, pre-meal-choice 1.7±0.9, and at-meal-choice 1.8±1.0. The children experienced hardly any 'Negative feelings' in the three conditions (p=0.29): no-choice 1.5±0.7; pre-meal-choice 1.7±0.7, at-meal-choice 1.7±0.8.

There was a main effect of trait reactance for 'Pleasant atmosphere' ($p=0.02$), 'Tension' ($p=0.02$), and 'Negative feelings' ($p<0.001$). Over the conditions, high reactant children scored lower on 'Pleasant atmosphere' and higher on 'Tension' and 'Negative feelings'. For 'Pleasant atmosphere', the neophobia*condition interaction was significant ($p=0.02$), and there was a main effect of age ($p=0.04$). The youngest tertile of children scored lower on 'Pleasant atmosphere' (4.0±0.8) than the medium age group (4.3±0.7; $p=0.056$), mainly due to the difference in the at-meal-choice condition ($p=0.01$).

Parents reported that the children in the pre-meal-choice condition were most happy with their choice situation ($p<0.01$). More children in the pre-meal-choice condition indicated that they experienced the amount of choice as very enjoyable: 75% compared to 63% in the no-choice condition and 62% in the at-meal-choice condition ($p=0.04$). The children enjoyed eating in our restaurant; there were no significant differences between the three conditions ($p=0.06$): no-choice 2.7±0.6, pre-meal-choice 2.8±0.5, and at-meal-choice 2.6±0.6 (measured on a 3-point scale). In the no-choice condition, high reactant children enjoyed eating in our restaurant less than low reactant children ($p=0.01$).

Children's 'Motivation to eat vegetables' was medium in all three conditions ($p=0.32$) as reported by the parents on a 5-point scale: no-choice 3.1±1.3, pre-meal-choice 2.9±1.4, and at-meal-choice 2.8±1.3. There were main effects of age ($p=0.02$), neophobia ($p=0.05$) and general vegetable liking ($p<0.001$). The youngest tertile of children was less motivated (2.6±1.3) than the oldest children (3.1±1.2; $p=0.01$), mainly due to a difference in the at-meal-choice condition ($p=0.04$). High neophobia children were less motivated (2.7±1.3) than low neophobia children (3.1±1.2; $p=0.03$). Highest vegetable likers scored highest on 'Motivation to eat vegetables' (3.4±1.2), medium likers second (2.9±1.3) and vegetable dislikers lowest (2.4±1.3). This was also true for all three conditions separately.

DISCUSSION

Our study showed no significant differences between the three choice conditions regarding children's vegetable liking and consumption, and the meal atmosphere was regarded as pleasant in all three conditions. Parents and children recognized our choice manipulation, and the children appreciated being able to choose. In the no-choice condition, high reactant children consumed less vegetables than low reactant children. Meal atmosphere was less pleasant for high reactant children over all conditions.

The children in our study enjoyed the act of choosing; this is in line with research showing that people feel happier when they have a choice [33]. However,

this enjoyment was not transferred to higher vegetable liking or consumption. One explanation may be the single exposure to the choice manipulation. Although various choice experiments have found positive effects after a single exposure [5, 6, 8], a longer period with multiple choice-offering opportunities may be needed for vegetables before effects on liking and intake become apparent. Since the children appreciated being able to choose, repeated vegetable consumption in this positive atmosphere should promote vegetable liking and intake [19, 34]. Second, the children were more excited about the restaurant setting than we had expected, and this may have overruled the impact of our manipulation. Third, there is a possibility that choice-offering is not effective in 4-6-year-old children. Although this age period marks a transition stage in The Netherlands, a choice manipulation may be more effective in older children or adolescents [14, 35]. The age effects regarding the rank-order scores, 'Pleasant atmosphere' and 'Motivation to eat vegetables' indicate that it would be worthwhile to undertake future research in other age groups. Finally, our power calculation was based on an SD of 36 grams [2], whereas the SD in our study was 46 grams. Since there was no trend in our data for vegetable intake (p=0.54), we expect that a bigger sample size would not have changed our findings.

Other studies have demonstrated that a high level of control - where no choice exists - leads to negative effects on children's eating behavior [36-38]. Our study has shown a strong and direct negative effect of no-choice in high reactant children. Their vegetable consumption in the no-choice condition was 28 grams lower than that of low reactant children, which corresponds to circa 50% of children's mean vegetable intake in our study. High reactant children experienced overall a more negative atmosphere and, in the no-choice condition, they enjoyed eating in our restaurant less than low reactant children. This is in line with previous work in adults [13]. Whereas our study confirms that high neophobia children [39] are at risk of low vegetable consumption, our results imply that high reactant children may also be more at risk, especially when choice is not offered.

We had expected highest vegetable intake in the at-meal-choice condition [20, 21], because both variety and choice were present on the children's plate. The parents reported highest autonomy for the pre-meal choice, second for the at-meal choice, and least for the no-choice condition. However, the children experienced only the pre-meal-choice condition as a real choice condition; the at-meal-choice condition did not represent a choice for them. This makes sense because, in the at-meal-choice condition, the children did not actively choose beforehand which vegetables they would get. Furthermore, the variety effect, which is based on attenuation of sensory specific satiety [20, 21], may not have occurred with a relatively small vegetable consumption of about 50 grams. Finally, the children in the at-meal-

choice condition may have believed that they had more vegetables, simply due to the fact that there were two vegetables on their plate [40]. This perception of a huge amount of vegetables may have hindered their intake. Our analyses regarding the rank-order scores, 'Pleasant atmosphere' and 'Motivation' confirm that the at-meal-choice condition was perceived as the least desired situation.

The parent-reported higher meal liking for children in the no-choice condition compared with the at-meal choice was also unexpected. Perhaps children's arousal plays a role here [41]. The excitement about eating in a restaurant may have led to high arousal levels in the children. Simply receiving one vegetable without a choice may have diminished this arousal, and parents may have interpreted this as higher meal liking.

The significant parent-child correlations for intake suggest that parental influence was present. Although we reduced parental influence as much as possible by instructing the parents about what they were, or were not, to do, parental modeling could not be prevented. Although the strategy of providing choice is an excellent opportunity for positive parenting [35] that can be beneficial in itself [19], parents may use a specific practice in combination with other practices [42] or within a parental style [43, 44]. Future research may control for parental strategies in which choice-offering is embedded.

A strength of our study was a high participation rate (73%). In addition, children's target vegetables were assessed on an individual basis to control for liking, which is essential in choice experiments [45]. Moreover, the control participants were explicitly denied a choice and were made aware of the choice alternatives, no reward external to choice was included, and choice overload because of too many choice alternatives was prevented [6, 10].

Since choice is valued differently in more socially interdependent cultures [5], future studies should focus on other populations besides high educated subjects from western cultures. The concepts 'Situational reactance' and 'Choice of type of food' had relative low reliability. Hence, the questions regarding meal experience should be validated in other studies. In order to measure trait reactance in the children, we adapted the Psychological Reactance Scale from a self-report measure to a parent-reported measure. Validation of this parent report of children's reactance is required.

As this was the first study about the effect of choice-offering on children's vegetable liking and consumption, future research should focus on this area of autonomy support during children's vegetable eating. It is worth investigating whether parent-offered choice is more potent than researcher-offered choice. In addition, since the children in our study were excited about the restaurant setting, it would be useful to repeat the experiment in a more familiar eating

setting, such as the family home situation or a school lunch setting where children are used to hot school meals. In the home situation, parents may be trained to offer choice, and their compliance may be monitored. A home setting would also facilitate a longer study duration or a within-subject design. Future studies may also extend our choice manipulation to complete autonomy support by providing the children with a meaningful rationale for eating vegetables ("Vegetables make you strong") and acknowledging their feelings ("I know vegetables are not your favorite"), besides providing choice [7, 8, 10, 46]. Finally, it should be studied which groups of children besides high reactant children, are most sensitive to choice manipulations.

In conclusion, this is the first experimental study that applies the self-determination perspective to the process of vegetable eating in children. Having a pre-meal choice was appreciated by the children but did not affect intake, liking, or motivation to eat vegetables. However, no choice decreased vegetable consumption in high reactant children. Future research should investigate the effects of multiple choice-offering opportunities in the long term and in more familiar eating settings.

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All authors contributed to the design of the study. GGZ organized and performed the study, analyzed the data, and wrote the manuscript. RJR, MAK, FJK, and CdG provided critical input and advice concerning data analyses and the manuscript. None of the authors had a personal or financial conflict of interest.

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General discussion

8

Children's fruit and vegetable intake is below that recommended in many countries worldwide. Research has shown that it is difficult to increase children's fruit and vegetable intake substantially and sustainably. Therefore, the aim of this PhD thesis was to develop age-specific strategies to increase 4 to 12-year-old children's fruit and vegetable intake. The research described in this thesis comprised observational (Chapter 2-4) and intervention (Chapter 5-7) studies. We focused on ways to increase preferences as an important determinant of children's intake. The role of cognitive development, parental strategies and properties of food have been investigated in relation to changing children's fruit and vegetable preferences and intake. In this chapter, the main findings and methodological considerations are discussed. In addition, implications for the field of children's fruit and vegetable intake are provided, and suggestions are made about future research. The chapter ends with implications for public health and practical recommendations.

MAIN FINDINGS

The main findings of this thesis concerning preference and intake are summarized in Figure 8.1. Our qualitative study showed that texture and appearance were important attributes for liking and disliking fruits and vegetables for 4-5-year-old children, whereas taste became more important in 11-12-year-old children. In addition, children aged 4-5 years categorized food as healthy depending on their own liking for the food in question, whereas this was not seen in 7-8-year-old and 11-12-year-old children.

Our parental survey study revealed that parents applied different strategies for fruit as compared to vegetables (Chapter 3). As a result, the vegetable-eating context was more negative than the fruit-eating context. 'Parental intake' and 'Choice' were the strongest predictors of children's fruit and vegetable consumption. Children with parents who used 'Choice' the most (highest 33%) ate more fruit (+72 grams/day) and vegetables (+40 grams/day) than children whose parents least used 'Choice' ($p<0.001$).

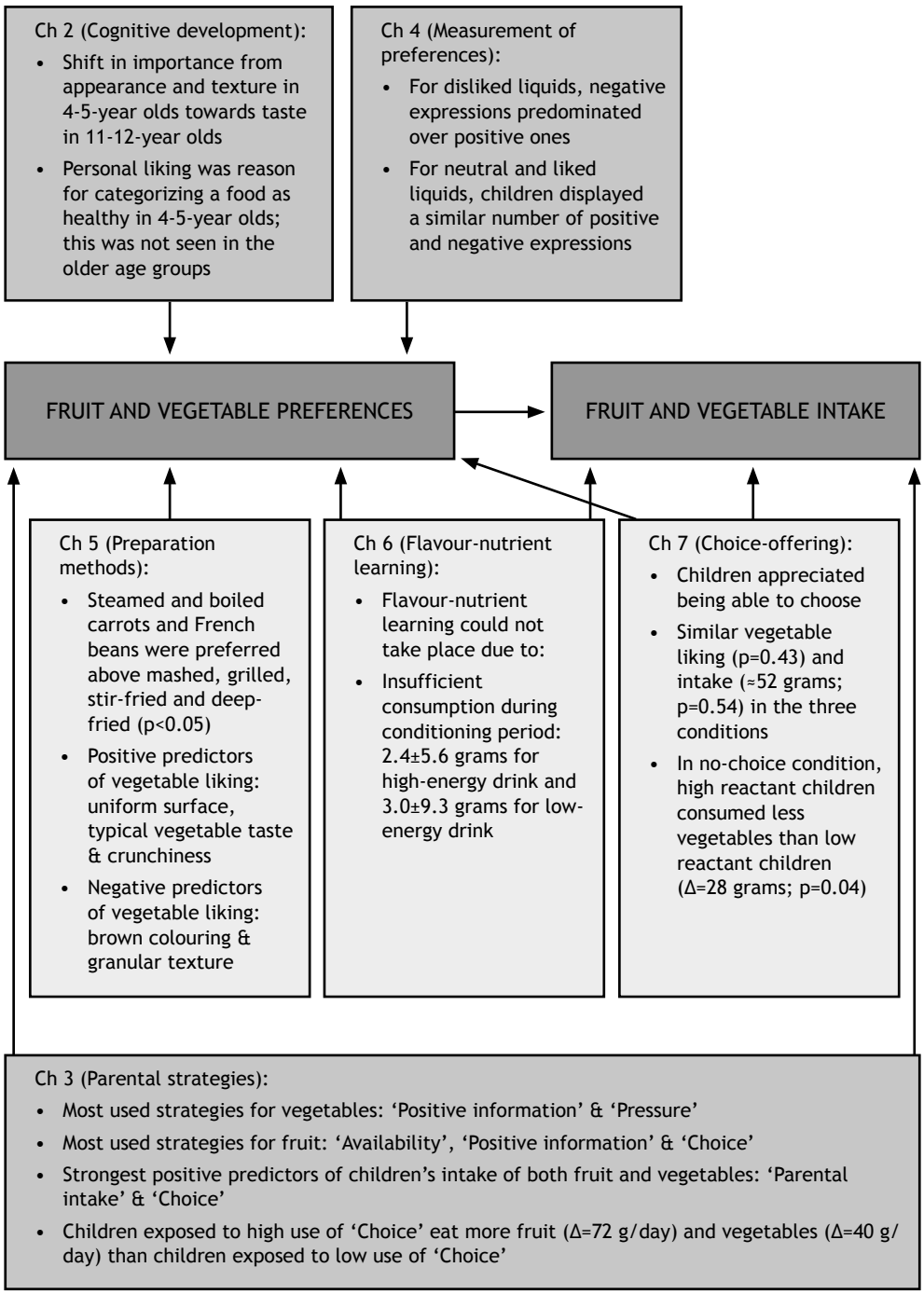

Figure 8.1 Overview of main findings of this thesis.

With regard to the use of facial expressions, we found that negative expressions predominated over positive expressions for disliked liquids. However, liked liquids could not be distinguished from neutral liquids because, for both, the number of positive and negative expressions was similar (Chapter 4).

On the basis of the results of these three observational studies (Chapter 2-4), we made the following decisions. First, we decided not to use the facial-expressions method as an indicator of food preferences in the subsequent studies. Second, the subsequent studies focused on vegetables only instead of both fruit and vegetables.

The result of our qualitative study regarding the diminishing importance of texture as children become older formed the basis for the vegetable preparation study. Children aged 4-6, 7-8 and 11-12 years preferred steamed and boiled carrots and French beans above mashed, grilled, stir-fried and deep-fried ($p<0.05$). Vegetable liking for all children was positively predicted by a uniform surface, the typical vegetable taste and crunchiness, whereas brown colouring and a granular texture negatively predicted vegetable liking (Chapter 5).

During the conditioning period in our flavour-nutrient learning study, children's consumption of the vegetable drinks (150 grams) was insufficient for flavour-nutrient learning to take place: 2.4±5.6 grams for the high-energy drink and 3.0±9.3 grams for the low-energy drink (Chapter 6). The pure vegetable taste was too intense and unacceptable to the children.

On the basis of the positive association between 'Choice' and children's fruit and vegetable intake (Chapter 3), we designed an experiment to investigate causality of this relationship for vegetables (Chapter 7). A pre-meal choice between two vegetable types was appreciated by the 4-6-year-old children, but the three conditions (no choice, pre-meal and at-meal choice) did not differ for vegetable liking ($p=0.43$) or intake (≈52 grams; $p=0.54$). In the no-choice condition, high reactant children consumed less vegetables (45±42 grams) than low reactant children (73±43 grams; $p=0.04$).

METHODOLOGICAL CONSIDERATIONS

The research process is bound by constraints. Consequently, several decisions have to be made during the design and performance of a study. Such decisions or methodological issues should be taken into account when interpreting the results of this thesis. In the following paragraphs, we discuss these methodological issues regarding study population, data collection methods and confounding. We hypothesize how the decisions could have influenced the findings.

Study population

Recruitment

The children who participated in the studies were recruited via primary schools in Wageningen and Bennekom (The Netherlands), with Franeker and Zeewolde as additional Dutch cities for the survey study in Chapter 3. Recruitment via schools can be a source of selection bias, because only schools or school principals that are motivated and interested in healthy eating will agree to participate. There are three other potential sources of selection bias. First, parents that are highly involved with, and interested in, healthy eating are likely to give permission for their children to participate. Second, children with non-Dutch-speaking parents may not have been included in our studies, since the information packs were in Dutch. Third, if parents forgot to sign an informed consent for their child, their children were excluded from participation even though the child was willing to participate.

It is unlikely that these selection biases have influenced our results in the facial-expression study and the three interventions studies. We focused on sensory, biological and psychological processes that are presumably not influenced by the involvement of parents, their forgetfulness or their habitual language. However, the fact that highly involved parents and schools agreed to participate may have affected the results of our qualitative study (Chapter 2) and the survey study (Chapter 3). Parents that are less interested in healthy eating may have other food habits or different perceptions about fruit and vegetables; this may influence the parental child-feeding strategies that they apply. This factor may also have influenced children's attitude towards fruit and vegetables in the qualitative study; the attitude of the children in our study may have been more positive than that of children from less involved families. Research among less involved parents is needed to confirm our findings.

Participants

Children of various age groups participated in the studies. In general, children aged 4-5 years, 7-8 years and 11-12 years participated together with their parents. These three age categories were taken as a proxy for cognitive development (see Chapter 2). However, children of a specific age may vary in their level of cognitive development [1, 2]. Therefore, age may not be the ideal indicator of cognitive development. On the other hand, testing each child's cognitive developmental stage would be extremely time consuming, because a whole test battery would have to be applied. This would have been inappropriate within the context of our studies. Furthermore, cognitive developmental differences between the age groups will have been larger than the differences within an age group. Therefore, we believe that this issue is not a threat to the validity of our results.

Number of participants

A major strength of our studies was the high response rate: Chapter 3: 93% of children, 86% of parents; Chapter 5: 96% of children; Chapter 6: 90% of children; Chapter 7: 78% of children, 73% of parent-child couples. In addition, the number of drop-outs during the different studies was nil, except for the choice-study in Chapter 7, where 23 children (7%) dropped out during the study for illness or unforeseen practical reasons. This can be considered as random drop-out and will not have distorted our findings.

In some studies, the absolute number of participants was relatively low, due to the method of data collection (Chapter 2, qualitative study: N=28), the feasibility of the study (Chapter 6, flavour-nutrient learning study: N=19) or the explorative character of the study (Chapter 4, facial-expression study: N=6). For the qualitative study and the flavour-nutrient learning study, the results would not have changed if the number of participants had been higher. For the facial-expression study, this is less obvious. The fact that our main finding – that negative expressions are more robust and easier to interpret – has been found in other studies [3-6], gives confidence that the main message would not have changed. However, the variability of expressiveness among the children and potential age differences warrant further research with larger numbers of participants.

Data collection

Research with children

Since children's cognitive capacities are limited compared with adults [1, 2, 7, 8], children need specific methods that help them to perform research properly in order to obtain reliable data.

Social desirability may be a more important issue in children, who tend to answer confirmatively or answer in the way that they think the researcher wants them to answer [1]. We were not able to adjust for this type of bias, but we tried to minimize it in various ways [9, 10]. First, we stressed during the interviews and testing that there were no wrong or right answers. Second, we assured the children that their responses were of great value to us. Third, beforehand, the children were familiarized with the research team, as well as with the procedures used in the study. Specific emphasis was placed on the fact that different responses between children or between stimuli were 'normal' and allowed. Finally, all research assistants were trained to use this child-friendly approach.

Qualitative research was applied to explore the relationship between cognitive development and children's fruit and vegetable perceptions (Chapter 2). We used focus group discussions (11-12-year-old children) and duo interviews (4-5-year olds and 7-8-year olds), as focus groups are too difficult for young children. In addition, we used game-like questions and pictures to make the

questions concrete. For the 4-5-year-old children, the interview was carried out in two separate sessions to match their attention span. We believe that this was the right approach to get rich data from the children [11-14].

In many of the studies in this thesis (Chapter 4-7), we applied *Birch's rank-order procedure* to measure children's preferences [15, 16]. This method was well understood and feasible for the children. The three smiley faces and the two-step approach make the method concrete and well-suited to the children. An explanation of the method and practising beforehand ensured that the children understood the procedure. Research has shown that the method discriminates well among samples and is related to children's food selection [16]. Although we measured children's preferences only once, research has shown that taste preferences are reliably measured in young children [1, 17-20]. Therefore, we are convinced that the rank-order procedure yielded reliable and accurate data.

In the parental survey study, we applied a *5-point smiley scale* together with photos of the products. Since we had 24 products, it was impossible to use the rank-order procedure. The use of photos is considered a good procedure when familiar products are used [19], as was the case. However, we observed that some 4-year-old children, who had just started attending school, had difficulties with this scale. Their responses were mostly binary: like or dislike. As children usually talk in terms of likes and dislikes [21, 22], one could propose that these children experience their preferences in a binary way: they like the food or they dislike it. An alternative explanation is that their cognitive capacities are not yet developed enough to be able to make more precise distinctions. Previous research confirms this difference in task performance between 4 and 5 year-old children [19, 23]. In addition, rating scales may be difficult for younger children and the smiley faces can be ambiguous for them [24]. The more extreme scoring of the 4-year olds may have influenced the preference data of the youngest age group, with more intense preferences and more intense dislikes as a result. As a consequence, the relationships between parental strategies and children's preferences may have changed slightly in magnitude, but not in direction. The more extreme preferences have not influenced the relationships between the use of parental strategies and children's intake.

Setting of child research

The reliability of children's responses depends also on the setting in which the data were collected. In most studies in this thesis, children were interviewed or tested one-by-one by a researcher; this ensured that children understood the procedures and that the children's responses were correctly written down. It is possible that the researchers influenced the children's responses, but this was minimized as much as possible by training the research assistants beforehand to

encourage a neutral approach and by making the children feel at ease. To prevent social influence from peers [25, 26], children were seated at least one metre from each other, with their faces outwards (their backs towards other children). It was stressed that we were interested in their own opinion.

Testing in group form was used in the flavour-nutrient learning study during the conditioning period and the two-flavour consumption test. The children could have imitated each other's consumption behaviour [25, 26], leading to more similar consumption values than would have occurred if the children had been tested individually. It is likely that this imitation occurred and that children's consumption would have been higher if they had been tested individually. But since children's liking did not change over time and their consumption was far below the required amount of 120 grams, we do not expect that individual testing would have led to sufficient consumption for flavour-nutrient learning.

Group interaction was used on purpose to obtain richer data in the qualitative study (Chapter 2) and to simulate a natural eating situation in the choice-offering study (Chapter 7). When there was a dominant child during the interviews, the social influence of this dominant child was diminished by inviting first the less dominant child to respond. It is expected that the undesirable social influence was not that large and that the advantages of group interaction outweighed the disadvantages of social influence. During the choice-offering study, parent-child couples were seated at their own table, at least one metre distant from another parent-child couple's table. Interaction between parents and children from different tables did occur when the parents or children knew each other. This between-table interaction may have diminished the impact of our choice-manipulation. Since the children gave their full attention when the choice-manipulation was offered and they perceived differences among the choice conditions, social influence did not outweigh our manipulation.

Parental report

In addition to the children, also their parents provided data. Self-report can lead to various biases due to social desirability, recall bias, incorrect perceptions or unconscious behaviour [27-31]. This particularly played a role in the parental survey study (Chapter 3). Because parents reported their own and their child's intake, it is likely that the parent-child correlations for intake are overestimated. Furthermore, both children's consumption and the reported frequency of parental strategy use may have been over- or under-reported by the parents. If some parents over-reported and others under-reported, the relationship between children's intake and applied parental strategies may have been distorted. The use of a validated questionnaire that is considered suitable for ranking individuals according to their fruit and vegetable intake [32] gives some confidence, but

distortion due to self-report cannot be excluded.

Since young children below the age of 7 years have a bad recall of their own food consumption [29, 31], asking children to report their own consumption was not an option. One could argue that parental report is a valid measurement for children's home consumption, but not for foods consumed outside the home. We expect that this is less a problem for fruit and vegetable consumption in The Netherlands, since the majority of fruit and vegetables are eaten at home [33] or eaten at school but provided from home. For older children, both the parents' and the children's report could be aggregated to get a more valid picture. For food intake, it may be difficult to determine who gave the 'correct' answer [34, 35]. For the use frequency of applied strategies, it is valuable to include both parental and children's views, as both 'tell the truth' [34, 36, 37]. It is desirable for future research to focus on more objective methods, such as observational studies or biomarkers for intake, although these may be too expensive and infeasible with large numbers of participants.

Confounding and effect modification

In the parental survey study, children's age and parental intake were included in the regression model for children's fruit and vegetable intake. Parental intake is strongly related to children's intake [36, 38-41], and children eat more as they grow older [42]. Omitting these two confounders would have distorted the relationship between parental strategies and children's fruit and vegetable consumption.

In the majority of the studies in this thesis, the children's level of food neophobia was measured to ascertain their participant type. High levels of neophobia are related to lower fruit and vegetable intakes [39, 43] and lower vegetable preferences [44]. This was confirmed by our choice-offering study, where high neophobia children ate less vegetables and were less motivated to eat vegetables than low neophobia children. It is possible that certain strategies for changing food preferences are less effective in high neophobia children. The interaction effect neophobia*condition for 'Pleasant atmosphere' in our choice-offering study gives initial support for this assumption. Besides neophobia, future research should also include trait reactance (Chapter 7) as a potential effect modifier.

INTERPRETATION AND EXTERNAL VALIDITY OF OUR FINDINGS

Education level

The parents that participated with their children in our studies were, in general, relatively highly educated. Most of the participants were recruited from Wageningen and the surrounding area, where highly educated persons are overrepresented in comparison with The Netherlands as a whole. In our choice-offering study

(Chapter 7), approximately 70% of the parents were highly educated, 25% middle and 5% were low educated. In contrast, 29% are highly educated, 42% middle and 29% low educated in the general Dutch population [45].

Research has shown that lower educated families often eat less fruit and vegetables [41, 46, 47], they may have other beliefs, perceptions and habits regarding fruit and vegetables [48, 49], and the educational level of parents can influence the strategies they use [48, 50]. Thus, our findings cannot be generalized to lower educated families.

The results of our qualitative study are in agreement with perceptions that have been found in children from lower educated families [51]; this gives confidence that our findings are a reflection of a more general child population. In the parental survey study (Chapter 3), we included cities other than Wageningen, namely Franeker and Zeewolde, with the aim of having the parental education level (48% high, 43% middle, 9% low) more comparable to the Dutch situation, but still highly educated parents were overrepresented. Because parents may use various strategies in combination [52-54] or within a parental style [28, 55-57], the effect of a specific strategy on intake may depend on the other strategies used, and may thus depend on parental education level. Therefore, the frequency with which strategies were applied in our parental survey study and the relationships between strategies and intake are valid for relatively highly educated families.

Given that the display of facial expressions is a response of facial muscles [58, 59], we have faith that these results (Chapter 4) are not influenced by the fact that we studied children of highly educated parents. Similar to the intervention studies, we do not expect that educational level influenced the mechanisms studied in Chapter 5 (preparation method), Chapter 6 (flavour-nutrient learning) and Chapter 7 (choice-offering). Nevertheless, future research should confirm our findings in children from lower educated families.

Context

Because the context is a crucial factor in relation to children's food preferences and behaviour [60, 61], it is important to realize that the results of our research are valid for the context in which the research was carried out.

Three studies were carried out at school (qualitative study, parental survey study and flavour-nutrient learning study). The children may have behaved more shyly or more toughly than at home, and this may have influenced their responses. On the other hand, parents were not present at school, so children could not 'check with their parents for approval of their answers' [1]. This ensures that the children's responses were their own opinion. Furthermore, school is an environment that requires 'seriousness', and the fact that children are used to performing tasks at school is advantageous for the validity of our findings.

The vegetable preparation study and the choice-offering study were performed in the Restaurant of the Future, a unique research setting similar to a real restaurant. During the choice-study (Chapter 7), about 30 parent-child couples per evening visited the restaurant to have a meal. Not only were the children more excited about the restaurant setting than expected, but also parent and child behaviour may have been different from the home situation. Therefore, we cannot generalize our findings to the home situation, and repeating this study in the home situation is recommended. In the vegetable preparation study (Chapter 5), the setting was probably less influential, as relative liking was assessed and the restaurant setting was less obvious. Replication of this study in a home situation would probably result in similar results.

Dutch situation

Our results relate to the Dutch situation and cannot be extrapolated to other countries. Other countries have different habits [62, 63] and different fruit and vegetables that are familiar or not [64-66]. Typically, in the Dutch situation lunch is not provided by the school, and there are no hot lunches at school. Most children go home for lunch or eat at school from a lunch box prepared at home. Lunch typically exists of sandwiches and a drink, and sometimes fruit. At the majority of Dutch primary schools, the two lowest classes (4 to 6-year-old children) have a fruit break in the morning, whereas this fruit break disappears in the older age classes. Vegetables are habitually consumed at dinner; the other Dutch meals hardly include any vegetables [33]. Therefore, the children's perceptions (Chapter 2) and the strategies that parents use (Chapter 3) are a reflection of the Dutch situation.

The fruit and vegetables that we used in the studies were based on the most eaten fruits and vegetables in The Netherlands [67]. These products were familiar to the children in our study, but these products may be less, or not at all, familiar to children in other countries. Since familiarity is an important predictor of children's preferences [17, 68], a taste session with fruits as in our qualitative study (Chapter 2), or a fruit and vegetable questionnaire as in the parental survey study (Chapter 3), may lead to different preference responses in other countries. For the intervention studies, familiar vegetables were needed for successful completion of the study. Unfamiliar vegetables would have been less liked, less accepted and may have resulted in more drop-outs or incomplete data. The intervention studies focused on the effectiveness of a specific method to increase preference. This implies that similar studies in another country would have led to similar results if other vegetables that are familiar in that country would have been used.

IMPLICATIONS FOR THE FIELD OF CHILDREN'S FRUIT AND VEGETABLE INTAKE

On the basis of the research in this thesis, there are general reflections relating to children's fruit and vegetable consumption that should be considered. In line with Figure 1.1 in the Introduction, we now discuss factors relating to the product, person and environment.

Product-related factors

A basic assumption in this thesis is that children's fruit and vegetable intake can be encouraged by increasing children's preferences. But a preference for a specific food is not sufficient to guarantee consumption [69, 70]. Although children like fruit [49, 64, 71, 72], their intake is still insufficient. A dislike may be a more important driver of behaviour [73], in that children refuse to eat disliked foods. This is obvious for vegetables; children's dislike hinders their vegetable consumption. This implies that increasing children's preferences is a more important strategy for vegetables than for fruit. In addition, a product-approach that changes vegetable characteristics (taste, texture) is more relevant for vegetables than for fruit. Both these points support the notion that fruit and vegetables should be treated separately and need different intervention strategies (see Chapter 3).

What is then needed for vegetables? The bitter taste of vegetables, the low energy content and textures that are difficult to control are not attractive characteristics for children [49, 74-77]. Strategies that reduce these characteristics would be most promising. However, due to children's dislike for vegetables, vegetable research among children is not easy; voluntary child participation may be challenging, drop-out during the study may be high [78] and it may be difficult to investigate effects of specific strategies when sufficient vegetable consumption is required. Research should focus on moderately consumed and moderately liked vegetables as these are most changeable [79]. Adding liked and familiar toppings or sauces to vegetables [78, 80], serving vegetables raw or as crunchy as possible [49, 81-83] and using spices to mask the bitter taste are fruitful ways to continue. Our flavour-nutrient learning study (Chapter 6) indicates that intense vegetable flavours should not be used.

A fundamental issue is the vegetable intake recommendations for children. Child recommendations vary between countries or there are no specific recommendations for children [84]. When there are child recommendations, they are deduced from the WHO adult recommendations. Since hardly any child worldwide reaches the recommended vegetable intake [27, 33, 40, 84-86], one could ask the question: Are these vegetable recommendations for children realistic and valid? In our choice-offering study (Chapter 7), the children consumed on

average 50 grams of vegetables, whereas 100-150 grams is recommended. Only 22% of the children ate more than 100 grams, and the children in this study came from relatively highly educated families. Although it is likely that children ate less due to the research setting, it is unlikely that their habitual intake would be double or triple. Therefore, more research about the 'right' recommendations per age group is required, as well as harmonization of the child recommendations worldwide.

One might also speculate that, if vegetables are so healthy for children, would there not be a biological principle supporting this? Although it is appealing to believe in 'the wisdom of the body', this wisdom has never been proved [87]. Whereas flavour-nutrient learning, neophobia, an inborn dislike for bitter tastes and a high taste sensitivity to bitterness were valuable in prehistoric times, they are not supportive of vegetable intake. In a world where safe food is in abundance, consuming vegetables may be helpful with regard to the obesity epidemic [88, 89]. In addition, food habits and preferences acquired at a young age track into adulthood [90-92]. So, eating plenty of vegetables as a child increases the probability of sufficient consumption in adulthood.

Person-related factors

We took cognitive development into account as a new perspective for studying children's fruit and vegetable behaviour. Our qualitative study (Chapter 2) indicated that the link between healthy and distaste [49, 93-95] is not yet present in 4-5-year-old children. It seems that, at a certain age, this association alters, and we hypothesize that vegetables play an important role in this switch. Parents may tell their children that they should eat their vegetables because vegetables are healthy [49], but, in the long term, this could result in a link between healthy and not tasty. Since pre-operational children are not yet able to make deeper and long-lasting associations [2, 8, 96, 97] and they do not yet understand the full concept of health (Chapter 2), it seems plausible that such a link emerges in the concrete operational stage, starting from the age of 7 years. Research is needed to confirm this hypothesis.

Another interesting topic concerning children's cognitive development is their perception of quantities. Children's perception of a particular quantity may depend on the shape in which it is presented [2, 96]. This developmental difference concerning perceptions of quantity was also present in our qualitative study and the choice-offering study. It seems therefore promising to present vegetable portions in such a way that children perceive these portions as doable instead of huge.

Besides cognitive developmental differences between age groups, there are also age-related differences concerning physical development. Developments concerning jaws, teeth and surrounding muscles [77] can influence which textures

are accepted or rejected. Developments concerning hand locomotion influence preparation skills and determine which fruit and vegetable products can become accessible to the child [98]. In addition, there are age-related differences in the intensity of certain trait characteristics, such as neophobia, which peaks between 2 and 5 years [99-101], and reactance [102-104]. These differences may run parallel with cognitive development and can influence fruit and vegetable eating experiences [105-108]. Therefore, we suggest more research into these age-related differences in order to make healthy eating interventions as relevant and meaningful as possible for children.

The research in this thesis focused on primary school-aged children. Is this the right age to increase children's vegetable preferences? Because food preferences and nutritional habits are relatively stable from early ages on [90-92], one could suggest starting earlier. Early exposure, such as via breastfeeding, positively influences vegetable acceptance [109-111], and there may be a sensitive period for learning in the first two years [99, 100]. Repeated exposure to vegetables in infants leads to large increases in intake [109, 111]. So, starting at a younger age would certainly be beneficial. On the other hand, we continue to learn to accept new foods beyond childhood (coffee, beer, olives etc), indicating that preference learning mechanisms are still present. In adults also, vegetable preferences can be increased by flavour-flavour learning [112]. Thus, although more effort may be needed when children become older, it is never too late to change food preferences.

Environmental factors

Although it is known that parents play an important role, the majority of fruit and vegetable intervention programmes are school-based with little parental involvement. Many parents are eager to encourage healthy eating in their children [113, 114], and are open for specific and concrete information that can help them. On the other hand, more and more parents are both employed outside the home and consequently have less time to take the action that may be needed. Parents search for convenient and flexible ways to serve their children healthy meals, while maintaining a pleasant meal situation. In addition, children themselves indicate the importance of parental support as a facilitator for healthy eating [115, 116].

The use of parental strategies is a complex area. Most research about parental practices is cross-sectional, making it impossible to elucidate cause and effect [117-120]. Parents often use a mixture of practices [52-54], and these practices are shaped via an interactional relationship: parents apply practices to influence their children's eating behaviour, but parental practices also develop in response to the children's behaviour [57, 120-122]. In addition, often subtle mechanisms are involved, with certain practices showing positive as well as negative effects on

children's eating [26, 56, 86, 123-125]. Whereas one would like to be able to confirm the effectiveness of one single practice that could easily be recommended, this may not always be a reflection of reality. Moreover, the literature about parental practices and strategies uses a variety of terms and concepts [120]. Thus, a deeper understanding of these concepts is needed together with more uniformity regarding the terms.

FUTURE RESEARCH RECOMMENDATIONS

On the basis of the results of this thesis and the aforementioned reflections, we offer suggestions for future research. Three approaches are described: product, person and environment.

Product-related approach

More research is needed about the specific aspects that make a vegetable appealing or not for children. Our vegetable preparation study indicated that a uniform appearance, easily-controllable textures and familiarity are appealing characteristics. However, this was a first step in this direction; further research needs to confirm and extend our findings regarding which combinations of texture, taste and appearance are attractive. It is necessary to vary these attributes systematically within one vegetable type and link these variations to children's preference data [126, 127] in order to understand which factors are most critical per vegetable type. On the basis of this information, vegetable liking could be increased by altering or reducing the undesired product attributes. Serving vegetables in mixed dishes, with sauces, salt, gravy or spices, or using different preparation methods (Chapter 2 and 5) may increase liking and intake via different processes: masking of bitterness, flavour-flavour learning, flavour-nutrient learning or reducing the newness of the product. Although adding salt may reduce bitterness [128], this may not be an optimal strategy from a health point of view. Sauces and gravy may increase the energy content of the meal; this may also be undesirable. However, low-fat sauces (i.e. ketchup, applesauce) and low-fat gravy do exist. Replication of our flavour-nutrient learning study (Chapter 6) with vegetable soups instead of vegetable drinks may elucidate whether flavour-nutrient learning can indeed be used to increase children's vegetable preference. In addition, today's international cuisine gives rise to new recipes with vegetables that may be appreciated by children [49]. Further research should examine which flavourings and dishes are most effective in increasing vegetable liking.

Person-related approach

If we want to increase children's fruit and vegetable consumption, we should start from their 'world'. Since many children prefer playing above eating [51] and children

like to play with food and share foods with friends [22, 129], marketing techniques could be used to make fruit and vegetables more attractive for children: using colourful packaging, attaching characters to the products (Sponge Bob, K3, Disney characters), making fruit and vegetables more child-sized ('snoeptomaatjes', mini-cucumbers, sliced apples) and increasing the play-value of the product. In this way, fruit becomes more available and accessible to children, and vegetable liking may be increased through evaluative conditioning between the positive context of eating (playful, child-focused, smiling friends) and the product itself. However, it should be investigated whether evaluative conditioning is strong enough to overcome children's vegetable dislike.

Environment-related approach (home situation)

As stated in the previous reflections, there is a need for a better understanding of parental strategies, which combinations are used, what are the causes of parental strategies and what are the effects. Longitudinal studies with camera observations at home are needed, eliminating biases of self-report. In a natural setting without interference, it may be elucidated whether parents use a specific strategy in response to their child's low consumption or whether this strategy causes the low consumption. Furthermore, these long-term observations can give insight into which strategies have long-lasting positive effects. Is the maximum effect reached after a certain period or is there a boomerang effect after a certain period in that children do the opposite of what the strategy intends?

Besides observation of the natural situation, parents can also be taught to use specific strategies at home. Compliance and the effects of these strategies on children's fruit and vegetable consumption should be observed. The most urgent strategies that require further study are pressuring and autonomy support by providing choices. We found that pressure was positively related to vegetable intake, whereas it was negatively related to fruit intake (Chapter 3). Other studies confirm that the effect of pressuring on children's eating behaviour is not straightforward [56, 86, 124] and that parental control behaviour may be more complex than it is studied now [54]. There may be various degrees of pressure. We hypothesize that subtle pressure that avoids reactance and instrumental eating increases exposure to the product and subsequently increases preference and intake. These subtle ways of exerting pressure should be identified, employed and studied.

In addition, we recommend repeating our choice-offering study (Chapter 7) in a home situation. It would be interesting to study parent-offered choice with different choice alternatives every day. Cameras could be used to observe compliance, and the long-term effects of providing choice versus no choice should be investigated.

PUBLIC HEALTH IMPLICATIONS

The Dutch Nutrition Centre recommends various strategies for supporting children's fruit and vegetable intake. In general, these strategies are in line with the literature and fit well with our findings: set a good example as a parent; do not reward the child for eating vegetables; offer a variety of fruits and vegetables; expose the child repeatedly to new tastes (~10x); offer a sandwich or fruit during the school break; provide fruit in the child's lunch box; offer children fruit and vegetables as a snack instead of cake, crisps and candy; have the child choose himself now and then.

On the basis of our findings, a number of other recommendations should be included. In order to prevent the development of a link between healthy and not tasty, parents should be advised not to use "It is healthy" as an argument for eating fruit and vegetables.

Regarding choice-offering, parents should serve a large variety of fruit and vegetables, with varying choice alternatives each day. Two liked products, but also two disliked products or two new products should be offered in order to expose the child also to fruit and vegetables that are new or less liked. Because children like to assist in fruit and vegetable preparation, cooking and gardening [130, 131], this should be encouraged, as this may support their feelings of autonomy, and this may, in turn, encourage liking and intake [132-134].

Whereas it is advised to eat fruit at lunch or as a snack, this is not so much emphasised for vegetables. Dutch children perceive vegetables as belonging to dinner, since vegetables are only eaten at that time. This prevents them from seeing other opportunities to eat vegetables (Chapter 2). Feeling compelled to eat vegetables at this one particular moment may provoke oppositional behaviour in children, as their freedom is restricted [102, 135]. Therefore, we suggest that other eating times should be encouraged.

Our work has clearly shown that children have a hard-wired aversion to pure vegetable tastes (Chapter 6). Mixing vegetables with other foods may induce flavour-flavour and flavour-nutrient learning, and this may support children's vegetable consumption. Although children often prefer to eat each meal component separately [100, 136], parents should encourage their children to mix vegetables with other meal components or they should provide them with mixed dishes.

Parents should also be advised to prepare vegetables in different ways to find out the most preferred preparation method for their own child (Chapter 5). Moreover, letting the children choose the type of preparation may also encourage their feelings of autonomy [133, 134, 137], and this, in turn, may positively influence liking.

Furthermore, it would be useful to inform parents about the development of food preferences. Presentations about healthy eating during parent evenings at school or child-care made clear that an explanation about the development and modification of food preferences can be a real eye-opener for parents. It can help parents to understand why fruits are usually liked and vegetables not. It can also reassure parents that they are not the only factor to blame if their child refuses to eat vegetables. Knowing this may already lead to a more relaxed eating atmosphere [100] that in itself will be beneficial for the child's healthy eating. Furthermore, offering practical ideas derived from the scientific evidence can motivate parents and health practitioners to apply the right strategies in practice.

Finally, our results emphasize the difference between fruit and vegetables concerning liking, moment of consumption and handling at home (Chapter 3). Fruit intake and vegetable intake are separate eating behaviours with different antecedents [27, 40]. Most campaigns target fruit and vegetables simultaneously, suggesting that both are interchangeable and ignoring the fact that they may need different strategies for changing intake. Campaign effects may be greater when fruit and vegetables are targeted separately.

CONCLUSION

The research in this thesis suggests that we should be careful about treating primary school-aged children as one homogeneous target group. Segmentation may be helpful to change children's fruit and vegetable intake optimally. Different intervention strategies should be used for fruit as compared to vegetables, since they are differently liked and differently handled at home, and the times at which they are eaten differ. Parents, caretakers and health professionals need to be persistent in order to increase children's vegetable preferences and intake.

The strategies recommended below are derived from this thesis and may be helpful to encourage primary school-aged children's fruit and vegetable intake. These strategies should not be considered as the 'golden standard', as we did not test all strategies in experimental settings; but, on the basis of our results, these strategies seem promising.

In order to encourage children's fruit and vegetable consumption, it may be helpful to:

1. Ensure a pleasant fruit- and vegetable-eating context, prevent a negative atmosphere (Chapter 3)
2. Serve as a role model and set a good example (Chapters 3 and 7)
3. Be persistent and patient in offering children a variety of both new and familiar foods in order to encourage acceptance of new foods (Chapters 3 and 5)
4. Encourage children's feeling of autonomy and prevent reactance by offering children a choice within the process of eating fruit or vegetables (Chapters 3 and 7)
5. Avoid the argument 'it is healthy' to persuade a child to eat healthy foods that he/she does not like (Chapter 2)
6. Make fruit available and accessible to the child, including during sports activities, at parties or when they are with friends (Chapter 2)
7. Increase the frequency of exposure to vegetables during a day; not only at dinner, but also at other times, such as lunch, celebrations or as a snack (Chapters 2 and 7)
8. Persuade children in a positive way to taste vegetables repeatedly (Chapter 3)
9. Offer vegetables in various mixed dishes and preparations to find out which vegetable dishes are preferred by the child and to encourage the different conditioning processes (Chapters 2, 5 and 6)
10. Offer vegetables as crunchy as possible, while preventing brown colouring and a granular texture (Chapter 5)

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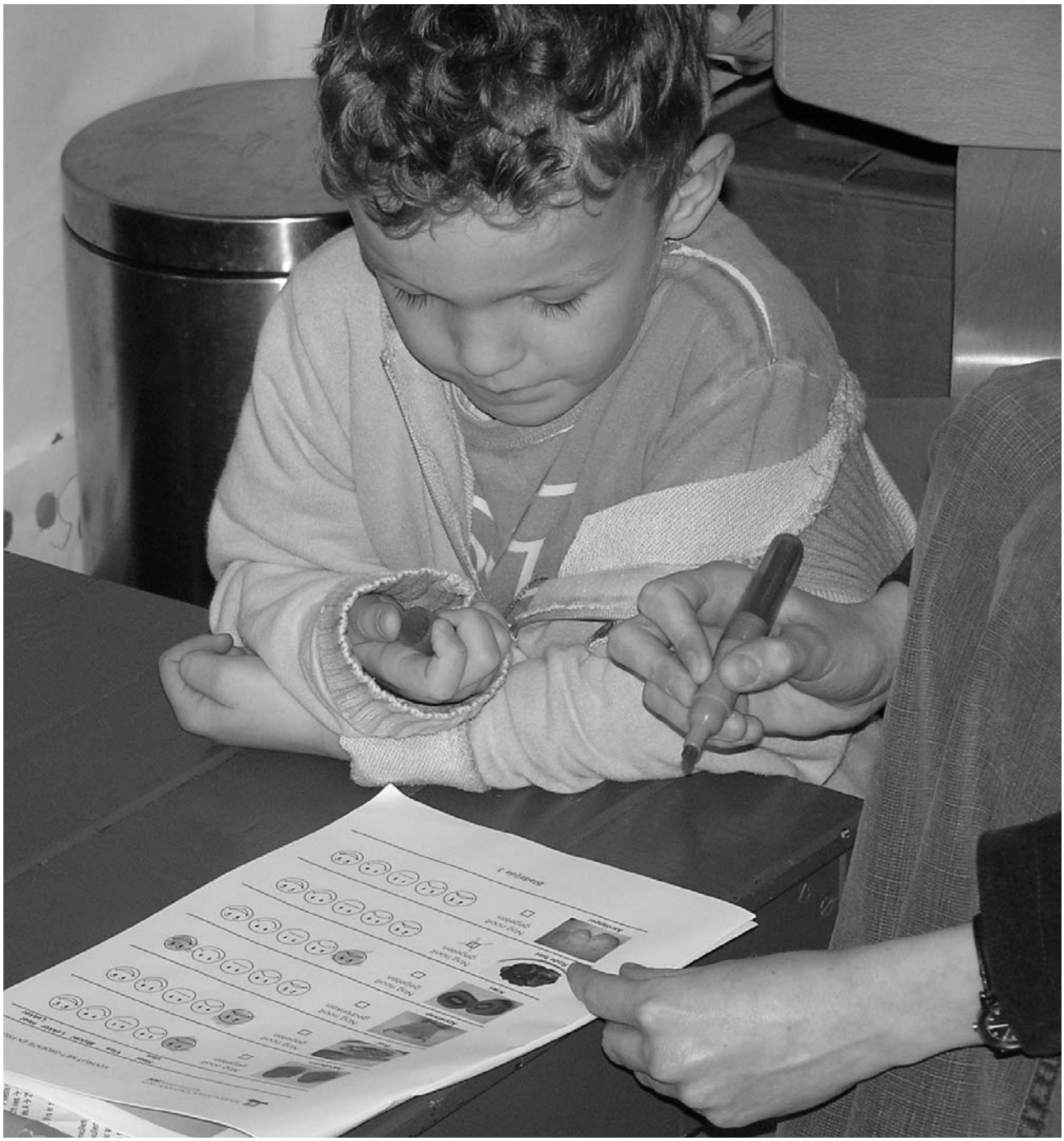
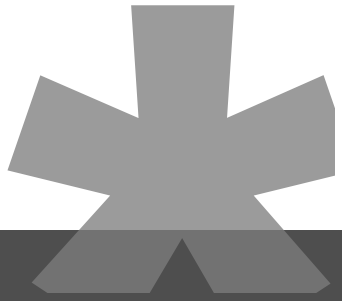
Summary





Fruit en vegetables provide essential nutrients. They may reduce the risk on cardiovascular disease and cancer, and may be helpful in maintaining a healthy body weight. Because nutritional habits and food preferences track into adulthood, it is important that children learn to acquire a healthy diet with plenty of fruit and vegetables at a young age. Currently, children's fruit and vegetable consumption is below that recommended. Research has shown that it is difficult to increase children's fruit and vegetable intake substantially and sustainably. Previous attempts have resulted in relatively small and short-term increases in fruit and vegetable intake. In order to develop new approaches for encouraging children's fruit and vegetable intake, the role of parental strategies, children's cognitive development and properties of food are investigated in this thesis. We assigned a prominent role to children's food preferences, because preference is an important determinant of children's food intake. Overall, the aim of this thesis is to develop age-specific strategies to encourage fruit and vegetable preferences and intake in 4 to 12-year-old children.

Research concerning the relationship between cognitive development and children's perceptions of, and preferences for, fruit and vegetables, is lacking. Therefore, a qualitative study was designed to explore this relationship (Chapter 2). Children from three age groups participated (4-5y N=8; 7-8y N=8; 11-12y N=12), with each age group representing a different stage of cognitive development. In-depth information was obtained by duo-interviews and focus group discussions. This study showed that the most important determinants for liking and disliking fruit and vegetables shifted from appearance and texture attributes in 4-5-year olds towards taste attributes in 11-12-year olds. One aspect of cognitive development is an increase in the level of abstraction. In our study, this development was clearly seen in children's improved understanding of health, and their cognitions and reasoning in relation to fruit and vegetables. Although children often associate healthy foods with distaste, our study indicated that this link may not yet be present in 4-5-year-old children.

Despite the fact that parents play a crucial role in children's fruit and vegetable consumption pattern, most intervention programmes have been school-based with relatively little parental involvement. Parents influence their children's eating behaviour through their own intake, their modelling behaviour and the parental practices or strategies they apply. Because the relationship between these strategies and children's intake has never been investigated for fruit and vegetables as two separate food groups, a survey study was performed at three primary schools (Chapter 3). The aim was to identify parental child-feeding strategies that have the potential to increase children's fruit or vegetable intake. Parents (N=242) provided information about their practices in relation to feeding their children and about their own and their children's fruit and vegetable intake. Children (4-12y N=259) completed a preference questionnaire about fruit and vegetables. The results showed that parents used different strategies for fruit as compared to vegetables. 'Positive information' and 'Pressure' were the strategies most frequently applied for vegetables, whereas for fruit, 'Availability', 'Positive information' and 'Choice' were most used. As a result, the vegetable-eating context was more negative than the fruit-eating context. Parental intake and offering children a choice were positive predictors of children's intake of both fruit and vegetables. Children with parents who used the 'Choice' strategy most often (highest 33%) ate more fruit (+72 grams/day) and vegetables (+40 grams/day) than children whose parents least used 'Choice' ($p<0.001$).

Because we aimed to encourage children's fruit and vegetable intake via increasing their preferences, an accurate and valid method is needed to assess (small) changes in their preferences. The pilot study in Chapter 4 sought to investigate whether facial expressions are a suitable and accurate method to assess food preferences in school-aged children. Six children, aged 5 to 13 years, tasted seven stimuli in randomized order: apple juice, sauerkraut and beetroot juice, skimmed milk, asparagus solution, a bitter and a sweet solution. The children indicated their preference for each stimulus using a traditional rank-order procedure. The whole tasting procedure was video-recorded to capture facial expressions, and these were analysed with the Facial Action Coding System. We found that negative expressions predominated over positive expressions for disliked liquids. However, liked liquids could not be distinguished from neutral liquids, because, for both, the number of positive and negative expressions was similar. On the basis of our results, we conclude that facial expressions are suitable to measure dislike, but not suitable to measure various gradients of food acceptance in children aged 5 to 13 years.

On the basis of the results of these three observational studies, we made two decisions. First, we decided not to use the facial-expressions method as an

indicator of food preferences in the subsequent studies. Second, the focus would be on vegetables only in the subsequent studies, because vegetables are less liked than fruit, fruit and vegetables are differently handled at home and previous intervention programmes have been less effective for vegetables than for fruit.

The results of our qualitative study (Chapter 2) regarding the diminishing importance of texture as children become older formed the basis for the study in Chapter 5. We investigated how different preparation methods influence children's liking for vegetables. Participants were children from three age groups (4-6y N=46; 7-8y N=25; 11-12y N=23) and young adults (18-25y N=22). Carrots and French beans were prepared in six different ways: mashed, steamed, boiled, stir-fried, grilled and deep-fried. During a taste session, the participants made a preference rank-order of the six samples of each vegetable. The young adults also rated the different vegetable preparations on fifteen product characteristics regarding appearance, texture and taste. Participants from all four age groups preferred boiled and steamed vegetables over the other preparations ($p<0.05$). Boiled and stir-fried were the most familiar preparation methods for both vegetables. Vegetable liking was positively predicted by a uniform surface, the typical vegetable taste and crunchiness, whereas brown colouring and a granular texture negatively predicted vegetable liking.

Chapter 6 describes a study which aimed to investigate whether flavour-nutrient learning is effective in increasing 7-8-year-old children's preference for vegetables (N=19). Flavour-nutrient learning refers to the process in which the flavour of a food becomes associated with the positive post-ingestive consequences due to, in this case, energy. This learning principle is considered an important mechanism for establishing food preferences, but has not yet been applied to vegetables. In our study, the children were offered repeatedly two vegetable drinks (150 grams) during a 14-day learning period. In the high-energy drink, a vegetable flavour was combined with added energy (maltodextrin), whereas the low-energy drink consisted of a second vegetable flavour without added energy. It was expected that children's preference for the flavour combined with added energy would increase more over time than for the flavour without added energy. Flavour-nutrient learning could not occur in our study, due to insufficient consumption during the 14-day learning period: 2.4 grams (SD=5.6) for the high-energy drink and 3.0 grams (SD=9.3) for the low-energy drink. The high taste intensity, the perceived increase in bitterness, saltiness and thickness, and the unexpected combination of vegetables in juice form, may have caused the insufficient consumption. On the basis of these results, we hypothesize that the pure taste of a vegetable by itself is not acceptable. By mixing vegetables with other foods, children may gradually learn to accept vegetables through flavour-

nutrient and flavour-flavour learning (association between a new flavour and a familiar, liked flavour).

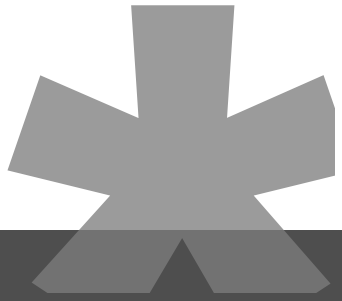
The parental survey study in Chapter 3 indicated that 'Choice' may be a valuable strategy to increase children's vegetable intake. This could be explained by self-determination theory: offering a choice stimulates feelings of autonomy and intrinsic motivation, and this may result in higher liking and enjoyment, greater satisfaction and improved performance. This relationship has not yet been studied experimentally for vegetables. In Chapter 7, we investigated whether having a choice between two vegetables enhances children's vegetable liking and consumption. Three hundred and three children aged 4-6 years visited our restaurant to have dinner with one of their parents. Parent-child couples were randomly assigned to one of three dinner conditions. The child was shown two similarly liked vegetables and was then offered 1) no choice: one of the two vegetables was randomly assigned to the child, 2) a pre-meal choice: child could point to the vegetable he/she wanted for dinner, or 3) an at-meal choice including variety: both vegetables were served on the child's plate. After the dinner, both parents and children completed questions regarding meal experience and vegetable liking. Food intake was determined by weighing each meal component before and after the meal. We found that the children considered only the pre-meal choice as a real choice condition. Although they liked being able to choose in this condition, the three conditions did not differ for vegetable liking ($p=0.43$) or intake ($p=0.54$): 56±45 grams in the no-choice condition, 51±46 grams in the pre-meal-choice condition, and 49±47 grams in the at-meal-choice condition. In the no-choice condition, high reactant children consumed less vegetables (45±42 grams) than low reactant children (73±43 grams; $p=0.04$).

In Chapter 8, our findings are put into broader perspective. It is important to realize that we studied children from relatively highly educated families. Similar research in lower educated families is recommended. In order to change children's fruit and vegetable intake, it is essential to consider the product, person and the environment. Concerning the product, our research indicated that a uniform appearance, easy-controllable textures and familiarity are appealing characteristics of vegetables. This needs to be confirmed in further research. In order to better understand how vegetables can be served in an attractive manner, product characteristics should be varied systematically within one vegetable type and this should be linked to children's preference data. It remains remarkable why vegetables have no biological reward function that supports their consumption. Because fruit is often well-liked by children, increasing preferences may be a more effective strategy for increasing vegetable intake than for increasing fruit intake. In relation to the person, the research in this thesis suggests that we should

be careful about treating primary school-aged children as one homogeneous target group. Age differences due to cognitive and physical development need further study and should be considered during the development of intervention programmes, in order to make these programmes as meaningful and effective as possible for children. Regarding the environment, parents are eager to know which strategies encourage healthy eating in their children and which strategies have detrimental effects. However, the use of parental strategies is a complex area. Parents often use a mixture of practices and these practices develop also in response to the child's behaviour. In addition, often subtle effects are involved. Therefore, longitudinal research in the home setting with camera observations is recommended. This provides an excellent opportunity to get more insight into the causes and effects of a certain strategy, and to investigate the effects of the parental strategy of 'Choice' in a more familiar setting.

In conclusion, parents, caretakers and health professionals need to be persistent in order to increase children's vegetable preferences and consumption. On the basis of the research described in this thesis, the following strategies may be most promising: 1) serve vegetables as crunchy as possible without brown colouring or a granular texture; 2) provide children with choice during the process of vegetable eating; 3) stimulate a positive vegetable-eating context. Finally, serving vegetables in mixed dishes is a good way to facilitate flavour-flavour and flavour-nutrient learning, but the effectiveness of flavour-nutrient learning for increasing children's vegetable acceptance needs to be determined in future research.

Samenvatting
(Summary in Dutch)



Groente en fruit bevatten essentiële voedingsstoffen, kunnen het risico op hart- en vaatziekten verlagen en spelen mogelijk een rol bij het handhaven van een gezond lichaamsgewicht. Voedingsgewoonten en voedselvoorkeuren worden vaak op jonge leeftijd aangeleerd en blijven gehandhaafd als men ouder wordt. Daarom is het belangrijk om op jonge leeftijd een gezond voedingspatroon met voldoende groente en fruit aan te leren. De huidige groente- en fruitconsumptie bij kinderen is lager dan wordt aanbevolen. Onderzoek heeft aangetoond dat het moeilijk is om de groente- en fruitconsumptie bij kinderen te verhogen; vaak zijn de toenames in consumptie relatief klein en van relatief korte duur. Om nieuwe interventieprogramma's te kunnen ontwikkelen, richten we ons in dit proefschrift op de rol van ouderlijke strategieën, de cognitieve ontwikkeling van kinderen en de kenmerken van het product. Een belangrijke rol is weggelegd voor voedselvoorkeuren, omdat deze een cruciale rol spelen in de voedselkeuze van kinderen. Het hoofddoel van dit proefschrift is het ontwikkelen van leeftijdsspecifieke aanbevelingen om de groente- en fruitconsumptie te bevorderen bij 4- tot 12-jarige kinderen.

Bij aanvang van dit promotieonderzoek was er nog geen onderzoek gedaan naar de relatie tussen cognitieve ontwikkeling van kinderen en hun voorkeuren voor, en inname van, groente en fruit. Daarom hebben wij een kwalitatief onderzoek opgezet om deze relatie te bestuderen (Hoofdstuk 2). Er hebben kinderen uit drie leeftijdsgroepen deelgenomen (4-5j N=8; 7-8j N=8; 11-12j N=12), waarbij elke leeftijdsgroep een andere fase van cognitieve ontwikkeling vertegenwoordigt. Via duo-interviews en focusgroepgesprekken hebben we diepte-informatie verzameld. De resultaten lieten zien dat de belangrijkste kenmerken voor het wel of niet lekker vinden van groente en fruit verschoven met de leeftijd. Voor de 4-5-jarigen waren uiterlijk en textuur (mondgevoel) het belangrijkste, terwijl dit voor de 11-12-jarigen smaak was. Een belangrijk kenmerk van cognitieve ontwikkeling is een toename in het abstractieniveau. We konden deze ontwikkeling duidelijk terugzien bij de kinderen in hun cognities en redeneringen ten aanzien van groente en fruit, en tevens in hun toegenomen

begrip van gezondheid. Hoewel kinderen vaak gezond associëren met 'niet lekker', gaf ons onderzoek aanwijzingen dat deze link nog niet aanwezig is bij 4-5-jarigen.

Hoewel ouders een aanzienlijke rol spelen in de groente- en fruitconsumptie van hun kinderen, zijn interventieprogramma's tot nu toe vaak op school uitgevoerd met relatief weinig betrokkenheid van de ouders. Ouders beïnvloeden het eetgedrag van hun kind via hun eigen consumptiepatroon, hun voorbeeldgedrag en de ouderlijke strategieën die zij toepassen. De relatie tussen deze strategieën en de consumptie van kinderen is nog niet onderzocht voor groente en fruit als twee aparte productgroepen. Daarom hebben wij een vragenlijstonderzoek uitgevoerd (Hoofdstuk 3). Het doel was het identificeren van ouderlijke voedingsstrategieën die de potentie hebben om de groente- en fruitconsumptie bij kinderen te verhogen. Ouders (N=242) vulden een vragenlijst in over hoe vaak zij verschillende strategieën toepassen, en over de groente- en fruitconsumptie van henzelf en van hun kind. De kinderen (4-12j N=259) vulden een voorkeursvragenlijst in over groente en fruit. Dit onderzoek toonde aan dat ouders andere strategieën gebruiken voor groente dan voor fruit. 'Positieve informatie' en 'Pressie' waren de meest toegepaste strategieën voor groente. Voor fruit werden 'Beschikbaarheid', 'Positieve informatie' en 'Keuze' het meest toegepast. Hierdoor was de eetcontext voor groente negatiever dan de eetcontext voor fruit. Groente- en fruitconsumptie van de ouders en het aanbieden van keuze waren positief gerelateerd aan zowel de groente- als de fruitconsumptie van de kinderen. Kinderen waarvan de ouders het meest (hoogste 33%) gebruik maakten van de 'Keuze'-strategie, aten meer groente (+40 gram/dag) en fruit (+72 gram/dag) dan kinderen met ouders die het minst gebruik maakten van deze 'Keuze'-strategie.

Omdat we de groente- en fruitconsumptie van kinderen wilden stimuleren via het verhogen van hun voorkeuren, is het noodzakelijk om over een nauwkeurig meetinstrument te beschikken dat (kleine) veranderingen in voorkeur kan meten. Met een oriënterend onderzoek is bestudeerd of gezichtsuitdrukkingen een geschikte en nauwkeurige manier zijn om voorkeuren te meten bij kinderen (Hoofdstuk 4). Zes kinderen tussen de 5 en 13 jaar hebben zeven verschillende sapjes geproefd in willekeurige volgorde: appelsap, zuurkoolsap, bietensap, magere melk, een oplossing met aspergesmaak, en een bittere en zoete oplossing. Met behulp van een traditionele rangordeprocedure hebben de kinderen hun voorkeur aangegeven voor elk sapje. Door de hele sessie te filmen konden de gezichtsuitdrukkingen worden vastgelegd om vervolgens geanalyseerd te worden met het 'Facial Action Coding System'. Het bleek dat onsmakelijke sapjes duidelijk te herkennen waren, omdat de kinderen bij het proeven daarvan meer negatieve dan positieve uitdrukkingen lieten zien. We konden echter geen onderscheid

maken tussen een lekker of een neutraal sapje, omdat de kinderen bij beide evenveel positieve als negatieve gezichtsuitdrukkingen lieten zien. Op basis van deze resultaten concluderen we dat gezichtsuitdrukkingen geschikt zijn om afkeer te meten, maar niet geschikt zijn om de verschillende gradaties van acceptatie te meten bij 5- tot 13-jarige kinderen.

Op basis van deze eerste drie onderzoeken hebben we twee beslissingen genomen. Ten eerste besloten we om de methode van gezichtsuitdrukkingen niet te gebruiken in vervolgonderzoek. Ten tweede besloten we ons in de vervolgonderzoeken alleen op groente te richten, omdat groente vaak minder lekker gevonden wordt dan fruit, groente en fruit thuis verschillend gehanteerd worden, en omdat eerdere interventieprogramma's minder effectief waren voor groente dan voor fruit.

Het resultaat van ons kwalitatieve onderzoek (Hoofdstuk 2) omtrent het verminderde belang van textuur met de leeftijd, vormde het uitgangspunt voor het onderzoek in Hoofdstuk 5. Daarin hebben we bestudeerd hoe de aangenaamheid van groente beïnvloed wordt door de bereidingswijze van groente. De deelnemers bestonden uit kinderen van drie leeftijdsgroepen (4-6j N=46; 7-8j N=25; 11-12j N=23) en een groep jongvolwassenen (18-25j N=22). Worteltjes en sperziebonen werden op zes verschillende manieren klaargemaakt: gepureerd, gestoomd, gekookt, roergebakken, gegrild en gefrituurd. Tijdens een smaaktest hebben de deelnemers een voorkeursrangorde gemaakt voor de zes bereidingswijzen van beide groenten. Tevens hebben de jongvolwassenen de zes bereidingswijzen beoordeeld op vijftien productkenmerken ten aanzien van uiterlijk, textuur en smaak. Alle vier de leeftijdsgroepen gaven de voorkeur aan de gekookte en gestoomde worteltjes en boontjes boven de andere bereidingswijzen ($p<0.05$). Gekookt en roergebakken waren de bekendste bereidingswijzen voor beide groenten. Het lekker vinden van groente was positief gerelateerd aan een egaal uiterlijk, de typische groentesmaak en knapperigheid. Bruinkleuring en een korrelige textuur waren negatief gerelateerd aan het lekker vinden van groente.

Het onderzoek in Hoofdstuk 6 had als doel om te bestuderen of energie-smaak-conditionering een effectieve strategie is om de groentevoorkeur te verhogen bij 7-8-jarige kinderen (N=19). Energie-smaak-conditionering verwijst naar het leerproces waarbij een koppeling wordt gemaakt tussen de smaak van een product en het gevoel dat veroorzaakt wordt door het consumeren van (veel) energie. Dit principe wordt beschouwd als een belangrijke manier waardoor voedselvoorkeuren ontstaan, maar het is nog niet onderzocht of dit ook bij groente werkt. Tijdens het onderzoek kregen de kinderen herhaaldelijk twee groentesappen (150 gram) aangeboden gedurende een leerperiode van 14

dagen. In het hoog-energie-sapje werd een bepaalde groentesmaak gekoppeld aan energie door het toevoegen van extra energie in de vorm van maltodextrine. In het laag-energie-sapje, met een andere groentesmaak, werd geen extra energie toegevoegd. Onze verwachting was dat de voorkeur voor het hoog-energie-sapje meer zou toenemen in de tijd dan de voorkeur voor het laag-energie-sapje. Echter, in ons onderzoek kon energie-smaak-conditionering niet optreden doordat de kinderen tijdens de leerperiode te weinig dronken van de sapjes: 2.4 gram (SD=5.6) voor het hoog-energie-sapje en 3.0 gram (SD=9.3) voor het laag-energie-sapje. Deze ontoereikende consumptie is mogelijk te verklaren door de hoge smaakintensiteit van de sapjes, de ervaren toename in bitterheid, zoutheid en dikheid, en de onverwachte combinatie van groente in sapvorm. Op basis van deze bevindingen veronderstellen we dat de pure groentesmaak op zichzelf niet acceptabel is. Door groente te mixen met andere voedingsmiddelen leren kinderen heel geleidelijk groente te accepteren door energie-smaak-conditionering en smaak-smaak-conditionering (koppeling tussen een nieuwe smaak en een bekende, aangename smaak).

Het vragenlijstonderzoek in Hoofdstuk 3 duidde erop dat 'Keuze' een waardevolle strategie kan zijn om de groenteconsumptie van kinderen te verhogen. Dit zou verklaard kunnen worden door de 'Self-determination'-theorie. Door het aanbieden van keuze wordt het gevoel van autonomie versterkt en de intrinsieke motivatie verhoogd. Dit kan leiden tot een hogere waardering, meer plezier, grotere tevredenheid en betere prestaties. Tot nu toe is deze relatie nog niet experimenteel onderzocht voor groente. Daarom hebben wij onderzocht of een keuze tussen twee soorten groente resulteert in een hogere waardering en consumptie van de groente (Hoofdstuk 7). Driehonderddrie kinderen in de leeftijd van 4-6 jaar hebben samen met één van hun ouders in ons restaurant een maaltijd gegeten. Ouder-kindparen werden op basis van toeval toegewezen aan één van de drie maaltijdsituaties. Elk kind kreeg twee soorten groente te zien, die hij/zij ongeveer even lekker vond. Vervolgens kreeg het kind 1) geen keuze: één van de twee groenten werd op basis van toeval toegewezen aan het kind, 2) een keuze vóór de maaltijd: het kind mocht aanwijzen welke van de twee groenten hij/zij wilde eten, of 3) een keuze tijdens de maaltijd inclusief variatie: het kind kreeg beide groentesoorten op zijn/haar bord geserveerd. Na de maaltijd hebben zowel de ouders als de kinderen vragen beantwoord over de maaltijdbeleving en de aangenaamheid van de groente. Door het wegen van alle maaltijdcomponenten voor en na de maaltijd, kon worden vastgesteld hoeveel elke deelnemer gegeten had. Het bleek dat de kinderen alleen de keuze vóór de maaltijd als een echte keuzesituatie ervoeren. Hoewel zij het erg leuk vonden dat ze mochten kiezen in deze situatie, was er geen significant verschil tussen

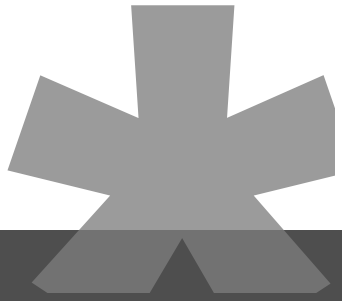
de drie situaties in aangenaamheid (p=0.43) en consumptie van de groente (p=0.54): 56±45 gram in de geen-keuze-situatie, 51±46 gram in de situatie met keuze vóór de maaltijd, en 49±47 gram in de situatie met keuze en variatie. In de geen-keuze-situatie aten tegendraadse kinderen minder groente (45±42 gram) dan niet tegendraadse kinderen (73±43 gram; p=0.04).

In Hoofdstuk 8 plaatsen wij onze bevindingen in een breder perspectief. Het is belangrijk dat men zich realiseert dat wij onderzoek hebben gedaan bij kinderen van relatief hoog opgeleide ouders. Wij raden aan om vergelijkbaar onderzoek te doen bij kinderen met lager opgeleide ouders. Om de groente- en fruitconsumptie van kinderen te veranderen, is het belangrijk om zowel het product, als de persoon, alsook de omgeving in beschouwing te nemen. Wat betreft het product toonde ons onderzoek aan dat een egaal uiterlijk, texturen die controleerbaar zijn in de mond en bekendheid aantrekkelijke aspecten zijn voor groente. Dit moet echter bevestigd worden in vervolgonderzoek. Om beter te begrijpen hoe we groente zo aantrekkelijk mogelijk kunnen aanbieden, is het noodzakelijk om een bepaald kenmerk van één groentesoort systematisch te variëren en de uitkomsten daarvan te relateren aan de gegevens van de kinderen over de aangenaamheid. Het is nog niet duidelijk waarom de beloningswaarde van groente zo laag is, waardoor groente niet uitnodigt tot eten. Omdat fruit meestal wel lekker wordt gevonden door kinderen, is het verhogen van voorkeuren waarschijnlijk een effectievere benadering voor groente dan voor fruit. Wat betreft de persoon geeft ons onderzoek aanwijzingen dat we basisschoolkinderen niet als één homogene groep moeten zien. De leeftijdsverschillen die ontstaan door cognitieve en fysieke ontwikkelingen vergen nader onderzoek. Bovendien zouden deze verschillen meegenomen moeten worden bij de ontwikkeling van interventieprogramma's voor kinderen om deze zo effectief en betekenisvol mogelijk te maken. Wat betreft de omgeving is bekend dat ouders graag willen weten welke strategieën een gezond eetpatroon stimuleren en welke dat juist tegenwerken. Het gebruik van strategieën is echter een complex onderwerp. Ouders gebruiken vaak verschillende strategieën tegelijkertijd, ze passen de strategieën ook aan als reactie op het gedrag van hun kind, en meestal hebben de strategieën heel subtiele effecten als gevolg. Daarom raden we aan om longitudinaal onderzoek uit te voeren in de thuissituatie met cameraobservaties. Op die manier kunnen we meer inzicht verkrijgen in wat de oorzaak is van een bepaalde strategie en wat het gevolg is, en kunnen we het effect van de ouderlijke strategie 'Keuze' bestuderen in een meer vertrouwde omgeving.

Concluderend: ouders, verzorgers en gezondheidsdeskundigen zullen vasthoudend moeten zijn om de voorkeur en consumptie van groente te verhogen bij kinderen. Op basis van het onderzoek in dit proefschrift lijken de

volgende strategieën veelbelovend: 1) serveer groente zo knapperig mogelijk zonder bruinkleuring of korrelige textuur; 2) geef kinderen enige keuzevrijheid binnen het proces van groente eten; 3) streef naar een positieve eetcontext voor groente. Tenslotte is het mixen van groente met andere maaltijdcomponenten in samengestelde maaltijden een goede manier om smaak-smaak-conditionering en energie-smaak-conditionering te stimuleren. Echter de effectiviteit van energie-smaak-conditionering voor het verhogen van de voorkeur voor groente moet in toekomstig onderzoek nog bevestigd worden.

Dankwoord
(Acknowledgements)



Vanaf deze plek wil ik graag een aantal mensen bedanken die hebben bijgedragen aan de totstandkoming van dit boekje.

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Hannie, wat hebben we veel gemeen: geboren en getogen in 'Fryslân', gestudeerd in Wageningen, AIO geworden, wonend op de Schaepmanstraat en onze passie voor sport (hardlopen, wandelen, schaatsen, fitness). We hebben het vaak over belangrijke keuzes in het leven: wat willen we, wat kunnen we, wat vinden we nou echt belangrijk en leuk om te doen. Ik vind het 'machtich moai' om dit samen te kunnen delen en ik weet zeker dat we onze weg daarin vinden.

In drukke tijden was het goed om te realiseren dat er nog een wereld is buiten het AIO-zijn. Arjenne, Carolien, Renske, Diane, Marleen, Mariska, Lieke, Margriet, Debbie en Marjolijn, dank voor jullie betrokkenheid, onze gezellige etentjes, dagjes stad, bezoekjes sauna, weekendjes weg en de lieve telefoontjes en mailtjes.

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Lieve Thomas, 2009 was een heftig jaar voor ons op alle fronten, gelukkig met goede afloop. Jij hebt me altijd gesteund! Dank voor je bemoedigende woorden, je rotsvaste vertrouwen in mijn kunnen en het helpen herinneren aan de kussensloopspreuk! Jij helpt me om dingen in het juiste perspectief te zien, wat me helpt bij het maken van keuzes. Samen gaan we een nieuw avontuur aan in Suriname, het land met het echte broccolibos. Ik heb er zin in!

Gertrude

About the author

CURRICULUM VITAE

Gertrude Gerlofke Zeinstra was born on the 10th of September 1979, in Leeuwarden, The Netherlands. At primary and secondary school, she was intensely involved in gymnastics and competed at the Dutch national level. This experience triggered her interest in health, nutrition and physical activity. After completing secondary school at 'Comenius College' in Leeuwarden with honour (cum laude), she started the program Nutrition & Health at Wageningen University in 1997. Her first MSc thesis, at the division of Human Nutrition, was entitled: The influence of twelve days exposure to different types of fruit juices on the intake and pleasantness in young and elderly persons. Gertrude performed her second MSc thesis at the market research agency 'Censydiam' in Amersfoort. She investigated whether various preference scales were well-understood and properly used by children aged 5 to 12 years. In the year 2001-2002, Gertrude organized, with five other students, the Annual Introduction Days for new students in Wageningen (AID 2002). After that, Gertrude did her internship at the INRAN (Institue Nationale Recherca Agglimentari Nutrizione) in Rome, Italy. She designed, carried out and evaluated an intervention program that aimed to encourage exercise in children. This internship resulted in a poster presentation at the 9th European Nutrition Conference (Rome, Italy). She received her MSc degree with honour in 2003, after which she was enrolled in the education program 'Sport & Exercise' at Windesheim in Zwolle for one year.

Since September 2004, Gertrude has been involved in the interdisciplinary PhD project 'CODE Delicious', a joint project of Human Nutrition and Communication Science at Wageningen University. Her research focused on the role of parental strategies, children's cognitive development and properties of food in order to develop new approaches to increase fruit and vegetable preferences and intake in 4 to 12-year-old children. During her PhD project, Gertrude attended several (international) conferences and courses, was involved in teaching and was a member of the Safety & Health committee of the division of Human Nutrition. In 2008, she was involved in the development of two new project proposals, which were both approved. One was a research proposal about the development of vegetable preferences in infants and young children. The other was a proposal for the European MSc specialisation in Sensory Science, which has started in September 2009. At present, Gertrude is preparing her one-year visit to Suriname, where she aims to work in the field of public health, nutrition and physical activity.

LIST OF PUBLICATIONS

Papers in peer-reviewed journals

Zeinstra GG, Koelen MA, Kok FJ, Graaf C de. The influence of preparation method on children's liking for vegetables. Submitted for publication.

Zeinstra GG, Renes RJ, Koelen MA, Kok FJ, Graaf C de. Offering choice and its effect on Dutch children's liking and consumption of vegetables: a randomized controlled trial. Accepted *The American Journal of Clinical Nutrition* 2009.

Zeinstra GG, Koelen MA, Kok FJ, Laan N van der, Graaf C de. Parental child-feeding strategies in relation to Dutch children's fruit and vegetable intake. In press *Public Health Nutrition* 2009 (doi:10.1017/S1368980009991534).

Zeinstra GG, Koelen MA, Kok FJ, Graaf C de. Children's hard-wired aversion to pure vegetable tastes: a 'failed' flavour-nutrient learning study. *Appetite* 2009; 52 (2): 528 - 530.

Zeinstra GG, Koelen MA, Colindres D, Kok FJ, Graaf C de. Facial expressions in school-aged children are a good indicator of 'dislikes', but not of 'likes'. *Food Quality and Preference* 2009; 20 (8): 620 - 624.

Zeinstra GG, Koelen MA, Kok FJ, Graaf C de. Cognitive development and children's perceptions of fruit and vegetables: a qualitative study. *International Journal of Behavioral Nutrition and Physical Activity* 2007; 4: 30 (doi:10.1186/1479-5868-4-30).

Essed NH, Staveren WA van, Kok FJ, Ormel W, Zeinstra GG, Graaf C de. The effect of repeated exposure to fruit drinks on intake, pleasantness and boredom in young and elderly adults. *Physiology and Behavior* 2006; 89 (3): 335 - 341.

Abstracts

Zeinstra GG, Graaf C de, Koelen MA. The influence of preparation method on children's liking for vegetables. In: Abstract Book 8th Pangborn Sensory Science Symposium, Florence Italy: 26 - 30 July 2009 (Poster presentation).

Zeinstra GG, Koelen MA, Kok FJ, Graaf C de. Children's hard-wired aversion to pure vegetable tastes. A 'failed' flavour–nutrient learning study. In: Abstract Book British Feeding and Drinking Group, Swansea UK: 2 - 3 April 2009 (Oral presentation).

Zeinstra GG, Graaf C de, Koelen MA. The influence of preparation method on children's liking for vegetables (abstract British Feeding and Drinking Group, Liverpool UK: 26 - 27 March 2008). *Appetite* 2008; 51 (3): 757 (Oral presentation).

Zeinstra GG, Graaf C de, Koelen MA. Children's preferences and consumption of fruit and vegetables: the role of parental strategies. In: Abstract Book Association for the Study of Obesity, Liverpool UK: 28 March 2008 (Poster presentation).

Zeinstra GG, Colindres D, Koelen MA, Graaf C de. The pilot study Face-Express: Facial expressions as an indicator of food preferences in school-aged children. In: Abstract Book 7th Pangborn Sensory Science Symposium, Minneapolis USA: 12 - 16 August 2007 (Oral presentation).

Zeinstra GG, Colindres D, Koelen MA, Graaf C de. The pilot study Face-Express: Facial expressions as an indicator of food preferences in school-aged children. In: Abstract Book British Feeding and Drinking Group, Newcastle upon Tyne UK: 2 - 3 April 2007 (Oral presentation).

Zeinstra GG, Graaf C de, Koelen MA. Children's preferences and consumption of fruit and Vegetables: the role of parental strategies. In: Abstract Book Second European Conference on Sensory Consumer Science of Food and Beverages 'A Sense of Diversity', The Hague NL: 26 - 29 September 2006 (Poster presentation).

Zeinstra GG, Graaf C de, Koelen MA. Social cognitive development and children's food preferences. In: Abstract Book Fourth Annual Conference of the International Society of Behavioral Nutrition and Physical Activity, Amsterdam NL: 16 - 18 June 2005 (Poster presentation).

Zeinstra GG, Graaf C de, Koelen MA. Social cognitive development and children's food preferences. In: Abstract Book 6th Pangborn Sensory Science Symposium, Harrogate UK: 7 - 11 August 2005 (Poster presentation).

Zeinstra GG, Graaf C de, Koelen MA. Social cognitive development and children's food preferences (abstract of the joint meeting of the British Feeding and Drinking Group & the Dutch Working Group on Food Habits, Wageningen NL: 11 - 12 April 2005). *Appetite* 2005; 45 (3): 377 (Poster presentation).

Zeinstra GG, Berni Canani R, Spada R, Branca F, Groot CPGM de. The challenge to increase physical activity in school-age children: the pilot study 'It's time to move' (abstract of the 9th European Nutrition Conference, Rome Italy: 1 - 4 October 2003). *Annals of Nutrition & Metabolism* 2003; 47 (6): 557 (Poster Presentation).

OVERVIEW OF COMPLETED TRAINING ACTIVITIES

Description	Organizer & location	Year
DISCIPLINE SPECIFIC ACTIVITIES		
Courses & workshops		
Gespreksvoering met kinderen (Communicating with children)	PAO, Utrecht (NL)	2005
Seminar Qualitative analysis 'How to cook it!'	Faculty of Spatial Sciences, Groningen (NL)	2005
Food perception and preference	Graduate School VLAG, Wageningen (NL)	2005
Regulation of food intake and its implications for nutrition and obesity	Graduate School VLAG, Wageningen (NL)	2006
15th ETC-PHHP Summer Course on strategies for health in Europe 'Sailing across new seas: Capacity building for Health Promotion Action'	European Training Consortium in Public Health and Health Promotion, Zagreb (Croatia)	2006
How to approach novelty? Responses to new foods in children and adults	ABS Finnish Graduate School, Helsinki (Finland)	2006
Baby FACS workshop	Nestlé, Lausanne (Switzerland)	2007
Conferences & meetings		
Symposium 'It's a matter of taste'	Division of Human Nutrition, Wageningen (NL)	2004
Symposium 'Proeven van succes II'	VMT & MOA, Bussum (NL)	2005
ISBNPA Conference	ISBNPA & Erasmus MC, Amsterdam (NL)	2005
Meetings Werkgroep Voedingsgewoonten (Nutritional habits)	WEVO	2005 - 2009
6th, 7th and 8th Pangborn Sensory Science Symposium	Elsevier Harrogate (UK) Minneapolis (USA) Florence (Italy)	 2005 2007 2009
Annual meetings of British Feeding and Drinking Group	BFDG Wageningen (NL) Newcastle upon Tyne (UK) Liverpool (UK) Swansea (UK)	 2005 2007 2008 2009
Second European Conference on Sensory Consumer Science of Food and Beverages 'Sense of Diversity'	European Sensory Network, The Hague (NL)	2006

Description	Organizer & location	Year
Symposium series 'Children & Overweight'	Leids Congres Bureau Rotterdam (NL) Amsterdam (NL)	 2006 2007
Symposium 'Early development and obesity'	Association for the Study of Obesity, Liverpool (UK)	2008
Symposium 'Food for kids: lekker en goed' (tasty and healthy)	VMT, Maarssen (NL)	2008
ECO Satellite meeting 'Cross-European community interventions and studies to prevent obesity'	VU Windesheim & Research centre for the prevention of overweight, Amsterdam (NL)	2009
GENERAL COURSES & WORKSHOPS		
Workshop Scientific Publishing	WGS, Wageningen (NL)	2004
Begeleiden Onderwijsgroepen (Facilitating group learning of students)	OWU, Wageningen (NL)	2005
Talent class 'Creative Thinking'	NWO, The Hague (NL)	2005
PhD Introduction week	Graduate School VLAG, Bilthoven (NL)	2005
Talent class 'Improving PhD skills' & 'Media training'	NWO, Zeist (NL)	2005
Project- and Time Management	Mansholt Graduate School, Wageningen (NL)	2006
Scientific Writing	CENTA language centre, Wageningen (NL)	2007
Effective behaviour in your professional surroundings	Meijer & Meijaard, Wageningen (NL)	2008
OPTIONAL COURSES & ACTIVITIES		
PhD study tour UK & Ireland	Division of Human Nutrition	2005
PhD study tour USA	Division of Human Nutrition	2007
Writing IP/OP proposal about the development of vegetable preferences in young children 'Mum, can I have Brussels sprouts again'	WUR, Wageningen (NL)	2008
Literature group 'Journal Club' and 'Olds Mobiles'	Division of Human Nutrition, Wageningen (NL)	2004 - 2009
Research presentations	Division of Human Nutrition, Wageningen (NL)	2004 - 2009
Research presentations	Department of Communication Science, Wageningen (NL)	2004 - 2009

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