INTERNAL AND EXTERNAL PREDICTORS OF FRUIT AND VEGETABLE CONSUMPTION IN CHILDREN

by

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Abstract

Past research on intake of fruit and vegetables (FV) in children has measured intake of FV as a unified concept, despite evidence that fruit intake has different drivers than vegetable intake. Further, studies on intake of FV in children have focused either on external or on internal influences, but rarely combined the two in one project. This thesis explored various internal predispositions and external predictors of FV intake in children. Intake of FV was analysed separately for fruit and for vegetables, and was also analysed separately for subgroups of FV which are characterised by strong sensory characteristics, such as astringent fruit and cruciferous vegetables. Intake of FV was analysed in two samples of children; a younger sample of 2-3 year olds and an older sample of 5-9 year olds. The results showed that lifetime exposure to FV was related to the quantity and diversity of FV consumed by the older children (Chapter III). Toddlers' liking of FV was not directly linked to intake of FV, but parental control moderated the link between liking and intake of fruit (Chapter IV). Past history of OM infections may affect intake of FV and adiposity levels in the school-age children but not toddlers (Chapter V) and individual levels of sweet taste sensitivity may affect intake of cruciferous vegetables and non-astringent fruit in school-age children (Chapter VI). The results of this thesis show evidence that fruit intake should be considered separately from vegetable intake when studying children's diets. It is also evident that there are intrinsic barriers to accepting FV, which may be overcome by creating home environments which facilitate FV intake. The findings presented in this thesis show support for the use of multi-level intervention programmes targeted for fruit or vegetable intake, which focus on both children and their parents.

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List of abbreviations

BV- Balance and variety

CFBQ- Child Feeding Behaviours Questionnaire

Ch.- Child

CT- Chorda tympani

FFQ- Food frequency questionnaire

FP- Fungiform papillae

FV- Fruit and vegetables

ICL- Infant and child laboratory

M.- Mother

OM- Otitis media

PALS- Pre-schooler Adapted Liking Survey

SDT- Sucrose detection threshold

CS- Conditioned stimulus

UCS- Unconditioned stimulus

CR- Conditioned response

Chapter I: Literature review

1.1 Introduction

Intake of fruit and vegetables (FV) in children in the UK is too low and does not meet the recommended guidelines (Public Health England, 2014), despite numerous campaigns and intervention programmes, which until now have not shown substantial effects on intake (Delgado-Noguera, Tort, Martinez-Zapata, & Bonfill, 2011). Over recent years there has been a very slow but consistent increase in intake of FV in children, however fewer than 1 in 5 children consume the recommended amount of FV a day, and 1 in 10 children consume only 1 portion a day (Bell & Tepper, 2006). FV have been shown to have beneficial effects on preventing cardiovascular problems (Gan et al., 2015) and their anti-mutagenic and anti-carcinogenic (Edenharder, Kurz, John, Burgard & Seeger, 1994) properties have been well established. In fact, epidemiological data show that 20,000 cancer cases a year could be avoided worldwide by increasing intake of FV by 1 serving a day (Reiss, Johnston, Tucker, DeSesso, & Keen, 2012). A recent report based on meta-analysis of 16 prospective cohort studies which incorporated 833,234 cases suggested that intake of 5 portions of FV a day is associated with reduced all-causes mortality (Wang et al., 2014). Understanding the predictors of FV intake is essential to improve the effectiveness of public health campaigns.

Developing healthy eating habits and consuming a diet rich in FV during childhood is particularly important, as several studies, which will be further discussed in this review, have demonstrated that eating habits develop during childhood and may remain stable throughout lifetime. Research examining determinants of FV intake in children can be divided into two areas, focused on external or internal factors. External drivers are various environmental factors, while internal drivers are personal factors which affect intake or preferences. While external and internal drivers interact and show bi-directionality, for the purpose of this review they will be considered separately. This review will summarise the current state of knowledge on the effects of these external and internal predictors on FV intake in children.

1.2 External determinants of FV intake

External drivers can be broadly described as environmental influences from the child's cultural, school and home environment, or any place where the child is exposed to food and any socio-cultural factors that are linked with intake of food. Factors reviewed here will be socio-demographic influences, early life experiences, home environment and parental influences.

1.2.1 Socio-demographic factors

1.2.1.1 Culture and Ethnicity

Past research generally shows support for FV consumption differences by ethnicity, however the findings are inconsistent. The conceptualisation of culture and ethnicity differs between studies, with some measuring race, some referring to ethnicity, and few considering immigration status, despite the fact that immigrants tend to eat more FV compared to natives, irrespective of race (Rodenburg, Oenema, Kremers & van de Mheen, 2012). For the purpose of this review, terms as conceptualised in the original papers will be used.

In a recent review, Noia and Byrd-Bredbenner (2014) identified 85 unique determinants of FV intake among low-income youth. They concluded that race/ethnicity was the strongest determinant of FV intake among 58 papers published between 2003-2013. Their findings indicated that Hispanic ethnicity was associated with higher FV intake compared to African-American or Caucasian race. Kim, Park, Cha & Yeo (2014) examined National Health Surveys between 2003 and 2010 and also concluded that Hispanic children consume more vegetables but not fruit, compared to non-Hispanic children. Rasmussen et al. (2006) in their review found cultural and ethnic differences in intake of FV, but did not detail where those differences are.

Those findings may however result from tertiary variables associated with ethnicity, such as income, education, differences in nutrition knowledge, or not accounting for immigration or acculturation status. Furthermore, the vast majority of studies looking at FV intake in different ethnic groups are American, where there may be different constraints on FV intake than in Europe, such as effects of neighbourhood on intake of FV or availability of FV in the local supermarkets (higher in Hispanic neighbourhoods; Timperio et al., 2008). Neighbourhood effects on FV intake are not apparent outside the US (Winkler, Tuller & Patterson, 2006).

1.2.1.2 Socio-economic status

Socio-economic status (SES) of parents has been shown to be linked with FV intake in children. Factors that are assessed when looking at SES are usually income, parental occupation and education, and the economic status of the neighbourhood (particularly in American studies). Studies consistently report that higher SES is linked with higher intake of FV among children, adolescents and adults.

In their review, Rasmussen et al. (2006) emphasised that despite differences in operationalisation and classifications of SES, low SES is associated with lower intake of FV, which is particularly consistent when using education as a proxy for SES. However, the choice of SES proxy affects results, including whether maternal or paternal SES was measured. For example, parental education level showed a positive relationship with child's FV intake in all studies reviewed, while other measures such as maternal or paternal income level, occupation or education showed lower strength of association across the studies.

The association between SES measures and children's FV intake can be explained in part by higher nutrition education among parents with higher SES. Hendrie, Coveney and Cox (2008) demonstrated that higher level of education was linked with greater nutrition knowledge and better awareness of the current recommendations for FV intake. Parmenter, Waller and Wardle (2000) replicated the results in the British sample and also showed that education level and other proxies of SES are positively associated with nutrition knowledge. Further, lower SES has been linked with higher frequency of outside home consumption of 'junk food' and lower parental control of meal preparation. Kirby et al. (1995) used a reciprocal determinism model to find influences of FV intake in children and found that children from low and very low SES were reported to be more responsible for preparing meals at home, were eating outside home more often and the food they ordered was 'junk food' rather than food which contained FV. The cost of FV has also been identified as a barrier or perceived barrier to purchasing FV in American (Yeh et al., 2010), Dutch (Kamphuis et al., 2006), Finnish (Laaksonen, 2003) and British samples (John, Yudkin, Neil & Ziebland, 2003).

In addition, lower SES is linked with higher intake of 'junk food' (Larsen, 2015) and in general has been closely tied with the so called 'obesogenic environment' due to links with lower availability of healthy foods, greater proximity to fast-food restaurants and more barriers to physical activity (Evans, Wells, & Schamberg, 2010). For that reason SES needs to be recognised as an important factor in the studies that look at FV intake in children, particularly with regard to the generalisability of study results. In the UK this is less of an issue with intervention studies which are based in school settings, but is an important barrier in experimental research, where volunteers typically represent high SES.

1.2.1.3 Age

Children's intake of FV in different age groups shows inconsistent findings. The association with age seems to differ across age groups and varies for fruit versus vegetable intake. Literature seems to consistently report that among children under 3 years of age there is the highest proportion of those who meet the recommended guidelines (Scottish Health Survey, 2012). For older children the association with age seems to be non-linear and difficult to interpret. The association also seems to vary between European and American reports.

The study by Lorson, Melgar-Quinonez and Taylor (2009) on a large American sample of 6513 children and adolescents between 2-18 year olds, showed that children between 2-5 years old had higher intake of fruit and fruit juice than older children, however vegetable intake was higher in children over 12 years old. While the number of portions showed the trend to decrease with age for fruit intake and increase with age for vegetable intake, the proportion of consumed FV to the overall daily intake was decreasing with age. Over 50% of 2-5 year old children met the recommended fruit intake guidelines, compared to less than 26% in 6-11 year olds. For vegetables, less than 22% of 2-5 year olds met the recommended guidelines, compared to 16.2% of 6-11 year olds. However, numerous other SES differences were found between the samples, such as gender and ethnicity, and these were not adjusted in analyses of age differences, which means that any differences found may be partially explained by other SES factors, not necessarily age.

In the most recent review of 58 publications examining FV intake, Noia and Byrd-Bredbenner (2014), showed that in the samples of low-income children and adolescents, 11 out of 13 studies did not find association between age and FV intake and two found a negative link with FV intake. However, the review does not specify the exact age range of the samples included, other than younger than 20 years old, including pre-schoolers. This makes interpretation of the results difficult, as studies specifically on children under 6 years of age often show this age dependent decrease in FV intake. In contrast, Rasmussen et al. (2006) in their review of papers examining children and adolescents between 6 and 18, found that 10 out of 22 papers reviewed reported decreases in FV intake with age and 9 found no association with age. The authors suggest that methodology of measurement of FV intake may lead to inconsistent findings, as those papers that reported the link between age and FV intake mostly used food frequency questionnaires, and those which did not find the link mostly used a 24 hour recall method, which suggests that possibly the measurement method affects the results. Additionally, it emerged that the majority of studies which did find the link between age and FV intake were conducted on European sample as opposed to American, studies which often found no association.

While the findings on the age differences are not consistent, it seems that European studies tend to report them, perhaps because of the differences in the outside home availability, which differs between the American and European samples due to differences in school policies. As such, age should be a factor considered when examining intake of FV in children, particularly when children of different age groups are tested in one study.

1.2.1.4 Gender

As with age, gender differences in intake of FV do not show consistent patterns, however research tends to support the view that boys eat fewer FV than girls, with studies showing different associations when fruit and vegetables are analysed separately. In the review by Noia and Byrd-Bredbenner (2014) 11 out of 14 (78.6%) studies did not find support for gender differences in FV intake and in the review by Rasmussen et al. (2006) 18 out of 49 papers (36.7%) did not find such a link, while 27(55.1%) showed that girls consumed more FV than boys. Again the authors suggest that papers which did not find such association were conducted mostly on the American population. It is unclear why such differences between European and American reports may exist, but gender differences in under-reporting of food portions of boys have been previously identified in the British studies (Glynn, Emmett, Rogers & the ALSPAC Study Team, 2005).

Gender differences have also been reported for liking and preference for FV. Cooke and Wardle (2005) showed that in the UK sample of children and adolescents between 4-16 years old, girls liked both fruit and vegetables more than boys did, however in an earlier study on a more age restricted sample of 2-6 year olds, Cooke et al.

(2004) showed that girls ate more vegetables than boys, but this effect was not seen for fruit. Mak et al. (2012) showed that in children between 1.5-10 years old, girls consumed significantly more fruit but not vegetables. Neither of those studies looked at whether those gender differences show different patterns across different age groups, separately for FV. Inconsistent findings on gender differences in FV intake seem to result from the sample characteristics (particularly European vs. Non-European) and differences in age groups tested.

Gender differences in FV intake are also well documented in adults, showing that women consume more FV than men, possibly because of differences in perceived norms, attitudes and perceived behavioural control (Emanuel, McCully, Gallagher, & Updegraff, 2012). Gender differences in FV intake can be explained with different feeding practices that mothers use with boys and girls (Harris, Mallan, Nambiar, & Daniels, 2014). At the same time boys are reported to like fatty and sugary foods and processed meats more than girls (Cooke & Wardle, 2005) and are more at risk for obesity than girls (National Obesity Observatory, 2010). Given the previously reported age dependent differences in FV intake, it seems that gender differences in FV intake are important to consider in the studies of children's FV intake.

1.2.2 Early life factors

1.2.2.1 Prenatal exposure

Studies on early flavour learning and early flavour experiences suggest that in utero exposure to flavours may affect postnatal acceptance of foods. This exposure begins with maturation of gustatory and olfactory systems, which starts in the first trimester with the formation of functional taste cells by 10th week of gestation and full maturation by 12^{th} week of gestation (Ventura & Worobey, 2013). The full in utero exposure to flavours occurs when tastant and nutrient-rich amniotic fluid is both ingested and inhaled by the foetus and in this way is exposed to the maternal diet.

There are relatively few studies that looked at prenatal exposure to FV and preferences or intake of FV postpartum, due to methodological and ethical constraints. Evidence shows that amniotic fluid changes odour in response to strong flavours, such as garlic (Mennella, Johnson & Beauchamp, 1995). One of the first studies looking at the postpartum preferences for odour showed that infants whose mothers often consumed garlic during pregnancy showed preference for garlic odour during the first 24 hours postpartum, compared to infants who were not exposed to garlic via amniotic fluid (Hepper, 1988). The results were later replicated for anise odour (Schaal, Marlier & Soussignan, 2000). In a classic study, Mennella et al. (2001) demonstrated that infants whose mothers drank carrot juice in the last trimester of pregnancy or during the first eight weeks of lactation had fewer negative facial expressions when exposed to carrot flavour 4 weeks after weaning, compared to a control group who were not exposed to carrot flavour. However, the differences were only found in facial expressions not the actual intake, so perhaps the mothers in the experimental conditions showed bias and exhibited positive facial expressions during the feeding and babies were mirroring that behaviour.

Evidence from animal studies seems to support effects of prenatal experiences on intake postpartum. Bilko, Altbacker & Hudson (1994) showed that in a rabbit model, exposure to juniper berries in utero affected preference for juniper berry-enhanced chow postpartum. Similar findings were found in lambs (Simitzis et al., 2008) where postpartum preferences for oregano flavoured ewe's milk, as a result of in utero exposure, were seen up to 7.5 months postpartum. This was also replicated in piglets (Figueroa, Solà-Oriol, Vinokurovas, Manteca & Pérez, 2013) and rats (Galef & Henderson, 1972).

It is yet unclear which flavours and odours are transmitted via amniotic fluid, but this has been shown for carrot, garlic, alcohol (Faas, Spontón, Moya & Molina, 2000) and tobacco (Mantella, Kent & Youngentob, 2013) and while it would be excessive to imply that all flavours and odours are expressed in amniotic fluid, there certainly seems to be the case that those characterised by strong odour or flavour have potential to get transmitted. Moreover, it has been demonstrated that infants show preference for the odour of their own amniotic fluid postpartum (Marlier, Schaal & Soussignan, 1998; Schaal, Marlier & Soussignan, 1998) which may suggest that they would show preference for odours of chemical compounds which they have been regularly exposed to during pregnancy, particularly during the third trimester when taste and odour receptors begin to actively communicate with the central nervous system in response to new chemical stimuli (Mennella and Ventura, 2010). Despite limited empirical evidence from human studies, it seems likely that regular exposure to odour and flavour of FV in utero may result in preference for those products postpartum.

1.2.2.2 Breastfeeding

The evidence for the effects of flavour exposure via breastfeeding on preferences is more robust compared to prenatal exposure. Just like amniotic fluid, breast milk contains elements of maternal diet which can substantially change the odour and flavour of breast milk, however the extent of this transfer shows individual differences (Hausner, Bredie, Molgaard, Petersen & Moller, 2008). Repeated exposure to flavours and odours present in breast milk aids acceptance and preference for those flavours at later stages of development, and facilitates novel flavour acceptance (Hausner, Nicklaus, Issanchou, Molgaard & Moller, 2010).

One of the first studies on sensory properties of human milk as a result of diet was conducted by Mennella and Beauchamp (1991), where they demonstrated that the odour of garlic is transferred to human milk in mothers who regularly ate garlic in the last trimester, and is obvious 2 hours after ingestion. They showed that the infants recognised the change of flavour and sucked more and for longer period of time when milk had the garlic odour. What is familiar is liked, at least during the early stages of life.

Furthermore, Mennella et al. (2001) showed that infants whose mother drank carrot juice either in the last trimester of pregnancy (condition 1) or during the first 8 weeks post-partum and breastfed (condition 2), had fewer negative responses to carrot flavoured cereal during weaning compared to mothers who did not drink carrot juice (condition 3). Forestell and Mennella (2007) further demonstrated that breastfed infants ate more peaches compared to formula-fed infants, consumed them at a faster rate and showed fewer negative expressions, as a result of probable higher maternal intake of fruit during lactation. This effect was not repeated for green beans, however the mothers were reported to not meet the recommended guidelines for vegetable intake. The exact intake of FV during breastfeeding was not reported. Higher intake of peaches by breast fed babies may have resulted either from infants being able to generalise flavours or from being exposed to higher variance of flavours in the breast milk, the taste of which is less monotonous than formula.

Past research also suggests that breastfeeding may facilitate acceptance of a novel vegetable after repeated exposure. Sullivan and Birch (1994) demonstrated that after 10 day exposure to a vegetable, breastfed infants showed increased intake of vegetables and consumed more of a test vegetable compared to formula-fed infants, possibly as a result of exposure to vegetable flavour during lactation or to greater variations of flavours from breast milk, as opposed to the homogenous flavour of formula. Similar results were found for animal models. Rat pups exposed to maternal diet via maternal milk showed preference for maternal diet during weaning, but pups exposed to maternal diet via odour cues from maternal fur or from faeces did not show such preference (Galef & Henderson, 1972).

It is generally established that breastfed infants consume more FV than formula fed infants, they are less likely to be obese and they are less likely to be overfed, which has recently been linked with intake of leptin secreted in breast milk (Palou & Pico, 2009). Breastfeeding seems to aid acceptance of specific flavours transmitted in breast milk and it seems to facilitate more general acceptance of novel flavours. It has been demonstrated that flavours which are a part of maternal diet are transmitted in breast milk, however there are individual differences in the extent of this expression. Breast milk is a medium which exposes child to specific FV flavours and gives the experience of flavour variety in contrast to formula. It is not known which of these types of exposure is necessary or most important for facilitation of acceptance of FV.

1.2.2.3 Weaning

Early experiences during weaning, or complementary feeding, also affect intake of FV. There is an ongoing debate about different effects, both positive and negative, on intake of FV based on the time of introduction of solid foods to child's diet, variety of flavour experiences at the beginning of weaning, and pre-weaning sensory experiences of non-milk products.

Current recommendations for the UK state that weaning should start at the age of 6 months, and not earlier than 4 months (WHO, 2001). However, several studies point to benefits of introduction of FV earlier than 6 months to a child's diet. Cooke et al. (2004) showed that earlier introduction to FV during weaning was linked to higher intake of FV at the age of 2 and 5. Similarly, Skinner, Carruth, Bounds, Ziegler & Reidy (2002) demonstrated benefits of early introduction of fruit (but not vegetables) on subsequent intake of fruit at later stages of development. Coulthard, Harris and Emmett (2010) showed that experiences during weaning may have long-term effects on feeding. They demonstrated that greater frequency of providing the infant with home-cooked FV at 6 months of age, predicted intake of FV at 7 years of age. Those studies demonstrate that age of introduction of solid foods may affect acceptance during later development.

As well as the age of introduction to solid foods, experience of early flavours affects subsequent acceptance. Barends, Vries, Mojet, and de Graaf (2014) showed that continuous 18-day exposure to either fruit or vegetable puree at the beginning of weaning resulted in increased intake of a vegetable puree at day 19 (almost double increase for vegetable group and 50% increase for fruit group). Weaning with vegetables continued to result in higher vegetable intake at 12 months, but at 23 months of age the differences were no longer present (Barends et al., 2014) which may be a result of greater influence of parental feeding practices, exposure to different FV and availability of FV at home. Maier, Chabanet, Schaal, Leathwood & Issanchou (2008) showed that introducing variety of FV during weaning led to better acceptance of a novel vegetable and the effect was stable after 2 months.

Coulthard, Harris and Fogel (2014) also demonstrated that the age of weaning may interact with the weaning strategy (single vs. multiple taste exposure) to affect acceptance of a novel vegetable. Infants who were weaned late (>5.5 month) and were weaned to a single flavour vegetable consumed significantly less novel vegetable, compared to infants weaned late to multiple flavours of vegetables or infants weaned early. This suggests that early age of introduction of pureed vegetables may facilitate acceptance of a novel vegetable, but in case of late weaning this delay can be compensated by exposure to variety of flavours. It is therefore evident that early experiences of complimentary feeding may facilitate future acceptance of novel flavours and in this way may contribute to intake of FV.

1.2.3. Family environment

Family environment has been consistently shown to affect intake of FV in children. Factors such as availability of FV at home, accessibility of FV in an easy to consume form or exposure to variety of FV have been linked with increased intake of FV. Home availability is discussed separately from home accessibility, and is defined as presence of FV at home. Home accessibility is defined as presence in an easy to consume form.

1.2.3.1 Home availability

It is a robust finding that greater availability of FV at home is associated with increased intake of FV in children and on the contrary, limited availability at home is associated with low FV intake, as by definition what is not available cannot be consumed. This is perhaps even more important in the case of toddlers whose diet, unless they attend nursery, is largely based in the home environment.

In a systematic review by Pearson, Biddle and Gorely (2008) greater home availability was associated with higher intake of fruit in 5 out of 6 studies in a sample of 6-11 year olds. For the same age group, positive relationships between home availability and intake of vegetables were found in 5 out of 7 studies. Interestingly, one of the studies included consisted of boys only and analyses were performed separately for normal weight and overweight boys. For overweight boys, there was a positive relationship between home availability and vegetable intake, but for normal weight boys no association was found, indicating possible moderating effects of weight status on intake of FV. This suggests that home availability affects intake of fruit and vegetables differently, and also this relationship differs by gender and adiposity.

Up to date, there has not been systematic literature review that has considered determinants of FV intake exclusively in pre-schoolers (3-5 years old) or toddlers (2-3 years old). However, numerous papers addressed the issue of contribution of home availability of FV to the diet of pre-schoolers. Goldman, Radnitz and McGrath (2012) found that home availability was the best predictor of intake of FV in pre-schoolers. Wyse, Campbell, Nathan & Wolfenden (2011) also showed that home availability was a significant contributor to intake of FV in Australian pre-schoolers. This was also shown in African-American children under 3 years of age (Bryant et al., 2011) and in 1-2 year olds (Gregory, Paxton & Brozovic, 2011). Specific interactions with weight status or gender differences have not been reported in this age group.

The relationship between home availability and intake of FV in children is robust. In the younger groups (<6) this finding is more consistent and the link seems to get weaker with increasing age. There seem to be gender effects in the samples of children above 6 years old, which might be attributable to different use of parental feeding practices with boys and girls, which will be discussed in subsequent parts of the thesis. Home availability is an important issue to consider, particularly when looking at children's FV intake as measured with the use of questionnaires and diaries. Often the results of epidemiological studies or correlational designs will be affected by home availability of FV, as children cannot consume what is not present in the home setting so low consumption may be the result of low availability rather than disliking. At the same time availability of other foods needs to be considered, as availability of high energy snacks may affect intake of FV and may reflect preferences rather than liking. Indeed past research showed that unhealthful food availability at home is linked with lower FV intake (Couch et al., 2014).

1.2.3.2 Home accessibility

Home accessibility has also been linked with FV intake, as a contributor separate from availability. The review by Pearson et al. (2008) identified accessibility as a contributor to both fruit and vegetable intake in children, however surprisingly in 6-11 year olds, 1 out of 3 studies evaluated found a negative association and 2 studies found none. In Rasmussen's et al. (2006) review only 1 paper fit inclusion criteria for accessibility, but that study found a positive link between parent-reported accessibility and FV intake in children, and child-reported accessibility and FV intake in girls only. The results indicate that parental perception of accessibility might differ from child's perception, which is an important consideration for interpretation of the results of retrospective studies.

This was supported by Reinaerts, Nooijer and Vries, (2007b) who demonstrated a weak agreement between child's and parent's perception of home environment, including accessibility to FV. Noia and Byrd- Bredbenner (2014) included two studies to assess influence of home accessibility on FV intake, which were not included in the previously mentioned reviews. One of them showed positive association between FV intake and home availability, and the other one showed no association with intake. This review however did not provide the operational definition of accessibility and upon analysis of findings included FV only served during dinner as a measure of accessibility.

In summary, home accessibility shows mixed effects on intake of FV based on three separate systematic reviews. Interestingly all three reviews conceptualised accessibility in different terms, included different studies in the analyses and provided inconsistent results showing positive, negative and no association. It is therefore important to specify the operational definition of home accessibility in order to allow comparisons between the studies. Again, it is important to consider availability of unhealthy foods, which are often in a more accessible form (e.g. snacks) and may negatively affect FV intake.

1.2.3.3 Exposure

Exposure to FV has been linked with intake of FV and seems to fit with mere exposure hypothesis by Zajonc (1968), which states that increasing familiarity with a product via exposure leads to increased liking or preference. As mentioned before, exposure to tastes during early stages of development has been linked with preference or intake of FV.

Studies consistently show that exposure leads to greater familiarity, which aids intake or liking of FV. Birch (1979a) first demonstrated that familiarity accounted for 51% of variance in intake of sandwiches that differed in fillings. In another study it was demonstrated that in 2 year olds, familiarity was the best predictor of fruit liking and that effect was stable over time (Birch, 1979b). In a subsequent study on 2 year olds, Birch and Marlin (1982) showed that preference for fruit increases as a function of exposure. Evidence suggests however that while increase in liking is an increasing function of exposure, liking does not increase indefinitely and at a certain point reaches a plateau, after which there is no further increase in liking despite further exposure. Past reports tend to show that between 10-14 exposures are necessary to increase liking (Fildes, Jaarsveld, Wardle & Cooke, 2014), however some reports show that as few as 6 exposures would suffice (Anzman-Frasca et al., 2012). Repeated prolonged exposure to the same product may however lead to monotony and boredom and may in fact decrease preference and intake (Mennella & Beauchamp, 1999). However, when there is delay between repeated exposure and subsequent testing which breaks the monotony, positive effects on intake are observed (Sullivan & Birch, 1990). The effects of exposure will be dependent on the type of food too, and sweeter products for example fruit will require fewer exposures than vegetables, particularly the bitter ones (Liem & de Graaf, 2004; Sullivan & Birch, 1990).

Exposure to novel produce requires fewer trials than to previously disliked produce, but liking of both types can increase (Wardle et al. 2003). There is some discrepancy as to the number of exposures that is required to alter or increase preference, but what seems to be consistent is that older children require more exposures than younger ones (Cooke, Haworth & Wardle, 2007) possibly because neophobic tendencies increase with age. Effects of exposure to one type of product can sometimes be generalised to other types that show some similarity to the internally stored prototype (Birch, Gunder, Grimm-Thomas & Laing, 1998). What needs to be acknowledged is the fact that certain intrinsic characteristics may affect the possibility of exposure, for example parents of children with higher neophobia levels or more fussy children may find it problematic to successfully expose children to new FV (Nicklaus et al., 2005).

Early research evidence suggested that exposure should be in the same modality as the tested preference, so visual exposure to FV would not suffice to increase preference for that produce, but when complimented with oral exposure, it may enhance the effect (Birch, McPhee, Shoba, Pirok & Steinberg, 1987). There are however some intervention studies which have shown that repeated visual exposure and anthropomorphisation of FV may result in increased preference for or liking of FV in infants, pre-schoolers and school-age children (Heath, Houston-Price & Kennedy, 2011; de Droog, Buijzen & Valkenburg, 2014; Byrne & Nitzke, 2002).

The majority of research on the effects of exposure on intake of FV comes from the repeated tasting studies. Repeated tasting of some new product increases acceptance possibly due to the 'learned safety', which has a positive effect on acceptance as the child learns that there are no negative digestive consequences from consumption of the particular food (Cooke, 2007). Intervention studies show that repeated tasting of a sample FV leads to increase in liking and intake of that product, both in the home setting (Wardle et al., 2003a) and in school setting (Lakkakula et al., 2011). While research on repeated exposure and preferences or exposure to a single product and preference for that product is abundant, not much is known about how lifetime exposure to variety of

FV affects intake. Lifetime exposure to FV deserves further attention given the previously mentioned effects of exposure to FV during early development on creating early taste preferences and effects of home availability. Measuring lifetime exposure to FV would provide information on possible combined effects of early life experiences of FV and effects of home availability on children's intake of FV.

1.2.3.4 Associative learning

Exposure to FV, as summarised above, leads to greater acceptance and intake of FV. However, sometimes mere exposure is problematic as children may be resistant to that exposure and some strategies to increase exposure may need to be applied. Associative learning, as the name suggests, is based on association of one stimulus with another stimulus and is based on classical conditioning principles where a conditioned stimulus (CS)is paired with an unconditioned stimulus (UCS) and results in a conditioned response (CR). In the area of food and nutrition, classical conditioning has resulted in postulation of the so called 'Garcia effect' which proposes that when ingestion of food results in some negative post-ingestive consequences such as food poisoning, this results in aversive response to that particular food.

The same principles have been applied to conditioning positive responses which may result in creating new likes and thus enhancing acceptance of novel, neutral or disliked flavours. Two conditioning mechanisms have been applied in the area of FV intake, flavour-flavour learning and flavour-nutrient learning. In both cases a novel, neutral or disliked FV (CS) is paired with an UCS i.e. a liked flavour (flavour-flavour learning) or a post-ingestive satisfying stimulus (flavour-nutrient learning) and results in learned preference for the CS.

1.2.3.4.1 Flavour-flavour learning

The principle of flavour-flavour learning is quite simple, in order to increase liking and intake of some novel, neutral or disliked FV, that particular product on numerous occasions is paired with some product that the child likes and accepts.

Baeyens et al. (1995) found that it is much simpler to create negative food responses or food aversions, than it is to create positive responses, or food likes. Havermans (2010) reported that 4-6 year old children evaluated and ranked 6 different vegetables. To two of those vegetables they were then exposed via principles of flavour-flavour learning, and one of those was sweetened with glucose. After 1 hour exposure children again ranked the vegetables and the sweetened one was ranked significantly higher than baseline. The results have been repeated for grapefruit juice, cauliflower and broccoli (Capaldi & Privitera, 2008).

Anzman-Frasca et al. (2012) also showed that liking of initially disliked vegetables improved after pairing them with a liked dip in a series of small tastings, with minimal ingestions. They showed that approximately 6 repeated pairings were necessary to improve liking. In order to ensure that flavour-flavour learning occurred as opposed to flavour-nutrient learning, only tiny tastes were offered, which would not lead to satiety. However, still it is difficult to dissociate the two mechanisms when the liked flavour is also energy dense. There are reports that not all children are prone to flavour-flavour learning, with some indications that between 30-40% of children may be resistant to associative conditioning, at least among pre-schoolers (Hausner, Olsen & Moeller, 2012). However, this may be due to sensory properties of the UCS foods, for example Capaldi-Philips & Wadhera, 2014 showed that for non-bitter vegetable mere exposure was sufficient to increase intake, but for the bitter Brussel sprouts flavour-

flavour and flavour-nutrient learning was more effective than mere exposure, perhaps because the CS used was a cream-cheese dip, and sour/dairy sensory properties of cream-cheese suppress the bitterness of Brussel sprouts. So rather than showing evidence for flavour-flavour learning, perhaps it just demonstrates that removing bitterness from vegetables increases acceptance. Individual differences in responsiveness to flavour-flavour learning need further research, as does testing for differing levels of effectiveness of flavour-flavour learning for different FV (e.g. cruciferous vegetables and astringent fruit).

While the results seem optimistic in their effectiveness to increase FV likes, not much is still known about sustainability of the effects long-term. There have been some ethical concerns, particularly with regards to intervention studies which used glucose or salt as a UCS to be paired with vegetables, with regards to the healthfulness of such approach. More information is still needed to access the effectiveness of flavour-flavour learning in neophobic children or children with high fussiness, who might be particularly sensitive to changes in flavour and may be resistant to acceptance of the UCS following the withdrawal of the liked flavour (CS). In addition, the most fussy children or the most sensitive children may experience the so called ‘contamination effect’ and may perceive the liked food which has been associated with a disliked food as a contaminant, and as a result may develop disgust for both (Brown, Harris, Bell & Lines, 2012).

1.2.3.4.2 Flavour-nutrient learning

Flavour-nutrient is based on the principle that positive post-ingestive consequences, for example satiety or energy, lead to increased liking of food. Flavour-nutrient learning seems to be more effective in the state of hunger (Appleton, Gentry & Shepherd, 2006) and is more pronounced in unrestrained but not restrained adults (Brunstrom & Mitchell, 2007). Flavour-nutrient learning is less understood than flavour-flavour learning because it is not directly linked to caloric content of foods but is also linked to nutrient content and metabolic speed with which nutrients are digested. This is why carbohydrate content seems to be a better UCS than fat content, probably because it is digested faster and has a stronger satiating effect despite carrying less energy per gram (Lucas & Sclafani, 1999).

Evidence from animal studies for the effectiveness of flavour-nutrient learning is substantial and shows that when neutral flavours are paired with intra-gastric post-ingestive delivery of energy (carbohydrates, fats and alcohol) this results in preference for the neutral flavour (Sclafani, 2002; Lucas & Sclafani, 1989; Ackroff & Sclafani, 2002). However, the evidence from humans is less obvious. One of the first studies which reported successful flavour-nutrient learning comes from Birch and colleagues (Birch et al., 1990), who showed that unfamiliar flavours became more preferred when paired with high energy drinks, compared to low energy drinks. In addition, higher energy intake was noted after children were exposed to low-energy drinks. The results were later repeated for energy derived from fats in yoghurt (Kern et al., 1993). Alternatively, there are quite a few studies reporting lack of effects of flavour-nutrient learning in humans, and most likely these are underreported due to bias in publications of null results (Zeinstra et al., 2009; Specter et al., 1998; Brunstrom et al., 2015).

From a methodological perspective it is quite difficult to dissociate flavour-flavour learning from flavour-nutrient learning, as liked flavours used in flavour-flavour paradigms more often than not are also calorific e.g. dips are high in fat and glucose inevitably is high in carbohydrates. At the same time energy density in flavour-nutrient paradigms will be associated with hedonic value of the UCS flavour. Indeed, Yeomans et al. (2008) demonstrated that when flavour-nutrient and flavour-flavour associations were paired together they were more successful in increasing liking than either separately, but flavour-nutrient pairing resulted in the actual changes in eating behaviour. Surprisingly, de Wild, de Graaf and Jager (2013) obtained exactly the opposite effect. They demonstrated that flavour-nutrient learning successfully resulted in change of preference for a vegetable soup, but there were not observable effects on intake. Only mere exposure improved intake in this study.

While evidence from human samples on flavour-nutrient learning is inconclusive and is quite scarce, what needs to be acknowledged is that vegetables, due to small post-ingestive benefits, are inherently more difficult to promote. Also within the FV family, the subgroups which are considered the most healthy i.e. cruciferous vegetables, green leafy vegetables or astringent fruit are also lower in energy content than other FV such as lentils, pulses or sweet bananas or grapes, and as such result in the smallest post-ingestive benefits.

1.2.3.5 Parental factors

Parental influences on child's intake of FV have been researched extensively. Parents are responsible for maintaining home food environment and determine the first flavour experiences of children. With age, children gain more independence in their feeding decisions, but up to adolescence parents constitute the primary feeding source for children. NB. The term parent will be used throughout to indicate relations with primary caregivers of children rather than indicating biological relationships.

1.2.3.5.1 Parental intake

Parental FV intake is perhaps one of the most consistently reported predictor of FV intake in children. Parents who consume large quantities of FV or have a diet rich in variety of FV would also be likely to make it available at home. This way parents visually expose children to FV and model eating of FV.

Indeed past research has demonstrated that parental intake is correlated with child's intake, in 2-5 year olds (Coulthard & Blissett, 2009), 4-12 year olds (Reinaerts et al., 2007) and 10-12 year olds (Bere & Klepp, 2004). However, with age this relationship seems to get smaller, possibly because of other influences outside the home environment. In the review by Rasmussen et al. (2006) 8 out of 9 papers reported a positive association between parental and child's FV intake, across different ethnic samples, countries and age groups.

1.2.3.5.2 Feeding practices

Blissett (2011) addressed the issue of inconsistency in the use of terminology in the developmental field, where parenting style, feeding style and feeding practices are incorrectly used interchangeably. She differentiated between feeding style, which was described as emotional climate that surrounds feeding and feeding practices, which are techniques or strategies used in the feeding context. These must be separated from parenting style, which refers to general parenting practices, not exclusive to feeding.

Two of the most researched feeding practices are pressure to eat and food restriction. Galloway, Fiorito, Francis and Birch, (2006) demonstrated that pressure to eat vegetables is counterproductive, as it not only results in lower intake but also creates negative affect towards the vegetable. Restriction of food has also been shown to be counterproductive as it increases liking and intake of the restricted food (Fisher & Birch, 2002), however there is some evidence that restrictive practices which limit intake of snacks are linked with lower intake of snacks and higher intake of FV (Gubbels et al., 2009). What needs to be acknowledged is the fact that parents may use restriction as a consequence of child's eating behaviour and that relationship is interactive. Indeed, Webber et al. (2010) showed that parents were more likely to use restriction with children who have higher appetites, independent of child's weight status. Gregory et al. (2011) in a longitudinal study showed that pressure to eat at 1 year of age predicted lower intake of fruit at 2 years of age, and showed strong trend for lower intake of vegetables at 2 years of age. Restriction on the other hand did not predict intake of fruit, vegetables or snacks at 2 years of age. Again, the interactive nature of this link needs to be acknowledged because parents use more pressure with more fussy children. For example, Webber et al. (2010) showed that parents were more likely to use pressure with more fussy children, children who ate slow and had lower appetite. The bidirectionality of parent-child interactions needs to be considered when evaluating the link between parental feeding practices and dietary intake in children. Furthermore, the use of pressure to eat and restriction have been linked with more obesogenic behaviours such as intake of unhealthy snacks (Brown, Ogden, Vogele & Gibson, 2008), frequency of snacking and time spent with screen media (Strien, Nikerk & Ouwens,

2009) which shows that negative feeding practices may affect not only FV intake, but also intake of foods in general.

Parental control is a feeding practice that is analysed separately from pressure and restriction, but it combines both parameters in one measure. Parental control is the degree to which the parent dictates child's eating, or the degree to which the parent allows the child to control their eating behaviour. Wardle, Carnell and Cooke (2005) showed that parental control is negatively associated with intake of FV in both boys and girls between 2-6 years old. However, some reports suggest that parental control may be negatively linked with FV preference but positively with FV intake (Bante et al., 2008). As with pressure and restriction, parental control has been also linked with increased unhealthy snack intake (Brown et al., 2008).

Another common feeding practice is using rewards to reinforce intake of FV. While using food rewards is quite common, their effectiveness is questioned. Bante Elliott, Harrod and Haire-Joshu (2008) showed that in a sample of mothers of 2-3 year olds almost 20% of parents rewarded children with a food item for trying a new food and almost 31% rewarded the child for eating one bite of all food items presented on the plate. While using rewards for intake was positively linked with intake of FV, it was also negatively linked with preference for FV. If food rewards lead to increased intake but not liking, then in the absence of the reward, intake will not occur and the effect is not sustainable. Parents typically offer a dessert reward in an attempt to increase intake of the main meal. Mikula (1989) demonstrated that this can increase liking for the reward food, without decrease in liking for the 'means' food when foods other than fruit or vegetables were tested. When fruit was used as a 'means' food, liking for that fruit decreased. This is referred to as the over-justification effect. This suggests that rewarding FV with other palatable foods may have differential effects, depending on the type of foods. However, using food as rewards has shown positive effects on acceptance of FV when analysing various teachers' action to increase acceptance of FV in pupils and was shown to be more effective than mere exposure (Hendy, 1999).

There are some recent findings from intervention programmes suggesting that using non-food rewards in multi-level interventions may be a more successful strategy. Laureati, Bergamaschi & Pagliarini (2014) in a school-intervention programme showed that a comprehensive intervention which included non-food reward (stickers, stationary, certificates etc.), food exposure and peer-modelling resulted in increased liking of FV, which was sustained 6 months after the intervention for fruit only. Horne et al. (2011) in an intervention which used modelling and non-food reward showed positive effects on intake of FV, which generalised to non-target FV and was sustained to the 6 month follow up. In both studies unique contribution of non-food rewards could not be established. It therefore seems that non-food rewards may be a successful feeding strategy, at least when accompanied with other strategies.

In studies with a more controlled design it has been demonstrated that when children were offered small non-food prizes for trying new FV, there was an increase in liking for those FV (Hendy, Williams & Camise, 2005). When the actual intake rather than liking was measured as the outcome variable, the results showed positive effects on preference for fruit with a combination of praise and tangible non-food rewards (Grubliauskiene, Verhoewen & Dewitte, 2012). Cooke et al. (2011) showed that there are long-term effects of using tangible and non-tangible rewards. Children in that study were exposed for 12 days to a disliked vegetable with a tangible reward, non-tangible reward (praise) or no reward. The control group was not exposed to the target vegetable. While liking of the vegetable increased in all three exposure conditions, intake in tangible reward condition was higher than in exposure-alone condition. During the 3 month follow-up, only the reward conditions showed positive effects on intake. This suggests that while there are clear positive effects of exposure, the use of rewards can perhaps sustain the effects for longer. However, there are reports of possible negative consequences of using rewards, as they can have negative consequences on intrinsic motivation, and paradoxically can decrease liking (Newman & Taylor, 1992), especially if intake of the rewarded food occurs beyond satiation (Rolls et al., 1981). Overall, the research seems to show that rewards, both food and non-food type, can have positive effects on intake but not necessarily liking of FV.

Parental modelling of FV consumption appears to be a successful feeding strategy. Parents who eat plenty of FV are modelling this behaviour to their children, but they also at the same time are likely to make more FV available at home and expose the child to more FV, whether by offering different tastes or by visual exposure. Children who see parents eat FV during meals are more likely to also eat it (Draxten, Fulkerson, Friend, Flattum and Schow, 2014). Parental modelling of healthy behaviours also facilitates acceptance of novel foods. Blissett, Bennett, Donohoe, Rogers and Higgs (2012) demonstrated that parental modelling of novel fruit consumption resulted in increased interest of their 2-5 year old children in that fruit. The results seem robust as they were replicated in the subsequent study using a similar paradigm (Blissett, Bennett, Fogel, Harris and Higgs, Unpublished). Conversely, parents can also model negative eating behaviours, such as diet poor in FV and rich in unhealthy foods, negative responses to FV, weight concerns or excessive dieting, which will have detrimental effects on child's diet (Dickens & Ogden, 2014). Parental modelling of healthy behaviours such as intake of variety of FV is therefore important for facilitating intake and facilitating initial responses to novel FV, which will further affect acceptance.

Parental encouragement has also been linked with intake of FV. Encouragement is a non-intrusive strategy which creates more opportunities for FV intake, making available FV that the child particularly likes, while being respectful and un-forceful about the child's choices. Robinson-O'Brien, Sztainer, Hannan, Champoux and Haines (2009) showed that parental encouragement was a significant predictor of child's FV intake in a group of 9-12 year olds. In a large cross-sectional study of boys across 9 European countries (De Bourdeaudhuij et al., 2006) active parental encouragement was related to intake of vegetables in overweight but not normal weight 11-year-old boys, indicating interactive effects of child's weight status.

Involving the child in meal planning and preparation has also shown positive effects on FV intake. When children are involved in preparing meals at home they are exposed to FV including to non-taste sensory properties of the foods. One study of 10-11 year old children showed that those who were involved in preparing meals at home had better diet quality and ate one more serving of FV compared to the children who did not help at home (Chu, Storey & Veugelers, 2014). In a sample of high school adolescents Larson, Perry, Story and Neumark-Sztainer (2006) showed that involvement in meal preparation and planning was associated with higher intake of FV and fibre, and lower intake of fats. Gross, Pollock and Braun (2010) identified involvement in meal preparation together with parental modelling as the most important contributors to FV intake in school age children. While data is missing from younger samples, it seems that involving the child in planning and preparing meals may aid intake of FV.

Finally, parental teaching about FV is a practice that has shown promise but has not been extensively researched. Teaching is a form of exposure to FV as it increases familiarity and could also be perceived as a form of encouragement. Blissett et al. (2012) showed that parents who spontaneously used teaching about healthy eating as a feeding strategy had more success with a toddler's acceptance of a novel fruit. There are no studies that directly measured the effects of parental teaching about FV on FV intake.
It seems that previous research has been centred around negative feeding strategies and their detrimental intake on diet in general, FV intake and children's weight. Perhaps focusing on positive feeding practices would be more valuable, as they would inform future intervention programmes and could aim at teaching new positive behaviours rather than trying to reduce the negative ones, which, as has been demonstrated in the past, is more challenging.

1.2.3.5.3 Feeding style

Feeding style is a subtype of parenting style that is specific to the feeding context. Types of feeding styles have been linked with FV intake in children, both directly and indirectly, by showing links with other determinants such as home availability or own intake. The three most common feeding styles reported in literature are authoritarian, where the parent exerts sole control over child's eating, authoritative where the child has some control over what is eaten but expectations for a healthy diet are high, and permissive where the child has sole control over what they eat (Patrick et al., 2005).

Authoritarian feeding style has been linked with detrimental effects on intake of FV as it is mostly characterised by negative feeding strategies such as pressure, restriction and control. Patrick, Nicklas, Hughes and Morales (2005) demonstrated that authoritative style is the optimal one and it was linked with higher intake of FV and better food environment at home which was richer in FV, compared to authoritarian feeding style. Hoerr et al. (2009) found that permissive feeding style resulted in the lowest intake of FV. Those who described their parents as having authoritative feeding style had the highest intake of fruit, while those with authoritarian parents showed the lowest intake. Those with authoritative parents also reported highest level of parental modelling, which shows that feeding styles are closely linked or maybe even a result of feeding practices used. Furthermore, an authoritative parenting style has been negatively linked with greater intake of fat and sugar (Pearson et al., 2009) in contrast to an authoritarian style which has been linked with greater home availability of sweet drinks and candy (Gable & Lutz, 2000).

There is not enough evidence in the literature to make specific inferences about feeding styles and FV intake and longitudinal paradigms would need to be applied in order to see long-term effects of feeding styles on children's FV intake.

1.2.4 Peer modelling

While undoubtedly home environment and parental factors are substantial determinants of children's FV intake, the role of peer modelling needs to be acknowledged too. Research evidence suggests that, in school age children, peer-modelling of FV intake is more influential than parental modelling (Hendy & Raudenbusch, 2000), especially when children observe peers who are older (Birch, 1980) or are liked or admired by the child (Bandura, 1977). Whilst most literature is focused on peer modelling of positive behaviours, peers can also model negative behaviours. For example, peers can increase rates of food rejection (Greenhalgh et al., 2009), and Pearson, Williams, Crowford and Ball (2012) demonstrated that in a survey based study of 3001 children between 7-9, a best-friend's meal skipping behaviour was a significant contributor to skipping lunch.

In terms of modelling positive behaviour, peer modelling can increase acceptance of novel foods (Hendy, 2002) or known disliked foods (Birch, 1980). Hendy (2002) showed that trained peer models can increase intake of novel fruit in pre-schoolers. In that study, 12 peer models were trained to model intake of 3 novel fruit by verbally expressing how tasty the novel fruit were. The results showed that girl models were more effective than boy models to encourage intake in both girls and boys and the results were particularly strong for girls who took more bites of the modelled foods. Peer modelling has often been used in intervention studies and has been shown to be an effective strategy to increase FV intake, especially when peer modelling is paired with rewards. Horne et al. (2004) showed that lunchtime and home consumption of FV increased after a 16 day intervention where children were watching videos of heroic peers consuming and praising the taste of FV, and in addition children were receiving non-food rewards for eating FV during lunch. The effect was larger for children who at baseline ate the fewest FV.

While children seem to imitate the behaviours of their peers, the influence would be more substantial in the older children compared to the younger ones, purely because older children tend to spend more time with other children as they attend school and younger children consume more foods in the presence of their caregivers. Nevertheless, wider social influences on intake of fruit and vegetables must be acknowledged as a contributor to intake, at least in the children who attend nursery and schools.

1.2.5 Adult non-parent modelling

Other than parents and peers there have been also reports of adults other than parents, modelling eating behaviours to children, but surprisingly little research has been conducted to date. Non-parent adults that might model eating behaviours in children include teachers and grandparents, as they are often present during mealtimes. Hendy (1999) conducted a study to look at effects of 5 conditions to encourage acceptance of novel foods and these were teacher modelling, dessert reward, choice-offering, bargaining and mere exposure. In that study, teacher modelling was the only condition which did not have beneficial effect on subsequent acceptance of the novel food. Hendy and Raudenbush (2000) wanted to further explore the role of teacher-modelling in acceptance of foods in children and conducted a series of studies to test the effectiveness of teacher modelling in pre-schoolers. In a qualitative design they found that teachers rated teacher modelling as the most effective strategy to encourage food intake among five other strategies. The subsequent quazi-experimental studies found that silent teacher modelling did not encourage familiar or novel food acceptance. They further showed that enthusiastic teacher modelling was effective in encouraging novel food acceptance. In the last study they compared the effects of teacher modelling and competing peer modelling and found that enthusiastic teacher modelling was ineffective when paired with competing peer model. There were also gender effects with girls imitating the competing peer model to the higher degree than boys. This study demonstrates that enthusiastic teacher modelling may have positive effects on acceptance of novel foods in children, but peer modelling is more influential.

In an intervention study Perikkou et al. (2013) demonstrated that teacher modelling was an effective strategy to promote fruit intake among school age children. This was a one year intervention programme in which one group received educational materials on healthy eating, one group was exposed to a teacher model who was instructed to eat fruit in front of the children on a daily basis and there was a control group with no intervention. The results showed that both education and teacher modelling groups had higher fruit intake than the controls at the end of the intervention. Only teacher modelling remained significant after the 1 year follow-up, showing that teacher modelling may be an effective way of promoting fruit intake among the school-age children.

There are also some reports on the influence of grandparents on eating behaviours in children. In 2010 in the UK around 66% of mothers were reported to work either part time or full time and half of those working mothers reported obtaining some level of help from their children's grandparents (Rutter & Evans, 2011). Research on the role of grandparents in children's nutrition is however scarce. There have been reports showing that greater grandparental influence on feeding in affluent families is related to greater adiposity in children (Pearce et al., 2010). Farrow (2014) showed that parents and grandparents may use different feeding practices, with grandparents providing healthier nutritional environment than parents, but using more negative feeding practices. In that study grandparents used more food for regulating emotions, less encouragement of balance and variety, less modelling of healthy eating and more restriction. At the same time grandparents have more FV in the home environment and less high energy snacks.

Reports from non-European research show that Chinese grandparents have more FV in the home setting than parents, and children living with grandparents eat more FV than children living with parents alone (Kobayashi et al., 2015). It was also demonstrated that there was a positive relationship of dietary intakes between families living together and that resemblance was maintained even after the families moved apart, indicating that food habits gained when living with grandparents may prevail long-term. Jingxiong et al (2007) demonstrated that in Chinese families who live with the grandparent, grandparents were the primary caretakers of children and were the primary feeders. They used maladaptive feeding practices and believed that heavier child's weight was a sign of healthiness. In a qualitative study among Black American low-income families, influence of extended family members emerged as one of the three themes of influences on FV intake, together with taste and availability (Molaison et al., 2005).

It is therefore evident that non-parent adults such as teachers and grandparents may affect intake of FV in children, however research in that area is scarce. It seems that grandparents in particular may have a substantial role in children's feeding, given that they often provide informal help with children. The role of teacher modelling may be influential in children's FV intake, but seems to be less important than peer influences.

1.2.6. External predictors: summary

A number of potential environmental contributors to FV intake have been identified. Socio-demographic differences need to be controlled for when designing studies on FV intake in children, particularly with regards to socio-economic status, which may limit generalizability of the data. Age of the sample needs to be also addressed, particularly with regards to pre-schoolers who spend more time in the family setting, make fewer independent feeding decisions and in addition show higher neophobia levels. It seems that the most influential environmental factors which affect FV intake are home availability, past exposure and parental factors. Children cannot eat what is not available to them, they are likely to eat the same foods as the parents, who are in charge of food preparation and who model eating behaviours. Parental factors already affect the first experiences with foods during the first years of life and even in utero. While parental feeding practices have been recognised as an important factor in child's diet, it seems to be the case that parental modelling is more influential than the feeding practices. It needs to be acknowledged that the environmental factors will also affect the child's general diet and indirectly may affect FV intake. For example, high home availability of unhealthy snacks, permissive feeding style and modelling of unhealthy behaviours will affect unhealthy behaviours in children.

1.3 Internal drivers of FV intake

While there are a number of different external correlates of intake of FV in children, there is a separate group of drivers which are personal or individual to the child. These factors usually get less attention than the external ones, nevertheless, understanding their role in children's FV intake is important because they may moderate the effectiveness of interventions. It must be pointed out that internal determinants of FV intake are also affected by the external factors, and should not be considered as independent from the external environment but as interactive with the environment. For example, internal drivers may affect perception of flavour and predisposition for FV liking and intake, but whether the child eats something is a result of more than just flavour evaluation and is also affected by external drivers. Internal factors which will be considered in the context of FV intake in children are individual preferences/liking, neophobia, sensory sensitivity, tongue morphology and physiological trauma.

1.3.1 Liking or Preferences

The intuitive premise is that what is liked is consumed and the majority of interventions which target FV intake in children aim at increasing liking of FV, making it equivalent to intervention success (e.g. Laureati et al. 2014; Lakkakula et al., 2011; Anzman-Frasca et al., 2012). However, the relationship between liking and intake is not as straightforward as it may seem. Liked products cannot be consumed if they are not present at home and they are not consumed when a more liked alternative is present. For that reason even children who like FV may not eat them if they are allowed to eat a more liked unhealthy alternative. Liking does not equal preference and those two concepts need to be separated. The concept of liking reflects hedonic or affective response to food, while preference is more reflective of 'wanting' rather than liking and by definition assesses foods on an ordinal scale where one item is preferred over another item. How the link between liking and intake changes over the child's development is at present unknown. When describing and evaluating the studies, the terminology as conceptualised in the original papers will be used.

Liking is consistently associated with intake, but variance in FV consumption explained by liking tends to be small (e.g. Resnicow et al., 1997; Domel et al., 1996; Baranowski, Cullen & Baranowski, 1999). In a study By Neumark-Sztainer, Wall, Perry and Story (2003) which looked at correlates of FV intake among adolescents, liking of FV and home availability were the main determinants of FV intake. Interestingly, even though there was a direct link between liking and FV intake, further analysis revealed that even when liking of FV was low, high availability was still positively related to intake. The overall model explained only 11% of the variance in FV intake, which suggests that there is a link between liking of FV and intake, but that association is weak.

In elementary school children, Domel et al. (1996) also showed that liking of FV was significantly but weakly related to intake, and the variance in intake explained by liking was marginal. Interestingly, liking of vegetables was a stronger predictor of all FV intake than fruit liking, which suggests that even though fruit are generally more liked than vegetables (e.g. Laureati et al., 2015; Peracchio, Henebery, Sharafi, Hayes & Duffy, 2012) it is the liking or perhaps more accurately disliking of vegetables that predicts overall intake. Similar results in this age group were obtained by Bere and Klepp (2004), who found preferences to be linked to intake, explaining 4% of unique variance. A study by Chu, Farmer, Fung, Kuhle and Veugelers (2013) on 10-11 year old Canadian children showed that liking and intake of FV had a dose-response relationship, although the real difference in intake between those children who really like FV and those who do not was marginal, ranging from 2-3 portions a week for fruit, to 0.5-2 portions a week for vegetables. Moderating effects of external variables on the relationship between liking and intake of FV need to be considered in order to understand the link between liking and intake of FV in children.

1.3.2 Neophobia

Neophobia has been previously defined as fear of trying new foods, which results in rejection of unknown products (Dovey, Staples, Gibson & Halford, 2007). Neophobia has been researched extensively in the context of FV intake, the rejection of which has commonly been attributed to neophobia. Whether neophobia is a personality trait or a state which shows age-dependent variation is debated (Rigal et al. 2006). It has been theorised that neophobia is an evolutionary artefact that protects young children from ingesting potentially dangerous foods (Zajonc, 1968; Harris, 1993). The exact mechanism is unknown, but foods are rejected based on visual and olfactory evaluation without being tasted and perhaps any difference from the internally stored prototype of what the food item 'should' look and smell like, would lead to rejection, however no evidence for that theory has been presented to date. The age of onset of neophobia is debatable, but it has been established that it peaks between 2 and 6 years of age, followed by a decrease (Adessi, Galloway, Visalberghi & Birch, 2005). Whilst there is evidence that higher neophobia is related to lower liking of all food groups not just FV (Russel & Worsley, 2008), FV are the most commonly rejected group of foods in neophobic children (Cooke, Carnell & Wardle, 2006; Howard et al., 2012; Laureati et al., 2015; Jaeger et al., 2011).

Despite detrimental effects of food neophobia on FV intake, research evidence shows that neophobia levels can be decreased. The most successful method seems to be exposure to novel foods (Pliner, Pelchat & Grabski, 1993), particularly good tasting novel foods (Loewen & Pliner, 1999), with particular emphasis on repeated exposure (Birch et al., 1987). One of the recently proposed theoretical models explaining neophobia is via malfunctioning of processing of perceptual food attributes (Brown &

Harris, 2012) which possibly could be explained by exaggerated attentional bias to foods in neophobic children (Maratos & Staples, 2015). Overall research shows that neophobia is linked to lower acceptance of FV, but it can be reduced by repeated exposure to unfamiliar foods. Why some children develop neophobic tendencies is at present unknown, but neophobia needs to be considered as a substantial barrier to FV intake in children, particularly pre-schoolers.

1.3.3 Picky/fussy eating

Picky/fussy eating is a concept separate from neophobia and is associated with different behaviours and aetiology (Dovey et al., 2007). While neophobia demonstrates as rejection of novel foods, picky eating demonstrates as limited diet and state-dependent rejection of both familiar and unfamiliar foods (Birch, 1999). Food neophobia and picky eating are correlated (Raudenbush, Schroth, Reilley & Frank, 1998). Picky eating has also been linked to higher sensitivity to tactile stimuli, as picky children often reject foods based not only on visual or taste properties, but also based on their texture (Smith, Roux & Naidoo, 2005). Due to problems with consistent operationalisation of picky/fussy eaters, there is no agreement on the best measurement method, which makes comparison of the results across different studies challenging. Rates of picky/fussy eating in childhood are quite high, with studies reporting between 8% to 50% in various samples (Mascola, Bryson & Agras, 2010). The peak of picky/fussy eating seems to coincide with that of neophobia, showing highest levels between 2-6 years of age (Carruth, Ziegler, Gordon & Barr, 2004).

Picky/fussy eating, just like neophobia, has been linked with lower intake of FV (Galloway, Fiorito, Lee & Birch,2005). Dubois, Farmer, Kelly and Fabiola (2007) showed that in 2-5 year olds, picky eaters were more likely to not meet recommendations for FV intake. They also found that those children who more frequently showed picky/fussy eating consumed less FV than those who showed picky/fussy eating on fewer testing occasions. Jacobi, Agras, Bryson and Hammer (2003) showed that picky children showed lower intakes of vegetables and Maciness et al. (2011) showed that picky eaters consumed significantly less of 75 out of 140 food items, compared to normal eating children and the most profound differences were observed for fruit, vegetables and legumes. While there has been some success in overcoming neophobic responses in children, less is known about possible intervention sites for overcoming picky/fussy eating. Certain feeding practices have been linked to picky/fussy eating such as pressure (Wardle et al. 2005), however the relationship is likely reciprocal with mothers of picky/fussy children taking more control over the children's eating behaviour. Given that picky/fussy eating is common, it has to be recognised as an important barrier to intake of FV.

1.3.4 Sensory processing/sensory sensitivity

Another factor which has been linked with intake of FV is individual sensory processing or sensory sensitivity. As the two terms are often used interchangeably, for the purpose of this thesis the term sensory sensitivity will be used throughout in order to distinguish children with normal and high/low sensory processing. Sensory sensitivity refers to individual processing and evaluation of sensory stimuli. Under the umbrella of 'sensory sensitivity' there are three different measures that are used as proxy of an individual's sensory profile. These are (1) the ability to detect the stimulus at suprathreshold level (e.g. to distinguish a 'different' taste sensation without specifying the exact flavour), (2) the ability to recognise the stimulus at superthreshold level based on its sensory properties (e.g. to correctly recognise sweet as sweet and salty as salty) or (3) to distinguish between different stimulus intensities (so to recognise that intensity 1 is higher/lower than intensity 2). Sensory sensitivity which is malfunctioning and results in inappropriate evaluation is referred to as sensory over or underresponsivity. It is important to identify the different operationalisations of sensory sensitivity as they provide different types of information about the sensory responsiveness of the child. It is particularly important for the evaluation of past literature findings. Sensory sensitivity in the context of FV intake in children is a novel, fairly unexplored, but promising approach.

1.3.4.1 Taste-smell sensitivity

Sensitivity to taste and smell stimuli has been the focus of past research on sensory sensitivity and has been researched more extensively than sensitivity in other domains. Taste and smell sensitivity should be discussed together as it is difficult to establish sensitivity to taste, partialling out the effects of odours, as the two domains are integrated in the mouth to form flavour evaluation (Breslin, 2013).

Taste receptors in the mouth provide information on various characteristics of the foods and go beyond simple flavour evaluation, as they also provide information on energy and macronutrient content, ripeness, spoilage or safety (Breslin, 2013). Flavour evaluation is established by sensory integration of the main taste qualities which are sweet, bitter, sour, salty and umami, and this evaluation leads to acceptance or rejection of foods. There are individual differences in sensitivity to the main taste qualities and those differences have been shown to affect intake of foods, while less is known about their link to FV intake.

1.3.4.1.1 Bitterness

The taste quality which has the most often been researched in the context of FV intake is bitterness. Bitter flavour is the quality that in nature is often associated with poisons or toxins and the ability to detect bitterness in food has been of evolutionary advantage. Infants and young children are more sensitive to bitterness than adults (Mennella, Spector, Reed & Coldwell, 2013). Their taste sensitivity would be the primary protective mechanism, as they cannot engage in cognitive evaluation of other properties of possibly poisonous foods. Sensitivity to bitter taste has been linked with FV intake, as some FV contain bitter phytonutrients and in addition are characterised by low quantities of sweet carbohydrates and low energy content (Dinehart, Hayes, Bartoshuk, Lanier & Duffy, 2006). This makes them an unattractive food option, and as such the development of mechanisms that aid intake of FV would not be favoured by natural selection. While sensitivity to bitter flavour served important evolutionary advantage in hunter-gatherer societies, today it is an artefact that has little advantage, but is a barrier to intake of important nutrients.

The first major discovery that instigated research on individual differences in bitter taste sensitivity was an accidental discovery of bitter taste blindness (Fox, 1932). It was established that some humans cannot detect the bitter taste of thiourea compounds and are bitter-blind. Another phenotype of bitter-tasting was later discovered and labelled supertasting (Barthoshuk, Duffy & Miller, 1994). Originally the bitter tasting stimulus used to distinguish between tasters and non-tasters was phenylthiocarbamide (PTC), later replaced with another compound called 6-n-propylthiouracil (PROP). The common method for establishing bitter taste sensitivity status is the ability to detect PROP and two phenotypes, non-tasters and tasters, can be distinguished. Tasters can be further subdivided into tasters and supertasters, although this subdivision is under debate (Hayes & Keast, 2011). Another alternative method commonly used in research on bitter taste perception is genetic screening of TAS2R38, gene associated with phenotypic expression of PROP tasting status (Behrens & Meyerhof, 2011).

Theoretical considerations of bitter-taste sensitivity gave rise to research on possible differences in dietary habits, and more specifically FV intake. As bitter taste sensitivity would show the strongest differentiation in FV intake on produce that is the highest in thiourea compounds, the Brassicaceae family of vegetables, or cruciferous vegetables, are often used as outcome variable in research. Anliker, Bartoshuk, Ferris and Hooks (1991) conducted one of the first studies on PROP status and dietary choices in children and found that PROP tasters showed high preference for milk and lower for cheese, compared to non-tasters, perhaps due to its bitter-sour components and aftertaste. They also reported some trends in different liking of FV. Keller, Steinmann, Nurse and Tepper (2002) found that taster children showed lower acceptance of raw broccoli compared to non-taster children. Bell and Tepper (2006) looked at genetic variation in PROP sensitivity and intake of vegetables, including cruciferous vegetables, in pre-schoolers and found that non-tasters consumed almost twice as much vegetables as tasters did. Of those vegetables, the more bitter ones such as olives, cucumber (also an astringent vegetable) or broccoli were also consumed more by the non-taster children. They also found that only 8% of non-taster children consumed no vegetables at all in a free choice test, compared to 32% of taster children. In a hedonic test, non-tasters showed higher liking of broccoli, compared to tasters, but there were no differences in the actual intake. There have been also numerous reports of greater adiposity among children who are bitter-blind, possibly linked to higher affiliation to high energy foods (e.g. Goldstein, Daun & Tepper, 2005; Lumeng et al., 2008; Padiglia, et al., 2010; Tepper, 1999; Hegde & Sharma, 2008). Those results suggest that in pre-schoolers bitter taster status might contribute to liking and acceptance of vegetables, but there may not always be a direct link between bitter taste status, liking and intake. Feeney, O'Brien, Scannell, Markey and Gibney (2014) in a recent study showed that PROP supertasters were less likely to have tasted cruciferous vegetables compared to non-tasters, but there were no differences in the overall intake.

Suomela et al. (2012) looked at bitter taste sensitivity expressed as hTAS2R3 taste receptor gene and liking of astringent berries and vegetables in a sample of children. They found that children of the genotype PAV/AVI (bitter tasters) ate more vegetables but not berries, compared to AVI/AVI children (non-tasters). They also reported differences in liking of different types of berries between the three genotypes of PAV/AVI, AVI/AVI or PAV/PAV (supertasters). Those differences in liking were attributable to different sensory profiles of the berries used i.e. differences in sweetness, bitterness and sourness level as well as differences in ratios of different taste properties, between different berry fruits. The authors concluded that there are differences in liking of berry fruits between children of different bitter taste sensitivity genotypes, but differences in intake may also be modified by external factors such as home availability. It seems that while berries are generally disliked, there are differences in liking of berry fruits between children of different bitter taste sensitivity genotypes, but differences in intake may be modified by external factors such as home availability.

Some studies report no relationship between PROP taster status and FV intake. Baranowski et al. (2011) and Lumeng et al. (2008) reported no relationship between PROP taste sensitivity in a large cross-sectional study of children and adolescents. It is possible that inconsistent findings are due to environmental factors, such as home availability or parental intake, or other personal factors such as adiposity, modifying the relationship between bitter taste status and FV intake and liking (e.g. Suomela et al. 2012). Heritability of bitter taste sensitivity when measured with PTC or PROP has been established as between 55-85% in a twin and family sample, depending on the bitter tastants used (Smith & Davies, 1973; Hansen et al., 2006). Interestingly, variance explained by genotype differs depending on the stimulus (bitter tastant) used. At the same time, unique environmental variance explains between 7-22% of bitter taste phenotype, and varies by diet, age and state of health (Hansen et al., 2006). While sensitivity to bitter taste is genetically determined, it can be altered by environmental factors such as diet or state of health, which shows the necessity to appreciate gene x environment interactions when looking at the role of sensory sensitivity in FV acceptance. Also, it should be noted that some studies use liking as outcome variable while others use the actual intake of FV, either reported by the parents or short-term intake in experimental paradigms. As discussed previously, association between liking and intake may be modified by tertiary variables (Suomela et al., 2012). Hence, in order to fully understand the link between bitter taste sensitivity and intake of FV, a number of environmental predictors must be controlled for, which has not been conducted thoroughly to date.

1.3.4.1.2 Sweet

Sensitivity to sweet taste is an area that has rarely been discussed in the context of children's FV intake, but may be an alternative or complimentary hypothesis to explain variation in FV intake alongside bitter taste sensitivity. It is now a well-established fact that we are born with preference for sweet taste, which is highest in children and decreases with age (Mennella, Pepino & Reed, 2005). However, some reports on preferences for sweet taste indicate possible individual differences. Maller and Desor (1973) looked at intake of sweetened and plain water in newborns and found differences in responsiveness between underweight and normal weight or heavy weight newborns, with underweight infants showing less sensitivity to taste changes (which may be however a result of factors that lead to being underweight). Individual differences in liking of sweet foods (e.g. Looy, Callaghan & Weingarten, 1992) and perception of sweetness intensity (e.g. Keskitalo et al., 2007) have also been established. It has been indicated that there are more individual differences in liking and perceived intensity at higher concentrations of sweetness (Keskitatlo et al., 2007).

Individual differences in sweet taste perception have been linked with intake of foods. Duffy, Peterson, Dinehart and Bartoshuk (2003) showed that in adults sweet foods were liked more by those who perceived them as more sweet. At the same time those who perceived them as more sweet, perceived the bitter tastant PROP as less bitter, suggestive of interdependence of bitter and sweet tastes (Lindemann, 2001). Further, this study revealed that those with higher preference for sweet taste and lower perceived bitterness intensity consumed more sweet foods on a daily basis.

While for some people liking of sweetness increases with concentration, for others liking increases until it reaches a peak, after which it shows a rapid decrease with increase in concentration. This is the usual strategy of distinguishing sweet-likers from sweet-dislikers (Looy & Weingarten, 1992). Panek-Scarborough, Dewey and Temple (2012) demonstrated that higher sucrose detection threshold (SDT) predicted the reinforcing value of food, indicating that higher SDT may contribute to overeating. Ettinger, Duizer and Caldwell (2012) supported this and showed that women with higher adiposity showed lower sensitivity to sucrose solutions (higher SDT) than normal weight women and women with lower adiposity. Those women were also sweet likers. Similar results were obtained in non-human primates, where animals with higher SDT were heavier compared to those with lower SDT (Simmen & Hladik, 1998).

To date the link between sweet taste sensitivity and intake of FV has not been explored but since there is evidence for different dietary patterns which result in higher weight and different preference for sweet taste among people who differ in sweet taste sensitivity, this link should be explored. There are reports of dysfunctions in sweet taste sensitivity in psychiatric disorders characterised by dysfunction of the reward system (Smithe & Berridge, 2007) which might suggest that individual levels of sweet taste sensitivity may be linked to intake of reward foods, possibly at the cost of FV intake, which however needs further exploration. Given links in transductions of sensory stimuli between sweet and bitter compounds, there are premises to explore the link between sweet taste sensitivity and intake of FV.

1.3.4.1.3 Salty

Sensitivity to salty taste and intake of salt have been explored in the context of general diet, given the now undeniable link between intake of salt and high blood pressure and links with coronary heart disease (Collins et al., 2014), but have not been looked at in the context of FV intake. Salty taste, like sweet, is generally liked and is thought to be shaped by evolutionary pressures in order to ensure water homeostasis in organisms (Wilkie & Capaldi-Philips, 2014).

Salty taste cannot be detected until approximately 4 months of age (Cowart & Beauchamp, 1986). Perceived liking of salty taste shows individual differences, but moderate concentrations are preferred to low or high concentrations. However, what is perceived as moderate concentration differs between individuals (Flynn, Schulkin & Havens, 1993). Liking of salty taste and sensitivity to salty taste are modifiable by diet low in sodium chloride (Beauchamp, Bertino, Burke & Engelman, 1990). The preference for salty taste matches that of sweet taste and shows decrease with age (Lanfer et al., 2013).

Sensitivity to salty taste and intake of foods in children show a complex relationship as salty taste interacts with other tastants and changes flavour quality of products. When salt is combined with bitter flavour, it mutes the bitterness (Wilkie & Capaldi Philips, 2013), which could be of advantage when offering cruciferous vegetables. Mitchell, Brunton and Wilkinson (2013) looked at salt detection threshold and acceptance of regular vs. reformulated reduced sodium vegetable soup. They found that salt detection threshold did not contribute to variability in acceptance of the vegetable soup or the low sodium version of the soup, perhaps because of the overwhelming effects of the current diet on detection thresholds for salt. Alternatively, it could be speculated that this study indicates that enhancing vegetables with salt does not aid vegetable acceptance, but reducing saltiness of vegetable soup would be recommended as there were no differences in intake between the standard and low-sodium version of the soup. Addition of salt to foods, including vegetable soups, increases their palatability up to a certain point, where further addition either does not change the pleasantness, or even decreases it. When salty taste is paired with sweet taste, the sweet taste mutes the salty taste so there is no difference in hedonic perception between low and high sodium chloride foods which are sweet (Balan et al., 2013). Given the well-established evidence that sensitivity to salt is modifiable by diet, there are no theoretical arguments for exploring sensitivity to salt in the context of FV intake, which are generally low in salt.

1.3.4.1.4. Sour

Human perception of sourness is complex and there is contrasting evidence concerning preference for sour taste. Research evidence suggests potentially inhibiting effects of sour taste on intake in infants, however the response is less obvious than that to bitter taste (Mennella & Beauchamp, 2010). From an evolutionary perspective, sourness is an indicator of ripeness or spoilage of FV and as such is an undesirable quality (Behrens & Meyerhof, 2011). Breslin (2013) referred to taste-flavour congruency and suggested that sour taste is desirable in certain flavours but not others and may either increase or decrease liking of the flavour, depending on the context of other tastes e.g. a degree of sourness would be desirable in certain fruit (e.g. oranges) and some vegetables (e.g. sauerkraut), but not in grains or cruciferous vegetables.

Little is known about sensitivity to sour taste and dietary preferences and habits, including intake of FV. In contrast to sensitivity to salty taste, which is environmentally driven, sour taste sensitivity seems to show moderate heritability (Tornwall et al., 2012). Sour taste liking has been linked to lower PROP sensitivity (Prutkin et al., 2000) and sour stimuli transduction mechanisms share pathways with sweet and bitter taste expression (Wilkie & Capaldi Philips, 2014). Sour properties are present in most fruit, but the highest degree of sourness would be found in citrus fruit and astringent fruit such as berries or kiwis. Suomela et al. (2012) demonstrated that children showed high liking of berries with small total acid content (bilberry) and showed clear dislike of berries with the highest total acid content (sea buckthorn). Bilberries were shown to have the highest sugars-to-acid ratio while the disliked berries had the lowest ratio, indicating that liking of fruit rich in acids may be dependent not only on the acid content but maybe more importantly, on the sugars-to-acid ratio content.

Liking of sour taste has been linked with greater dietary diversity in adults (Frank & van der Klaauw, 1994). Liem and Mennella (2003) replicated those results in children and demonstrated that in 5-9 year olds, children who liked extremely sour taste had lower neophobia and ate more variety of fruit. This may be due to environmental influences such as greater exposure to sour flavours or intrinsic lower sensitivity to sour taste, which lead to greater acceptance of sourness. Kildegaard, Tonning and Thybo (2011) demonstrated that in 9-14 year old children perception of sourness intensity was negatively linked with preference for apple juice and fruit drink. They found a small group of children, sour-likers, who showed increase in liking with increased sourness, which is consistent with previous findings (e.g. Liem & Mennella, 2003). However, in this study sweetness perception of drinks was not measured, so perhaps the sugar-to-acid content would help interpret the findings.

Sourness detection thresholds have not been linked to FV intake. It would be expected that those children who are more receptive to sour stimuli would find sour tasting fruit more aversive than children with lower sensitivity to sourness, or might show preference for fruit with higher sugars-to-acid ratio, compared to less sensitive peers.

1.3.4.1.5 Umami

Umami, the most mysterious of tastes, is not yet well understood. Umami taste is difficult to describe, but most commonly is referred to as the 'savoury' taste signalling amino acids and is usually measured using monosodium glutamate (MSG). It is hypothesised that umami evolved as taste which signals ingestion of sources high in energy such as proteins, and as such high sensitivity to umami flavour would be favoured by natural selection (Behrens & Meyerhof, 2011). Indeed, studies on infants show positive responses to umami flavour during early stages of development (Ventura & Worobey, 2013). Umami tastant l-glutamate is also present in vegetables, such as tomatoes, green peas, corn or spinach (Wilkie & Capaldi Philips, 2014). Umami is detected by Type II cells, which also are responsible for detection of sweet and bitter compounds (Behrens & Meyerhof, 2011). Recent discoveries also indicate interdependence of sweet and umami taste, as umami blind knockout mice showed lower sensitivity to sucrose (Kusuhara et al., 2013). There is also evidence for large individual differences in perception of umami (Lugaz, Pillias & Faurion, 2002) and some similarities to phenotypic expression similar to that of bitter taste, including umami-blindness, have been hypothesised. Umami blindness has been reported in approximately 4% of the population (Hayes, Feeney & Allen, 2013).

Sensitivity to umami taste has not been analysed in the context of FV intake or liking. Given the preference for umami taste and properties of umami to mute bitterness, it would be expected that children with higher sensitivity to umami would show higher preference or possibly intake of vegetables with higher glutamate content, especially for vegetables with low content of bitter phytonutrients.

1.3.4.1.6 Smell

Sensitivity to odour can also affect intake of foods, as odour evaluation via orthonasal ('via the nose') and retronasal pathways ('via the upper respiratory passage and nasal cavity') contributes to evaluation of flavour which can further result in acceptance or rejection of foods. Odour can either enhance or suppress taste qualities and vice versa (Pickering, Haverstock & DiBattista, 2006). It has been suggested that bitter taste status may also predispose to smell sensitivity, both ortho- and retronasal. Pickering et al. (2006) demonstrated that PROP supertasters perceived retronasal odours to be more intense than tasters and non-tasters. This suggests that being supersensitive to bitter taste can also lead to supersensitivity in the smell domain. As odour of some cooked vegetables, especially those with sulphurous compounds in cruciferous vegetables, is not very appealing, both domains may contribute to negative evaluation of flavour of the vegetables in a summative way. However, the smell of foods is processed prior to evaluation of taste and as such evaluation of smell of foods may lead to rejection before the food is even tried.

The link between sensitivity to smell and acceptance of foods, including fruit and vegetables, has not been explored in great detail. There have been some studies looking at sensitivity to specific compounds and intake of foods containing those compounds in adult samples. Engel, Martin & Issanchou (2006) demonstrated that non-consumers of cauliflower were significantly more sensitive to the odour of the bitter compounds of cooked cauliflower (e.g. sinigrin) compared to moderate and high consumers of cauliflower. Similarly, Jaeger et al. (2011) showed that odour sensitivity to a specific compound (cis-3-hexen-1-ol) present in FV and their derivatives with green/grassy qualities has a systematic small effect on acceptability of foods (including FV, and their derivatives such as hummus and tea). Participants with higher sensitivity to this compound had stronger negative reactions to foods. Also, food intake differences were noted between participants sensitive and non-sensitive to the compound, as measured by 24-hour recall.

While studies have shown that sensitivity to certain odours affects intake of associated foods, general olfactory sensitivity has not been tested in the context of FV intake in children. However, it has been shown that PROP sensitivity may predispose to hypersensitivity to odours and unpleasant odours may inhibit intake in children. While it can be speculated that unpleasant odours may inhibit intake of certain vegetables, it is not known whether pleasant fruity odours may facilitate FV intake and whether that varies by individual odour sensitivity.

1.3.4.2 Tactile sensitivity

Another sensory domain that has been discussed in the context of FV intake is tactile sensitivity. Tactile sensations are present during eating and lead to processing of various texture information such as crunchiness, creaminess, sliminess, chewiness and also process astringency, which is a mixture of taste and tactile sensations. Astringency, apart from acidic properties interpreted by taste receptors, leads to 'puckering' and 'shrinking' sensations on the tongue, processed by mechanoreceptors and as such is interpreted as a mixture of taste and tactile stimuli (Bajec & Pickering, 2008). Tactile mechanoreceptors innervate the fungiform papillae (FP), the structures that carry the taste buds on the tongue, but the exact nature of this innervation is not yet well understood. However, there is evidence that tactile sensitivity affects cognitive evaluation of foods.

There is evidence that PROP supertasters perceive more tactile oral stimulation compared to non-tasters. This will reinforce the pleasantness of fats, which would be perceived as more creamy (Bartoshuk et al., 1996), and would also reinforce negative attributes of astringent fruit (Prescott, Soo, Campbell & Roberts, 2004) or burning from capsaicin present in chillis (Green & Hayes, 2003). Dinella, Recchia, Tuorila and Monteleone (2011) looked at how individual levels of responsiveness to astringency in juices affect acceptance of FV. Adult participants were characterised as low, medium or high responding to astringency. They found that participants with high responsiveness perceived astringency of different fruit juices as more intense and liked them less, compared to medium and low responsive participants. Also, low responsive participants reported higher familiarity with astringent FV.

Furthermore, differences with tactile sensitivity have also been linked to picky/fussy eating. It has been established that children avoid lumpy and slimy foods, which are linked with difficulty in oral manipulation, and are fond of crispy and crunchy textures (Szczesniak, 2002). Also congruency of texture between the stored prototype of what the texture of the product should be like, and what it is may affect food acceptance i.e. the prototype texture of an apple is crisp and crunchy, so when the child experiences a mushy soft and lumpy apple this is incongruent with the prototype and as such would be rejected and might lead to disgust response. Children who are more sensitive to incongruency in texture would therefore be more likely to reject foods and would be described as picky/fussy eaters (Zeinstra, Koelen, Kok, & de Graaf, 2010). It has also been suggested that children who are more sensitive to tactile stimulation and show stronger negative affect to tactile stimulation may be more sensitive to textures of food (Dunn, 1997). Smith et al. (2005) found that children who were more sensitive to touch, rejected more FV and showed higher neophobia compared to children with normal responses to touch. Coulthard & Blissett (2009) demonstrated that in 2-5 year olds, children who had higher tactile sensitivity ate fewer FV and had higher neophobia. Nederkoorn, Jensen and Havermans (2015) in an elegant study which utilised behavioural measures of tactile sensitivity found that in children between 4-10 years old, there was a positive association between tactile sensitivity to touch and tactile sensitivity to oral stimulation, which was particularly strong in the younger age group.

There is evidence that tactile sensitivity to touch is linked with tactile sensitivity to food textures, and that there are individual differences in sensitivity to food textures, perhaps linked with taste (PROP) sensitivity. Children with higher sensitivity are more likely to reject FV based on their texture and astringency level, thus FV are likely to be more rejected by more sensitive children. At the same time, the reinforcing value of fatty foods, resulting from higher perceived creaminess, means that those children find them more pleasant and intake of fatty foods is therefore reinforced.

1.3.4.3 Visual sensitivity

Sensitivity to visual stimuli in the context of FV intake has been studied to a lesser extent than taste and tactile sensitivity. Visual sensitivity would affect responsiveness to food colour or changes to food colour such as rejection of banana with brown spots. Visual sensitivity may be particularly important as it would affect willingness to try foods and may be a barrier in introducing new foods, which have a potential to be rejected before they are even tasted, reminiscent of smell sensitivity.

Colour of food may provide information on chemical composition, which then translates to expectancy of flavour. Studies show that perceived intensity of taste and flavour increases with increase in colour intensity of solutions (Hyman, 1983). Also, certain colours are associated with tastes, such as red is perceived as sweeter than blue (Johnson & Clydesdale, 1982). This is likely to be because red is associated with sweet fruit and in vegetables, reddish or orange vegetables have lower levels of bitter compounds and higher levels of carbohydrates (tomatoes, carrots, pumpkin) compared to the dark green vegetables (broccoli or spinach). Red is also an indicator of ripeness of fruit, and as such indication of the content of bitter tannins and sweet carbohydrates which show inverted association with fruit ripening. This way colour of FV actually provides information on chemical composition and thus creates associations with flavour. Brown spots on FV may in turn signal spoilage and so naturally mechanisms promoting avoidance or creating disgust for brown spots on FV would be favoured on the evolutionary pathway. Colour of food is therefore an important signal for its nutritional content and safety.

While there is some evidence that visual cues affect liking and perception of FV, not much is known about individual differences in processing of visual cues. Dunn (1997) suggested that changes in visual properties of foods may lead to rejection by children sensitive in the visual domain, but individual differences in sensitivity to visual cues in the context of FV intake have not been widely explored. Neophobic children refuse to try novel FV and that rejection is often based on visual cues, which suggests that there might be a close link between visual sensitivity and neophobia, or perhaps neophobia is some form of visual over-responsiveness. However to what degree smell sensitivity would contribute to this variance is unknown. Coulthard and Blissett (2009) found that individual audio-visual sensitivity was associated with food neophobia but not with intake of FV in 2-5 year olds. Furthermore, foods that are similar to other disliked foods may be rejected by generalisation, again only based on visual cues (Dovey et al., 2007).

Overall, it seems surprising that not much research has been done on the effects of visual sensitivity on intake of FV. It seems that this should particularly be explored within children with higher neophobia levels and perhaps tested in picky/fussy children who show state-dependent rejection of groups of foods, perhaps because of being particularly sensitive to incongruency with stored prototype which results in rejection of both unknown and known foods.

1.3.4.3 Auditory sensitivity

Even less is known about how auditory properties of foods affect their perception and intake. Auditory properties of foods refer to food crunchiness and crispiness and affect perception of freshness and water content (Verhagen & Engelen, 2006). For example, the crunchy apples are an indicator of high water content and freshness, while mushy soft apples indicate low water content and long period of time since falling off the tree. As such, auditory properties of foods indicate possible spoilage.

Audio feedback during eating is used to assess crispiness and crunchiness of foods. Studies show that manipulating amplitude of auditory feedback during biting of potato crisps enhanced perception of crispiness in an adult sample (Zampini & Spence, 2012). It was also demonstrated that muting the sounds produced during mastication impaired the ability to discriminate between different textural properties of foods (Spence & Shankar, 2010). Auditory feedback will therefore be closely linked with tactile feedback, as inevitably auditory stimuli such as amplitude of crunchiness will be inversely linked with textural property such as softness, and dissociation of the two properties will be very difficult to measure.

While importance of audio feedback for perception of flavour has been established, individual differences in auditory sensitivity on intake of FV have never been measured, however given the dominance of other sensory properties of foods on perception of flavour, individual differences in auditory feedback are likely to only show minor effects on intake and liking of FV.

1.3.5 Fungiform papilla

Another intrinsic factor which has been identified as a correlate of FV consumption is the genetically determined anatomy of the tongue. The tongue is covered with three types of projecting papillae which carry taste buds. Fungiform papillae (FP) are located on the anterior tongue, foliate papillae are located at the back edges and circumvallate papillae are arranged in a half circle shape at the back of the tongue (Todrank & Bartoshuk, 1991). FP resemble button mushrooms and are concentrated at the tip of the tongue. Each one of them carries between 0 to 15 taste buds (Breslin, 2013). Their density has been linked with taste sensitivity and intake of FV.

Density of FP has been associated with sensitivity to the bitter tastant PROP (Bartoshuk et al., 1994). Supertasters have been shown to have the highest count of FP, which is not surprising given that they would be likely to possess the most taste buds.

Duffy et al., (2010) showed that FP density was positively associated with perceived bitterness of quinine. Prutkin et al. (2000) reported that adult females have a greater range of FP count than males, with 17% of females having more FP than any males, which suggests possible gender differences in FP count. It has also been shown that FP count is stable throughout lifespan (Prutkin et al., 2000) but innervations and the number of functional taste buds carried by FP decreases throughout lifespan (Srur et al., 2010). Despite the well-established link between FP density and PROP phenotype, the association between the two is not perfect, as PROP tasting is subject to methodological bias and other factors, especially hormonal variations in females (Prutkin et al., 2000). The association between FP density and PROP phenotype may indirectly impact intake of FV.

FP density has been directly linked to intake of FV, but the nature of this association is complex. Duffy et al. (2010) reported that PROP non-tasters consumed more vegetables than PROP tasters, however the non-tasters with more FP ate more vegetables of all type than PROP non-tasters with smaller density of FP, which has been interpreted as facilitation of vegetable intake by FP when bitterness of vegetables is not a factor. The same pattern was reported by Feeney et al. (2014) in a sample of 7-13 year olds, who also found a positive association between vegetable intake and FP count but only in AVI/AVI, or PROP non-tasters. This suggests that FP density may in fact be a separate contributor independent of PROP status and may be an independent phenotype linked to PROP phenotype.

FP density may also be associated with texture perception and retronasal olfaction, as FP are also innervated by tactile fibres and the distance between them has been associated with touch perception (Prutkin et al., 2010) however the exact nature of this innervation is unknown. This hypothesis has recently been supported by Bakke and Vickers (2010) who found that adding bleached bran to bread for increased roughness increased liking of bread and this increase in liking was larger for participants with higher FP count and for subjects less sensitive to PROP, suggesting that FP count may be linked to food intake by a combination of taste and texture perception.

There is emerging evidence that FP is linked with intake of FV. If FP are linked to liking and intake of FV by a combination of taste and tactile properties, then testing FP density and intake and liking of astringent fruit, which serve as both taste and tactile stimuli, would result in the greatest individual differences between participants of differing FP density. While FP links to FV intake deserve more consideration, they are beyond the scope of this thesis.

1.3.6 Chorda tympani damage

Fungiform papillae are in 25% innervated by the chorda tympani nerve (CT), and in 75% by trigeminal nerve. The CT is a cranial nerve VII, which traverses through the middle ear to the anterior portion of the tongue and is commonly referred to as a taste nerve (Nelson et al., 2011). Together with the trigeminal nerve (cranial nerve V) and glossopharyngeal nerve (cranial nerve IX), which transmit thermal, pain and tactile signals, they are responsible for transmitting flavour sensations. Those three nerves have inhibitory properties on one another, which means that damage to one of the nerves releases inhibition on the remaining nerves, which may lead to intensification of flavour perception. Damage to more than one nerve may result in inhibition of flavour perception (Bartoshuk, 2000).

Recent discoveries have linked damage to CT nerve with intake of foods, including FV. Studies looking at possible effects of CT damage have focused on Otitis Media (OM), or middle ear infections, as viruses that cause OM may damage the CT nerve where it traverses the middle ear. OM is prevalent in childhood with peak incidents between 6-18 months, with epidemiological data suggesting as many as 75% of children suffering from at least one episode of OM during childhood (Duffy et al., 2003). As such, OM related CT damage may be of public health importance, and yet surprisingly little research evidence addresses that issue.

Children with chronic OM have been found to show a decrease in perceived intensity of quinine and an increase in perceived intensity of citric acid suggesting possible effects on taste sensitivity (Bartoshuk, Duffy & Miller., 1994). There is also evidence that children with OM history are at higher risk of overweight however the reasons behind this are at present unknown (Nelson et al., 2011; Kim et al., 2007). Arsenault et al. (2004) reported that children with more severe history of OM ate fewer vegetables and had higher preference for sweets. Peracchio et al. (2012) showed the first published evidence that CT damage due to OM exposure in children may be linked to liking of FV. They demonstrated that children with the highest exposure to OM had lower reported liking of FV and higher adiposity, suggesting affinity for energy dense foods. The exact mechanism is not well understood but may be linked to changes is perception of tastes as a result of sensory damage. To add to this, Seaberg et al. (2010) found that children with OM history had lower thresholds of CT conductivity compared to controls without OM history suggesting greater CT acuity (or sensitivity).

Together those findings warrant further investigation of the possible effects of OM related CT damage on FV intake. There is evidence for OM related changes in taste perception and reports on differences in preferences for FV and fatty foods compared to healthy controls, which may be expressed as differences in adiposity, which requires further investigation.

1.3.7 Internal predictors: Summary

Internal predispositions may affect initial responses to foods and may contribute to development of likes and dislikes. The link between internal predispositions and intake of FV is not yet well understood, as it has been studied to a lesser extent than the external factors. The evidence seems to point to neophobia as the main internal barrier to food acceptance in children. Not much is still known about how sensory sensitivity to tastes, odours, vision or touch contributes to intake of FV in children, or how this sensitivity is linked with neophobia. Currently, the most researched component of sensory sensitivity in the food context is the phenotype for bitter taste, however there is emerging evidence that sensitivity to other tastes and in other modalities may affect intake of foods.

1.4 Gene x environment interaction

In this review extrinsic predictors of children's FV intake have been discussed separately from internal predictors. However, in reality those two groups of factors interact and affect one another. Indeed, substantial evidence has been given on the role of gene environment (GxE) interactions not only in FV intake, but also in general diet.

There is substantial evidence for moderate family resemblance in dietary intake. Beydoun and Wang (2009) showed that on a nationally representative sample of

Americans, there were significant correlations between parent-child dietary intake for all food groups, with the strongest resemblance of FV and the weakest resemblance in saturated fat intake as proportion of overall intake. Mother-child resemblance was stronger than father-child resemblance, probably due to the fact that mothers tend to be primary feeders in the families. However, it is more difficult to establish the proportion of variance in this resemblance attributable to environmental and genetic factors. That resemblance is not surprising given previously mentioned influence of home availability of various foods and parental intake of foods which inevitably will affect what parents feed their children. Parental likes and dislikes will affect home food environment and what the child is exposed to.

Little is still known about the hereditary component of parent-child dietary resemblance. Twin studies, albeit limited, provide evidence that there is genetic influence on food preferences. Wardle et al. (2001b) demonstrated high heritability for preference for proteins, moderate heritability for FV and weak for desserts. In a much smaller twin study on 13 monozygotic twins Krondl et al. (1983) showed heritability of taste sensitivity to the bitter PTC, and preferences for grapefruit juice and green beans. Similarly, Falciglia and Norton (1994) on a small sample of 14 pairs of monozygotic twins and 21 pairs of dizygotic twins showed that food preferences were stronger among monozygotic twins and that there were hereditary preferences for FV, dairy, sweetened cereal and hamburgers. The hereditary component has been linked to sensitivity to tastes, such as previously discussed sensitivity to bitter taste. It has also been suggested that neophobia or food pickiness could be the hereditary component which affects preferences (Wardle & Cooke, 2008). Some reports suggest that even 78% of variability in neophobia could be hereditary (Cooke, Haworth & Wardle, 2007).

Reed et al. (1997) postulated that general dietary choices are to some extent hereditary, in particular via genetic markers of carbohydrate and fat perception, and in this way point to hereditary components in propensity for overweight. A small hereditary component has been also shown in preference for serving sizes and consumption frequencies, although much smaller than contribution of environmental factors (Van Der Bree, Eaves, & Dwyer, 1999). Scheibehenne et al., (2014) in a large recent study on genetic components of dietary variety demonstrated that in a sample of over 5500 middle age mono and dizygotic twins, almost a third of the variance in dietary variety was due to heritable components and the majority was due to unshared environmental influences. However, Rozin and Millman (1987) proposed that hereditary component in food preferences is minimal and is limited to acceptability of hotness in chilli peppers (therefore taste/tactile sensitivity). They compared preferences among mono and dizygotic twins and found no differences in resemblance, with the exception of hotness preference. They concluded that family environment was the main component of dietary resemblance, not the heritability of preferences. Similarly, Dubois et al. (2013) examined the role of genetic and environmental influences in dietary intake in 9 year old twins and also showed that both energy and macronutrient intake has a moderate heritable component ranging from 0.34-0.42. There was different genetic component to intake of different food groups, with lipid intake showing the highest proportion of heritability. Energy from proteins and carbohydrates was only based on shared and unique environmental influences.

It is difficult to establish the role of GxE in dietary intake, especially since there are a number of identified environmental influences which affect not only FV intake, but intake in general. It is now established that food preferences are hereditary to some degree but environmental influences have a larger influence on diet than the genetic components. Genes may affect preferences via heritability of sensory sensitivity, neophobia or food pickiness, however family environment, parental modelling and food availability and exposure will moderate the effect of genetic predispositions on eating behaviour.

1.5 Aims of the thesis

It has been demonstrated that FV intake in children is affected by both external and internal drivers. While many of those factors have been explored in great detail there are still many inconsistencies and gaps which need to be filled. This thesis explores various internal and external factors which may be associated with intake of FV in children, such as lifetime exposure to FV, liking of FV, selected maternal feeding practices, history of OM, weight status and individual sweet taste sensitivity. The aim of this thesis is also to explore whether there are differences in FV intake attributable to different sensory properties of products within the FV family; whether the effects of various internal and external factors are different for fruit than they are for vegetables, and also for subgroups of FV which elicit strong sensory sensations such as astringent fruit and cruciferous vegetables.

Chapter III will look at the association between lifetime exposure to FV and intake of FV in school-age children. Lifetime exposure will be conceptualised as exposure to diverse flavours of FV, but will also be measured separately for exposure to fruit and to vegetables. The contribution of lifetime exposure to explaining FV intake in children will be examined. Further, Chapter IV will look at moderating effects of maternal feeding practices on liking and intake of FV in toddlers. Maternal feeding practices that will be analysed are teaching, encouragement of balance and variety, involvement and control, as little is known about those practices. Past reports indicated that OM history is linked with the risk of overweight and increased liking of energy dense foods. Chapter V will be an exploratory analysis of effects of OM history on intake of FV in children in the context of children's adiposity. This analysis will be conducted on two samples of toddlers and school-age children. Furthermore, past literature has linked individual differences in taste sensitivity to intake of energy dense foods and FV, particularly in the context of adiposity. This thesis took a novel approach to analysing sweet taste sensitivity in the context of FV intake in school age children, while looking at possible differences in adiposity, which will be explored in Chapter VI. The results of this thesis will help understand both internal and external contributors to intake of FV and will provide evidence for the necessity to analyse intake of fruit separately from intake of vegetables.

Chapter II
General Methodology

2.1 Introduction

The research questions which are addressed in the current thesis have been analysed in two participant samples (2-3 year olds and 5-9 year olds) with a mixture of measures. This chapter will provide detailed information on the new and standardised paper measures used. Detailed information about the procedures carried out with each of the samples and general socio-demographic information will also be outlined in this chapter.

2.2 Overview

2.2.1 Sample I

Studies conducted on Sample I were funded by Internationale Stiftung für Ernährungsforschung und Ernährungsaufklärung (International Foundation for the Promotion of Nutrition Research and Nutrition Education). Sample I consisted of children between 5-9 years old who were tested in the school setting. Data obtained were used to establish the link between Sucrose Detection Thresholds (SDT) and intake of FV in children (Chapter VI). A number of different paper measures were obtained, which will be discussed in detail in the subsequent part of this chapter. Parents provided details of their own and their children's lifetime FV intake, which was the basis of Chapter III. Furthermore, parents also provided information on children's medical history of middle ear infections, which was used to test hypotheses presented in Part I of Chapter V.

2.2.2 Sample II

Sample II was tested as a part of a larger project on introduction of novel fruit to toddlers. Parents completed a number of paper measures (discussed below), which formed the basis of Chapter IV, examining the moderating effects of parental feeding practices on liking and intake of FV in toddlers. Further, based on information collected from Sample I, effects of middle ear infections history on intake of FV were also tested in this sample in order to get the comprehensive overview in different age groups, which are reported in Part II of Chapter V.

2.3 Recruitment and Procedure

2.3.1 Sample I

Ethical consent was granted by the University of Birmingham Ethics Committee (ERN_10-0010). Participants were recruited between October 2011 and June 2012. First, 61 local primary schools were contacted and four schools expressed interest in participating. All four schools were located in affluent areas of Birmingham. Index of Multiple Deprivation Rank (2010) indicated that the schools were located in the top 5% of the most affluent areas in the UK. Once the schools confirmed that they would be able to secure a separate room for testing purposes, they were sent sufficient questionnaire packs for the number of pupils in the designated age group. The questionnaire packs contained participant information sheet (see Appendix A-1), consent form (Appendix A-2) and the full set of questionnaires (described below). Overall, approximately 487 questionnaire packs were distributed among the pupils from the four schools, with a return rate of 24%.

Next, teachers distributed the questionnaire packs among the pupils. Parents who wished their child to take part in the study were instructed to return the questionnaire pack together with the consent form in a sealed envelope to a designated box in the school foyer. Once the consent and questionnaires were returned, the child was tested within the period of 7 days. Once the child was tested, identifying information was discarded and the participant was further only known by their ID. After the testing the children received a debriefing sheet (Appendix A-3) which they were requested to pass on to their parents. Specific details on the experimental procedure of SDT estimation are presented in Chapter VI. The schools received a £100 Amazon voucher for taking part in the study.

2.3.2 Sample II

Ethical consent was granted by the University of Birmingham Ethics Committee (ERN 12-0465AP1). Recruitment took place between April 2012 and March 2013. Participants were recruited using Infant and Child Laboratory (ICL) database and from the local child groups and nurseries. Parents who expressed interest were tested in the ICL on the University premises. Participants received an email with an information sheet (see Appendix A-4) in order to obtain confirmation that they were eligible for participation and to confirm the date for testing. Once they arrived at the University premises, they completed the study which was not related to this thesis, and not reported here. Next, they signed a consent form to participate in further studies (see Appendix A-5) and were given a number of questionnaires (see below). After completion participants were debriefed (see Appendix A-6). Participants were reimbursed for travelling (£10) and the child received a small toy for participation.

2.4 Questionnaires

2.4.1 Standardised questionnaires

A number of established measures were used in order to address the research questions. Those measures are described below.

2.4.1.1 Sensory sensitivity in children

Sensory sensitivity was measured in both samples in order to assess its possible influence on children's intake of FV and was considered as a covariate in all of the chapters.

To assess children's general sensory sensitivity, parents completed the Short Sensory Profile questionnaire (SSP; Dunn, 1999; Appendix A-7). This profile gives a comprehensive view of a child's behavioural and emotional responses to sensory stimuli, as well as information on sensory processing and sensory modulation. This measure was developed from a larger 98-item Sensory Profile (SP; Dunn, 1999), and was shown to discriminate well (>95%) between children with and without sensory dysfunction. The measure contains 38 items completed by the caregiver, which evaluate sensitivity in 7 domains: tactile sensitivity, taste/smell sensitivity, movement sensitivity, underresponsive/seeks sensation, auditory filtering, low energy/weak and visual/auditory sensitivity.

For the purpose of this study only 3 domains previously related to dietary preferences (Coulthard and Blissett, 2011; Smith et al., 2005) were assessed (16 items in total): Tactile (e.g. *Reacts emotionally or aggressively to touch*), Taste/Smell (e.g. *Will only eat certain tastes*) and Visual/Auditory (e.g. *Holds hands over ears to protect ears from sound*) sensitivity. The responses range from Always to Never, on a 5 point Likert scale. Based on the added total scores children are classified as showing typical (higher scores) or atypical behaviour (lower scores) in particular domain, according to guidelines by Dunn (1999). This measure has been previously used in a number of studies examining children's eating behaviours (e.g. Farrow and Coulthard, 2012; Smith et al., 2005). Internal consistency of sections within the scale ranged between 0.70-0.90. Cronbach's alpha for the scale was indicated at .870. Sensory Profile (SP) and SSP by Dunn (1999) are currently the most widely used measures of sensory sensitivity (Reynolds and Lane, 2008).

2.4.1.2 Neophobia

Neophobia was tested in Sample II only and was used as a covariate in Chapter IV and Chapter V Part II. Neophobic tendencies in children and mothers were measured with the Food Neophobia Scale (FNS; Pliner & Hobden, 1992; Appendix A-8). This measure contains 10 items on a 7-point Likert scale (from Disagree Strongly to Agree Strongly). Half of the items are reverse scored. Higher scores are indicative of higher neophobia, which is described on a continuum scale. The scale has been shown to predict responses to novel foods in children and adults (Hobden & Pliner, 1995; Falciglia, Pabst, Couch & Goody, 2004). Cronbach's alpha for the scale was established at 0.887 (Pliner & Hobden, 1992). This measure was used as it was practical for the sake of comparison to use the same measure for parents and their children. FNS is one of the most commonly used food neophobia measures (Coulthard & Blissett, 2009; Laureati et al., 2015; Howard et al., 2012).

2.4.1.3 Fruit and vegetables intake

In Sample II a Guided One Day Dietary Recall (Robinson, Higgs, and Blissett, 2011; Appendix A-9) was used to measure FV intake in toddlers and their parents. This measure was used in Chapter IV and Part II of Chapter V.

This measure instructs the participant to carefully examine the last day's food intake, step by step from the moment of waking up to the moment of going to sleep. The intake is recorded into separate boxes, with each box representing one eating episode. In each box the participant is requested to write what was eaten, when was it, where was it, and what the portion was. Prompting the participant with questions is supposed to optimise recall. The participant completed the same measure for their child. This measure was chosen as the participants have been shown in the previous studies to have an accurate recall of foods consumed in the past 24 hours (Armstrong et al., 2000). This questionnaire was chosen over other more established measures, as prompting questions used to aid recall are likely to result in a more accurate record of participant's FV intake (Robinson et al., 2013).

2.4.1.4 Feeding Practices

The Comprehensive Feeding Practices Questionnaire (CFPQ; Musher-Eizenman & Holub, 2007; see Appendix A-10) was used to examine feeding strategies used by the parents. CFPQ consists of 12 factors that were built from 49 items. Only 4 facets were used and these were: control (e.g. *If this child does not like what is being served, do you make something else?),* encourage balance and variety (e.g. *I encourage my child to eat a variety of foods.),* involvement (e.g. *I allow my child to help prepare family meals*) and teaching about nutrition (e.g. *I discuss with my child why it's important to eat healthy foods*). The parents were asked to answer questions on a 5-point Likert scale, ranging from ‘never’ to ‘always’ for items 1-13, and ‘disagree’ to ‘agree’ for items 14-49. The measure has shown good validity and reliability (Musher-Eizenman & Holub, 2007; Haszard et al., 2013).

2.4.1.5. Preschool Adapted Liking Survey

The Preschool Adapted Likng Survey (PALS; Appendix A-11) was used to measure children’s liking of FV. PALS has been validated in an American population of pre-schoolers and it has been shown to be a proxy for FV intake, as measured with dermal carotenoid status (Scarmo et al., 2012) and has demonstrated high reliability (r>0.7). PALS is a form of a general hedonic scale, as parents are asked to report liking of different products compared to the highest liking or disliking of any kind. Parents were specifically instructed to rate the child’s liking of all items compared to ‘the strongest liking or disliking you can imagine’. This way liking was rated in an ordinal way and allowed for comparison between the different participants. Participants are not instructed to compare the liking score of food items to some specific non-food item, for example sound, as perception of sound, like any other sensory stimulus, will vary depending on child’s sensory sensitivity. By asking the parents to rate child’s liking of foods compared to non-specific liking scores, that inter-participant variability in sensory sensitivity is removed. Past studies showed that parental reports of child’s likes and dislikes are reliable (Byers et al., 1993).

PALS contains 54 food and non-food items. The food items contain representative items for all groups of products including fruit, vegetables, proteins, fat/sugar foods and juices. PALS contains non-food items as it also serves as generalised labelled magnitude scale (gLMS) where liking of different foods can be compared to liking of other positive non-food reinforcers. Therefore, PALS is a good alternative to traditional measures of liking because of its use of relative liking scores.

Parents are asked to report their child's liking/disliking of foods and non-foods on a visual analogue scale, ranging from 'loves it' to 'hates it'. Faces reflecting the liking/disliking were placed at the top of the page to aid reporting. If the child has never tried the item, the parent was requested to tick the box next to the item. The liking scores were generated ranging from +6.8cm indicating 'he/she loves it' to -6.8cm indicating 'he/she hates it'. Liking scores were used as a continuous variable.

The PALS scale contains 5 fruit and 8 vegetables. Liking of fruit was established as mean of liking of 5 PALS items: raisins, strawberries, banana, apple and melon. Liking of vegetables was established as mean of liking of 8 items: peas, beans, sweetcorn, carrot, broccoli, tomatoes, salad and spinach. Liking of FV was not subdivided into liking of astringent/ non-astringent fruit and cruciferous/ non-cruciferous vegetables as PALS did not contain a sufficient number of representative items from those subcategories.

2.4.2 New measures

2.4.2.1 FV Intake and lifetime exposure

A new measure of FV intake was developed to test Sample I, which allowed for specifying intake of subcategories of FV, namely astringent fruit and cruciferous vegetables (see Appendix A-12). This measure also allowed to collect data on lifetime exposure to FV within one measure. Data collected with this measure were used in Chapter III, Chapter V Part I and Chapter VI.

This measure has a form of a FFQ with 122 items (63 fruits and 59 vegetables). The FV included in the questionnaire were chosen on the basis of their availability in the local supermarkets. Products that could be consumed in more than one form (e.g. raw or cooked) were listed separately to prompt memory and to help establish the portion size. There were empty spaces for any FV consumed that were not included in the list. The parent indicated which FV the child consumed, rather than which FV the child was offered, and to indicate how many portions were consumed in the preceding 24 hours. Portion size of every product was indicated next to it to aid normalisation of the responses and to clarify the portion size consumed by the participants. The measure also consisted of a separate column where the parent was requested to mark any items that the child had never consumed before. The parent was requested to complete identical questionnaire reporting their own 24 hour intake of FV and exposure to a variety of FV.

This measure was developed as it allowed acquisition of detailed information about the types of different products consumed, which is central to this thesis. Furthermore, this measure allowed acquisition of information about the lifetime exposure to a variety of different FV within one questionnaire, which was time-efficient for the participants.

2.4.3 Demographics questionnaires

Sample I

Parents were given a very brief demographics questionnaire to provide information about their own and child's ethnicity, age and information on history of OM, tonsillectomy and illnesses in the preceding 4 weeks (see Appendix A-13).

Sample II

Parents were given a more elaborate demographics questionnaire and provided information on their own and child's age, ethnicity, income level, education, special dietary requirements, history of OM, tonsillectomy and full-term birth (see Appendix A-14).

2.5 Measuring adiposity

2.5.1 Sample I

The participant was weighed in light clothing without the shoes using standard kitchen scales (accurate to 0.1 kg) and height was measured using a stadiometer (Seca Leicester Portable height measure) at the end of the experiment. Children's weight and height were used to establish their BMI, which were later converted to z-scores, corrected for age and gender using British 1990 Child Growth Reference Chart (UK90). Further, the z-score values were converted to BMI centiles, which were used in some analyses as continuous variables and also used to categorise children to healthy weight and overweight/obese.

2.5.2 Sample II

Weight was expressed in the form of BMI centiles which were calculated using the same procedure as described for Study I. Mothers were also weighed and their height was measured. Next, their adiposity was expressed in the form of BMI units. A waist-to-height ratio (WHtR) was used as a supplementary measure of central adiposity and was calculated by dividing waist circumference (cm) by height (cm). WHtR has been shown to be a reliable method for detecting central adiposity in children and a stronger predictor of cardiometabolic risk than BMI (Mokha et al., 2010; Khoury, Manlhiot & McCrindle, 2013), as BMI as does not allow the differentiation of lean tissue from fat mass and is unable to differentiate between central and peripheral adiposity (Stefan et al., 2008). Waist circumference was measured following a standard WHO (2008) protocol in a standing position at the end of expiration, approximately 2cm (width of the indicating and third finger) above the umbilicus, tight (with the tape held snugly) but not constricting, using a stretch-resistant tape with an indicator buckle, thus reducing differences in tightness.

2.6 Analysis of FV intake

Number of portions of FV consumed by the mother and the child were calculated according to the NHS guidelines which are presented on NHS website (NHS, 2012). For data analysis FV intake data collected from both measures were subdivided into separate groups. Fruits were split into astringent and non-astringent fruit and vegetables into cruciferous and non-cruciferous groups. Fruit juice was analysed separately and was not included in the FV count. Astringent fruit contained fruit with astringent and irritant properties due to high content of tannins (berries, sharon fruit and pomegranate), naringin and hesperidin (lemons and limes) and ascorbic acid (kiwi and pineapple). Yoghurts were not counted as it would be difficult to estimate the portion size of fruit in yoghurt. Potatoes were not included in the vegetable count. FV analysis was conducted separately for reported intake and reported variety. Intake was calculated as the number of portions reported by the parent and variety was calculated as the number of different FV consumed, irrespective of the portion size.

The following fruit was included in the astringent fruit count: blackberries, blackcurrants, blueberries, gooseberries, kiwi, passion fruit, pineapple, pomegranate, lemon, raspberries, rhubarb, Sharon fruit, strawberries and any other berries which parents listed as 'other fruit'. Non-astringent fruit count included all the remaining fruit i.e. apples, apricots, bananas, cherries, clementines, dates, figs, mandarine orange, mango, melon, nectarines, oranges, papaya, peaches, pears, plums, prunes, satsumas, watermelon, cranberries, raisins and any other fruit which parent listed as 'other fruit' which did not have astringent properties. The following vegetables have been included in the cruciferous vegetables count: cabbage, Brussel sprouts, broccoli, cauliflower, bok choy, Chinese cabbage, kohlrabi, kale, turnip root, rocket, garden cress, watercress and radish. The remaining vegetables have been included in the non-cruciferous vegetable count: artichoke, asparagus, aubergine, beans, soya beans, beansprouts, beetroot, butternut squash, carrots, celery, chickpeas, courgettes, cucumber, leeks, lentils, lettuce, marrow, mushrooms, okra, onion, parsnips, peas, peppers, pumpkin, spinach, sugarsnap peas, swede, sweet potato, sweetcorn, tomatoes or any other vegetables which parents listed as 'other'.

2.7 Sample

General information about the sample will be outlined in this section, as data on FV intake collected in the older sample were used in Chapter III, V and VI. More detailed specifics, which were used as covariates in the studies, will be listed in the Methodology section in every empirical chapter.

Sample I

The majority of the children were White British (n=87; 91.6%), and the remaining were of Asian (n=4; 4.2%) or Mixed origin (n=4; 4.2%). The paper measures collected were completed by primary caregivers, who were mothers (n=84), fathers (n=9) or the grandparent (n=2).

Sample II

The sample was predominantly white British (n=82; 81.2%), and the remaining participants reported Asian (n=8; 7.9%) or other origin (n=11; 10.9%). The majority of the sample were educated to University level (n=72; 71.3%) and reported a household annual income of £30k or higher (n=76; 75.2%).

Chapter III
Lifetime exposure to variety of fruit and vegetables, and intake in 5-9 year olds.

3.1 Abstract

The aim of this study was to test whether lifetime exposure to variety of FV is related to 24hour intake of FV in 5-9 year old children, both in terms of portions and variety. Parents completed a food frequency questionnaire in which they reported their own and their children's intake of FV in the preceding 24 hours. Parents also reported which FV, out of a list of 122 products, the child and themselves had never tried before. Lifetime exposure to FV variety was analysed as a combined FV count, and also separately for fruit and for vegetables. Similarly, 24hour FV intake was analysed as an overall FV count and separately for fruit and vegetables. Partial correlations controlling for covariates revealed that children exposed to higher variety of FV ate more portions and greater variety of FV in the past 24 hours. Looking at FV separately, lifetime exposure to variety of fruit was linked to variety of fruit eaten, and lifetime exposure to variety of vegetables was linked to variety of vegetables eaten, but those links were not evident for the quantity eaten, only for diversity. Regression analyses revealed that lifetime exposure to FV variety was a small but significant unique contributor to children's 24hour intake of variety and portions of FV overall, and a contributor to vegetable intake when FV were analysed separately. Lifetime exposure to FV variety did not predict quantity of fruit consumed. One plausible explanation for the findings is that exposure to FV may aid intake of neutral flavours, but does not affect highly liked (e.g. fruit) or highly disliked (e.g. cruciferous vegetables) flavours.

3.2 Introduction

Parental intake of FV is consistently shown to be a significant contributor to child's intake, however the reported strength of this relationship varies and may not always be direct (e.g. Bere & Klepp,2004; Miller, Moore & Kral, 2011; Baranowski et al., 1999). Parental intake of FV will influence other home or family factors that may further affect child's FV intake, such as home availability or accessibility (Pearson et al., 2009). Parental intake is therefore a direct and indirect contributor to child's FV intake and as such must be controlled for when analysing children's FV intake and children's exposure to foods, which is largely under parental control.

Home availability and accessibility will substantially affect child's exposure to various FV. Exposure to FV is a concept which can be defined and analysed in various ways (details in Chapter II). Many studies looking at exposure to FV have focused on the effects of exposure to a specific product on subsequent intake of that product, and used short term exposure as an independent manipulated variable in experimental designs. Wardle et al., (2003) showed that exposing a child to an initially disliked vegetable for a period of 14 days resulted in an increase in preference and intake of the target vegetable after the exposure period. In that study the design evaluated the effect of repeated tasting of a specific flavour on subsequent acceptance of that same flavour. Another example of such a design was that of Schindler, Corbett & Forestell (2013), who exposed pre-school children to variety of FV and found that, compared to the control group, the children were more likely to accept or try FV after being exposed to them. Other studies that have used repeated tasting/exposure paradigms have found similar effects (Birch and Marlin, 1982; Lakkakula et al., 2010). While short term effects of repeated tasting paradigm support positive effects on liking and intake, other paradigms of measuring effects of exposure have been less common in current literature.

Surprisingly, the effects of lifetime exposure to variety of FV on intake have not been analysed thoroughly. Reinaerts et al. (2007) measured children's lifetime FV exposure and their FV intake. They quantified lifetime exposure as the number of FV that the child had never tried out of 14 popular fruit and 15 popular vegetables. The results showed that exposure to more fruit was a significant predictor of higher fruit intake, and exposure to more vegetables was a significant predictor of higher vegetable intake. This study suggests that exposing children to different flavours of FV may contribute to increased intake of FV, not necessarily to the specific flavour to which they were exposed. However, this study measured exposure only based on a small number of the most common FV, and as such would not account for potential effects of exposure to a wide variety of less common products. Skinner et al. (2002) supported those findings, and also showed that exposure to a wide variety of fruit during early childhood was predictive of consumption of a wide variety of fruit during late childhood. Similarly, Resnicow et al. (1997) found that lifetime exposure to variety of FV was correlated with FV intake in a 7-day recall paradigm. It seems that exposure to one group of products facilitates subsequent acceptance of similar group of products. Together, these studies suggest that lifetime exposure to variety of FV may have effects on future intake of FV and variety of FV consumed.

Most studies that analyse intake of FV do not acknowledge that different subgroups of FV differ in sensory properties and their acceptance varies depending on those properties, because they affect palatability. Acceptance and rejection rates are therefore different across different types of FV. A subgroup of vegetables which is typically rejected by children is Brassicaceae (Reed, Tanaka & McDaniel, 2006), commonly called cruciferous vegetables, which contain bitter polyphenols. Similarly, certain fruit have unpleasant astringent properties, and as such are typically characterised by low palatability and show low intake rates (Laaksonen, 2013). For that reason it might be expected that if those subgroups of FV have different sensory properties, they will also have different drivers of intake, and as such should be analysed separately from the other FV.

Past studies showed that intake of FV, and particularly of cruciferous vegetables and astringent fruit, may be affected by child's sensory sensitivity, as sensitivity to different types of stimuli might affect palatability of FV with strong sensory properties and thus might affect acceptance. For a detailed evaluation of sensory sensitivity refer to Chapter I. For that reason, it is necessary to control for individual sensory sensitivity when analysing intake, particularly of cruciferous vegetables and astringent fruit, which may evoke strong taste, smell and tactile sensations.

Past studies, however limited, indicate that exposure to particular flavours is linked with intake of that particular flavour. It has also been demonstrated that exposure to a group of flavours such as fruit or vegetables is linked with subsequent intake of that particular group of flavours. Up to date, the effects of lifetime exposure to a variety of FV flavours on children's intake of FV which differ in sensory properties have not been analysed. Examining the effects of lifetime exposure to variety of FV on general intake and intake of specific subgroups of FV might provide important information about the extent to which parents can facilitate acceptance of FV, also those least accepted and palatable, by a simple method of exposing children to various flavours of FV. Furthermore, past studies have measured FV intake as either the number of portions or the variety that is consumed. Both those factors have not been analysed in one study up to date, but contribute to different aspects of diet quality.

The aim of this study was to test if children who have been exposed to fewer FV types across their lifespan are reported to eat fewer FV portions and fewer types of different FV in the preceding 24 hours. Links between lifetime exposure to variety of FV and 24hour intake were tested separately for lifetime exposure to variety of fruit, vegetables and FV overall, and separately for intake of fruit, vegetables, cruciferous vegetables and astringent fruit. It was therefore hypothesised that higher lifetime exposure to variety of FV flavours will be related to higher 24hour intake of FV portions and higher 24hour variety of FV eaten. Finally, the study aimed to establish the amount of variance in children's 24hour FV intake of portions and variety consumed that could be explained by unique contribution of lifetime exposure to variety of FV.

3.3 Methodology

3.3.1Participants

The participants of this study were 99 children (50 boys and 49 girls) between 5 and 9 years old. Details on study procedure and participants are summarised in Chapter II. The mean age of children in the sample was M=7.20 (SD=1.31) years old. Parental mean age was 38.91 (SD= 9.52) years old. For simplification, data of primary care givers will be referred to as parental data.

3.3.2 Materials

3.3.2.1 Fruit and Vegetables

FV consumption over the past 24 hours was reported by the parents (see Appendix A-12). Data on both the number of portions and variety of FV have been collected for both parents and children. Detailed description of the questionnaire is presented in Chapter II.

3.3.2.2 Lifetime exposure to variety of FV

In the questionnaire measuring FV intake the parents were requested to mark all of the products that their child and themselves have never eaten before (see Appendix A-12). The number of FV never consumed was taken as a measure of total exposure to FV variety (all FV counted together), fruit variety exposure (only the number of fruit never tried) and vegetable variety exposure (only the number of vegetables never tried). As the parents marked FV that the child has never tried, the number of products marked by the parent was conceptualised as the measure of lifetime exposure to FV variety, and as such after summing them up, higher scores of products never tried represented lower exposure to variety.

3.3.2.3 Sensory sensitivity

To assess general sensory sensitivity of a child, parents were asked to complete 3 facets of the Short Sensory Profile (SSP; Dunn, 1999; see Appendix A-7) testing the child's tactile, visual/auditory and taste/smell sensitivity. Higher scores correspond to more typical sensory processing. A detailed description of the questionnaire is presented in Chapter II.

3.3.2.4 Adiposity

Children's adiposity was expressed as BMI centiles (see Chapter II for details on measurement and conversion procedure).

3.4 Results

3.4.1 Descriptive results and evaluation of covariates

24hour intake of portions and variety of FV were analysed for both children and parents. Additional preliminary analyses were conducted to test possible links between various sample characteristics, exposure and intake to identify possible covariates.

3.4.1.1 Intake in portions

Data on 24hour FV intake of children and their parents were collected from week days (72.7%) or weekends (27.3%) but no differences in the mean intake of fruit (Mann-Whitney U; $U=802.5$ $p>0.05$) or vegetables ($U=810.5$, $p>0.05$) were found between those two groups. There was a surprisingly large range of reported FV intake (between 0-27 portions). It was assumed that the parents over-reported the number of portions of FV consumed by their children and participants who scored more than 3 SD from the median were excluded from the analyses (n=3), decreasing the reported range to 0-17 portions (method adapted after Baranowski et al., 2012). Mean 24hour intake of FV of children and parents and the relationships between them, are reported in Table 3.1, and did not show normal distribution (KS; $p<0.05$).

There were moderate to strong relationships between child's and parental FV intake in portions, and therefore parental FV intake will be controlled for in inferential analyses of portions. There were no gender differences in 24hour intake of portions of FV, or their subdivisions (for details see Appendix B-1).

Table 3.1 . Mean number of portions and SE (in brackets) of fruit and vegetables reported for the preceding 24 hours for parents and children, and the relationship between intake in the parent-child dyads (Spearman's rho).

	Child	Parent	Correlation (r) between parent and child
Fruit	2.68 (0.21)	3.17 (0.28)	0.27***
Astringent	0.58 (0.09)	0.52 (0.08)	0.48***
Non-astringent	2.09 (0.18)	2.65 (0.23)	0.21*
Juice	0.98 (0.1)	0.51(0.07)	0.23*
Vegetables	3.13 (0.28)	4.36 (0.40)	0.56***
Cruciferous	0.46 (0.08)	0.61 (0.10)	0.64***
Non-cruciferous	2.67 (0.25)	3.75 (0.35)	0.54***
FV (total)	5.82 (0.40)	7.54 (0.54)	0.48***

*<0.05 ; **<0.01; ***<0.001

Next, the child's 24hour FV intake in portions was correlated with child's age, BMI centiles and parental age (Table 3.2). Child's age was positively related to intake of astringent fruit and child's BMI centiles were positively related to intake of fruit juice. Inferential analyses on intake of fruit juice and astringent fruit will be adjusted for child's BMI centiles and age respectively.

Table 3.2. Relationship between child's 24hour FV intake and various sample characteristics (Spearman's rho).

	Child's age	Child's BMI centiles	Maternal age
Fruit	.06	-.19	-.12
Astringent	.25*	-.01	.03
Non-astringent	-.06	-.18	-.12
Juice	.14	.22*	-.12
Vegetables	.20	-.05	-.03
Cruciferous	.06	-.06	-.10
Non-cruciferous	.20	.01	-.01
FV (total)	.17	-.12	-.09

**p<0.05*

3.4.1.2 Intake in variety

Exclusion criteria for over-reported portions of FV applied in the previous analysis of intake of portions were not applied in the analyses of 24hour intake of variety, as there did not seem to be any unrealistic quantities reported (see Figure 3.1). Mean values of 24hour reported variety for children and their parents, and the relationship between them are presented in Table 3.3. 24hour variety of FV consumed did not show normal distribution (KS; $p<0.05$). There was a strong relationship between maternal and child's variety of FV consumed, and therefore maternal FV variety will be used as covariate in inferential analyses. There were no gender differences in 24hour variety of FV consumed (see Appendix B-2).

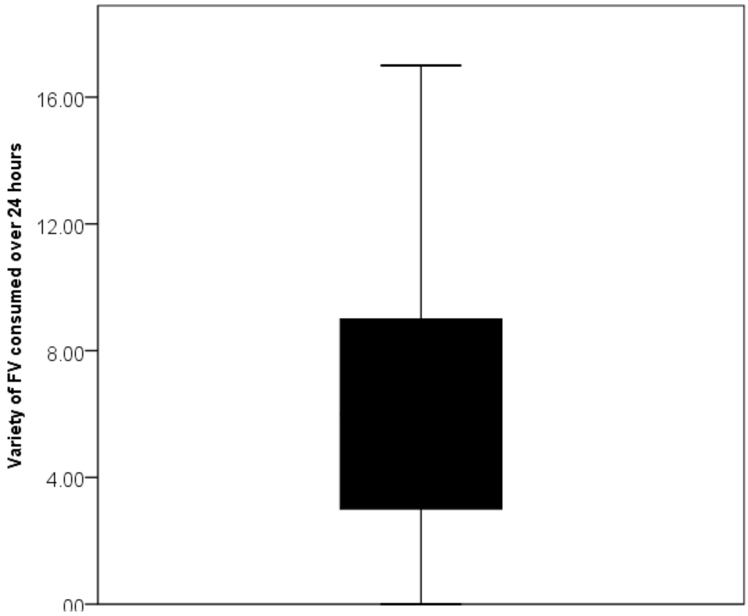

Fig. 3.1. Distribution of reported intake of variety of FV consumed by children in the last 24 hours.

Table 3.3 Mean reported variety (SE in brackets) of FV consumed over 24hour period by children and their parents, and the relationship between parental and child's consumed variety (Spearman's r).

	Child	Parent	Correlation (r)
Fruit	2.61 (0.19)	2.83 (0.23)	0.27***
Astringent	0.56 (0.07)	0.47 (0.07)	0.43***
Non-astringent	2.05 (0.16)	2.36 (0.19)	0.23*
Vegetables	3.29 (0.30)	4.37 (0.36)	0.59***
Cruciferous	0.54 (0.08)	0.60 (0.08)	0.57***
Non-cruciferous	2.70 (0.25)	3.77 (0.32)	0.59***
FV (total)	6.48 (0.41)	7.21 (0.50)	0.51***

****p<0.01, *p<0.05*

Next, variety of FV intake was correlated with sample characteristics (Table 3.4). Older children consumed a greater variety of FV, specifically astringent fruit and non-cruciferous vegetables. Therefore, child's age was used as a covariate in inferential analyses examining 24 hour FV (astringent fruit, vegetables and non-cruciferous vegetables) variety.

Table 3.4 . Relationship between variety of FV consumed over 24 hour period and sample characteristics (Spearman's rho).

	Child's age	Child's BMI centiles	Maternal age
Fruit	.08	-.18	-.12
Astringent	.25*	.01	.04
Non-astringent	-.04	-.18	-.13
Vegetables	.24*	.01	-.01
Cruciferous	.04	-.01	-.10
Non-cruciferous	.23*	-.02	-.02
FV	.22*	-.05	-.11

*p<0.05

3.4.1.3 Exposure to FV variety

Exposure to FV variety was measured as a number of FV types the child has never tried, so higher values indicate lower exposure. Five children were excluded from the analyses as exposure to variety data were missing. The reported number of FV that the child had never tried ranged between 0 and 93 out of the possible 122 (M=32.24, SD=20.13). For fruit specifically, the range was between 0 and 53 (M=17.58, SD=11.33) and for vegetables between 0 and 40 (M=14.66, SD=10.53). Exposure to FV variety showed a normal distribution (KS; p>0.05). Figure 3.2 depicts the distribution of data.

Seven parents were excluded as their exposure data were missing. The parental lifetime exposure to FV variety ranged between 0 and 68 (M=8.71, SD=11.72). The number of fruit the parent has never tried ranged between 0 and 43 (M=4.76, SD=7.51) and vegetables between 0 and 25 (M=3.95, SD= 4.96). Parental exposure to FV variety did not show normal distribution (KS; p<0.05). Figure 3.3 depicts the distribution of data.

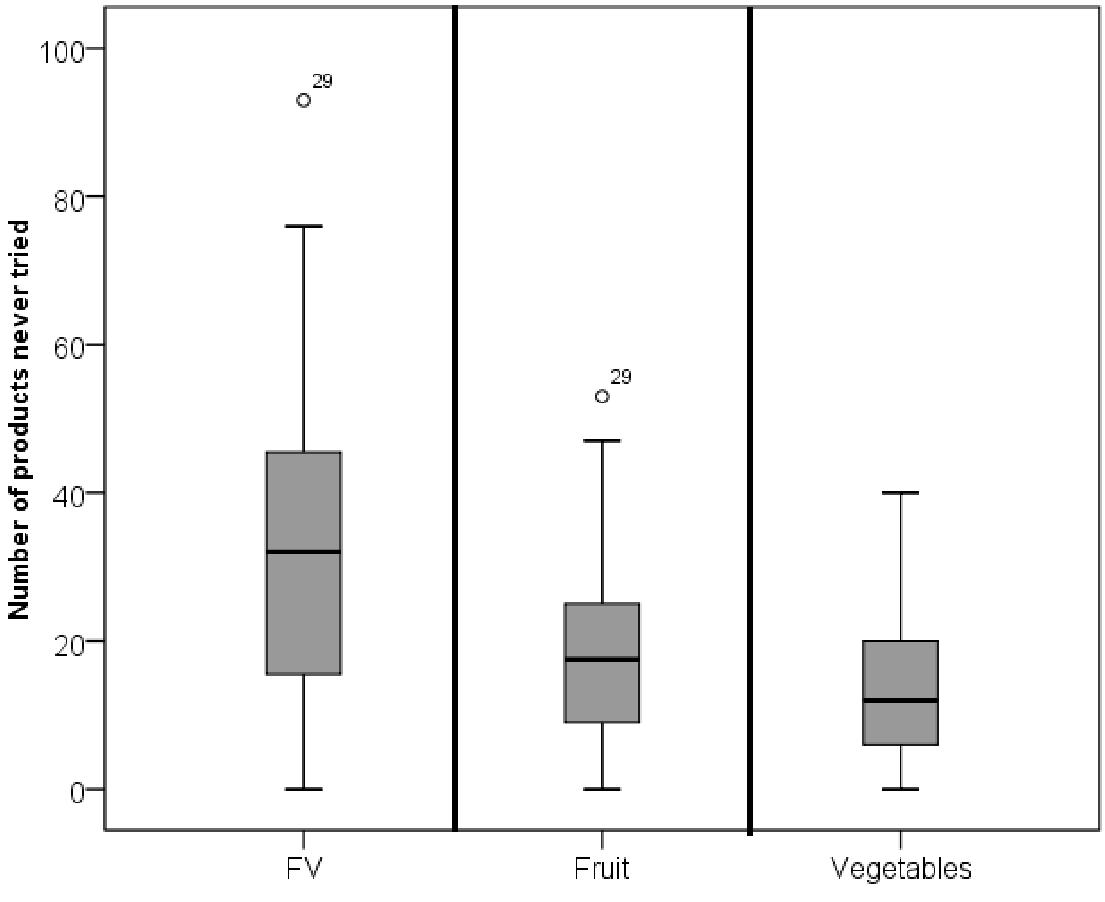

Fig.3.2 Distribution of data indicating lifetime exposure to FV variety among the children.

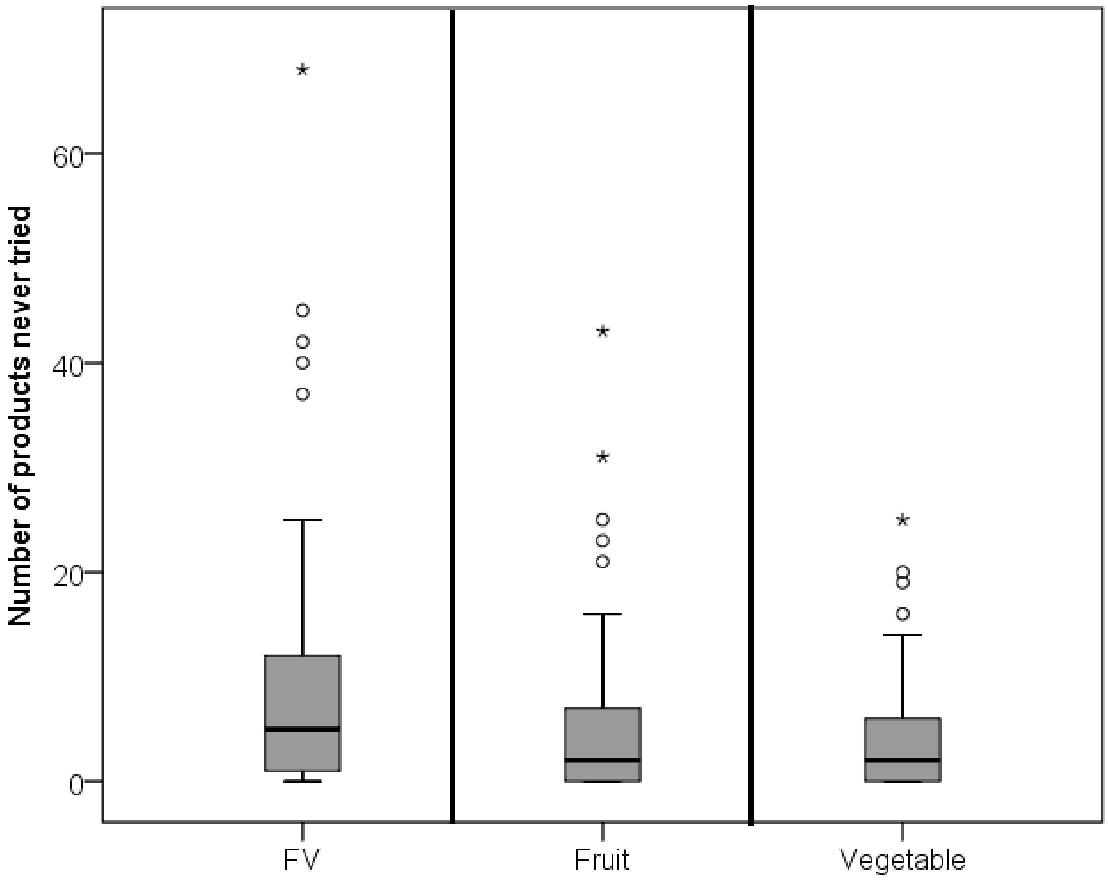

Fig. 3.3 Distribution of data indicating lifetime exposure to FV variety among the parents.

Child's and parental lifetime exposure to FV variety were then correlated. The results showed strong relationships between parental lifetime exposure to FV variety and child's lifetime exposure to FV variety (Pearson's r; $r=0.57$, $p<0.001$), parental and child's lifetime exposure to variety of fruit ($r=0.60$, $p<0.001$) and parental and child's lifetime exposure to variety of vegetables ($r=0.49$, $p<0.001$). As the relationship between the child's and parental lifetime exposure to FV variety showed strong association, parental lifetime exposure to FV variety will be used as a covariate in the inferential analyses.

Boys (M=37.55, SD=19.58) were exposed to fewer FV types than girls (M=27.53, SD=19.87; t=2.37, df= 85, p=0.020). There was a non-significant trend for gender differences in lifetime exposure to variety of vegetables (t=1.84, df= 85, p=0.069) and significant differences were found in lifetime exposure to variety of fruit (t=2.54, df= 85, p=0.013). The average lifetime exposure to variety of vegetables for boys was M=17.05 (SD=10.19) vegetables never tried and for girls M=12.88 (SD=10.87) vegetables never tried. The average lifetime exposure to variety of fruit for boys was M=20.50 (SD=10.89) fruit never tried and for girls was M=14.65 (SD=10.62) fruit never tried. Lifetime exposure to FV variety was not correlated with maternal age, child's age or child's BMI centiles (see Table 3.5).

Table 3.5 Relationship between lifetime exposure to FV variety and sample characteristics (Pearson's r).

	FV	Fruit	Vegetables
Child's age	-.06	-.06	-.06
Child's BMI centiles	.01	-.02	.02
Maternal age	-.08	-.18	.04

3.4.1.4 Sensory sensitivity

Sensory sensitivity in taste/smell (M=15.95, SE=0.45), tactile (M=30.43, SE=0.39) and audio/visual domains (M=21.92, SE=0.27) were analysed as control measures. Sensory sensitivity was not correlated with child's age, child's BMI centiles or maternal age (see Appendix B-3 for details).

Boys and girls did not differ in sensory sensitivity in taste/smell (t=-1.16, df=89, p=0.248), tactile (t=-0.92, df= 90, p=0.361) or audio/visual domain (t=-0.91, df=90, p=0.365). Correlations examining the relationship between child's sensory sensitivity and lifetime exposure to FV variety were not significant (see Table 3.6).

Table. 3.6 Relationship between sensory sensitivity and child's exposure to FV variety (Pearson's r).

Exposure	Taste/smell	Tactile	Audio/Visual
FV	-.11	-.02	-.15
Fruit	-.02	-.01	-.09
Vegetables	-.19	-.03	-.20

Next, sensory sensitivity was correlated with 24hour intake of portions and variety of FV consumed. The results are presented in Table 3.7. Children with more typical taste sensitivity showed higher intake of both portions and variety of vegetables, particularly of the non-cruciferous subtype. The overall 24hour intake of portions and variety of FV was also higher in children with more typical taste sensitivity. Tactile and audio/visual sensitivity did not show significant relationships with 24hour intake of FV. For that reason taste sensitivity will be used as covariate in analyses examining 24hour intake of portions and variety of FV, vegetables and non-cruciferous vegetables.

Table 3.7 Relationship between children's sensory sensitivity and intake (portions and variety) over the last 24 hours (Spearman's rho).

		Sensory sensitivity		
		Taste	Tactile	Audio/Visual
Number of portions	Fruit	0.14	0.04	0.09
	Astringent	0.13	-0.01	0.19
	Non-astringent	0.13	0.01	0.05
	Juice	-0.15	0.06	0.05
	Vegetables	0.28**	0.02	0.19
	Cruciferous	0.07	0.03	0.02
	Non-cruciferous	0.29**	-0.12	0.19
	FV Total	0.28**	0.06	0.17
Variety	Fruit	0.12	-0.01	0.04
	Astringent	0.11	-0.04	0.12
	Non-astringent	0.12	-0.03	-0.03
	Vegetables	0.23*	0.06	0.12
	Cruciferous	0.09	-0.16	0.02
	Non-cruciferous	0.24*	-0.03	0.13
	FV Total	0.20*	-0.05	0.12

*p<0.05, **p<0.01

3.4.2 Inferential analyses

Next, a series of analyses were conducted to test the hypotheses. Covariates identified in the preliminary analyses were used for statistical adjustments, and these are listed immediately before analyses.

3.4.2.1 Relationship between lifetime exposure to FV variety and 24hour intake of FV portions

To test the hypothesis that lifetime exposure to FV variety is correlated with 24hour intake of portions of FV, partial correlations were conducted. Lifetime exposure to FV variety and exposure to variety of fruit and vegetables separately were correlated with 24 hour intake of portions of FV overall and subdivisions of FV. The control variables were: maternal lifetime exposure and maternal FV intake for all analyses, BMI centiles for analysis of juice intake, child's age for analysis of astringent fruit intake, and taste sensitivity for analysis of FV, vegetable and non-cruciferous vegetables intake.

The results showed that children who were exposed to fewer types of FV consumed fewer portions of vegetables in the preceding 24hour, especially of the non-cruciferous type. They also consumed fewer portions of FV in general. Lower lifetime exposure to FV variety was not linked to lower intake of portions of fruit.

Furthermore, when the effects of lifetime exposure to FV variety were analysed separately for fruit and vegetables, it emerged that lower lifetime exposure to variety of fruit was not linked with 24hour intake of fruit portions. Intake of juice was not associated with exposure to variety of FV. Lower lifetime exposure to variety of vegetables was not linked with intake of vegetables (see Table 3.8).

3.4.2.2 Relationship between lifetime exposure to variety of FV and 24hour intake of FV variety

To test the hypothesis that lifetime exposure to variety of FV is correlated with variety of FV consumed, a series of partial correlations were conducted. Lifetime exposure to variety of FV was measured as exposure to FV types overall, and exposure to variety of fruit and vegetables separately. Similarly, 24hour variety of FV consumed was measured as overall FV variety and as separate counts of consumption of fruit, vegetables and their subdivisions. The control variables were: maternal exposure and maternal FV intake for all analyses, child's age for analysis of FV, astringent fruit, vegetables and non-cruciferous vegetables, and taste sensitivity for analysis of FV, vegetable and non-cruciferous vegetables intake.

The results showed that children who were exposed to fewer types of FV consumed less variety of fruit, vegetables, especially the non-cruciferous type, and less variety of FV in general, in the preceding 24 hours.

Further, when the effects of lifetime exposure to FV variety were analysed separately for fruit and vegetables, the same pattern emerged indicating that those children who in their lifetime were exposed to fewer types of fruit ate lower variety of fruit in the preceding 24 hours. Similarly for vegetables, those children who in their lifetime were exposed to fewer types of vegetables, ate fewer types of vegetables in the preceding 24 hours. Intake of astringent, non-astringent fruit, fruit juice and cruciferous vegetables did not show any associations with lifetime exposure to FV in general, and measures separately for fruit and for vegetables (see Table 3.8).

Table 3.8 Relationship between lifetime exposure to FV and 24 hour intake of portions and variety of FV in children.

	Intake	Lifetime exposure to variety FV	Fruit	Vegetables
Portions	Fruit	-.21	-.17	–
	Astringent	-.13	-.15	–
	Non-astringent	-.17	-.12	–
	Juice	.02	.02	–
	Vegetables	-.27*	–	-.15
	Cruciferous	-.10	–	-.05
	Non-cruciferous	-.28*	–	-.16
	FV	-.32***	–	–
Variety	Fruit	-.23*	-.24*	–
	Astringent	-.16	-.21	–
	Non-astringent	-.17	-.16	–
	Vegetables	-.33***	–	-.24*
	Cruciferous	-.14	–	-.10
	Non-cruciferous	-.26*	–	-.14
	FV	-.33***	–	–

*p<0.05 ***p<0.01

Note *The relationships which did not have theoretical merits based on past research were not tested and are indicated by -.*

3.4.2.3 Regression analyses of intake in portions

Correlational analyses revealed that 24hour intake of portions of fruit was not associated with lifetime exposure to variety of fruit, and 24hour intake of portions of vegetables was not associated with lifetime exposure to variety of vegetables. Overall exposure to FV variety was however linked to both intake of portions of vegetables and intake of FV overall. For that reason further regression analyses predicting intake of portions of FV were conducted with the predictor of lifetime exposure to overall variety of FV, which was the most consistent correlate of intake in the correlational analyses. Separate lifetime exposure to variety of fruit and vegetables was not analysed as it did not show many significant links with 24 hour intake. Lifetime exposure to overall FV diversity was used as a predictor of portions of the overall 24hour FV intake, and 24hour intake of fruit, vegetables and non-cruciferous vegetables.

FV intake in portions

Hierarchical regression analyses were conducted in order to establish the amount of variance in intake of portions of FV which could be explained by lifetime exposure to variety of FV. Four regression analyses were conducted, separately for 24hour intake of fruit and vegetables, non-cruciferous vegetables and for FV intake overall. In step 1 the predictors entered were parental 24hour FV intake, parental lifetime exposure to variety of FV and taste sensitivity. In step 2 child's lifetime exposure to FV variety was entered. For all four regressions the parameters of collinearity were met (VIF within acceptable limits).

3.4.2.3.1 Portions of FV

The results revealed that at step 1 the predictor variables explained 25.9% of variance in FV intake ($F(3,81)=10.41, p<0.001$). At step 2 introducing the new variable of lifetime exposure to FV variety to the model added significantly to the model, and explained an additional 6.8% of the variance ($p<0.01$). Overall, the model explained 32% of variance in FV intake in children ($F(4,81)=10.54$, $p<0.001$). The strongest predictor in the model was parental intake followed by child's lifetime exposure to FV. See Table 3.9 for details.

Table 3.9. Results of a hierarchical regression predicting 24hour intake of portions of FV from parental intake of FV, parental lifetime exposure to FV variety, child's taste sensitivity and child lifetime exposure to FV variety.

	B	SE B	Beta	T	P	ΔR^2	Adjusted R^2
Step 1						0.286***	0.259
(Constant)	1.13	1.59		0.71	0.481		
Parental intake	0.31	0.07	.43	4.42	0.0001		
FV exposure (p)[a]	-.03	0.03	-0.11	-1.10	0.273		
Taste sensitivity	.20	0.01	.22	2.24	0.028		
Step 2						0.068***	0.320
(Constant)	3.08	1.67		1.85	0.069		
Parental intake	0.31	0.07	0.44	4.66	0.0001		
FV exposure (p)[a]	0.02	0.04	0.08	0.68	0.499		
Taste sensitivity	0.18	0.09	0.19	2.07	0.041		
Exposure FV (ch)[a]	-0.06	0.02	-0.32	-2.84	0.006		

Note ch= child; p=parent; [a]=Exposure to variety of FV

3.4.2.3.2 Portions of fruit

A second hierarchical regression analysis was conducted with two steps and the dependent variable of 24hour intake of portions of fruit. The results are presented in Table 3.10. The results revealed that at step 1 the predictor variables explained 13.7% of variance in fruit intake ($F(3,81)=4.12$, $p=0.009$). At step 2 introducing lifetime exposure to FV variety to the model explained an additional 3.6% of the variance however the addition of lifetime exposure to FV variety did not improve the model significantly ($F(4,81)=3.32$ $p=0.072$). The overall model explained 17.2% of variance in child 24hour intake of fruit, with parental 24hour FV intake being the only significant predictor in the model.

Table 3.10. Results of a hierarchical regression predicting child's 24hour intake of portions of fruit from parental intake of FV, parental lifetime exposure to FV variety, child's taste sensitivity and child's lifetime exposure to FV variety.

	B	SE B	Beta	T	P	ΔR^2	Adjusted R^2
Step 1						0.137***	0.137
(Constant)	2.13	0.94		2.26	0.027		
Parental intake	0.09	0.04	0.22	2.05	0.044		
FV exposure (p)[a]	-0.04	0.02	-0.24	-2.22	.029		
Taste sensitivity	0.03	0.05	0.06	0.59	0.544		
Step 2						0.036[a]	0.172
(Constant)	2.89	1.02		2.84	0.006		
Parental intake	0.09	0.04	0.22	2.11	0.038		
FV exposure (p)[a]	-0.02	0.02	-0.11	-0.81	0.420		
Taste sensitivity	0.02	0.05	0.05	0.44	0.665		
FV exposure (ch)[a]	-0.02	0.01	-0.23	-1.82	0.072		

a $\Delta F= 0.072$; p= parent; ch=child; a= Exposure to variety

3.4.2.3.3. Portions of vegetables

The third hierarchical regression analysis was conducted with two steps and the dependent variable of child's 24hour vegetable intake in portions. The results revealed that at step 1 the predictor variables explained 25.7% of variance in child's 24hour vegetable intake ($F(3,81)=8.98, p<0.001$). At step 2 introducing lifetime exposure to variety of FV to the model explained an additional 4.6% of the variance. Overall, the model significantly improved with an addition of child's lifetime exposure to FV variety and explained 30.3% of variance in vegetable intake in children ($F(4,81)=8.38$, $p<0.001$). The strongest predictor of children's vegetable intake was parental 24hour FV intake. See Table 3.11 for details.

Table 3.11. Results of a hierarchical regression predicting child's 24hour intake of portions of vegetables from parental intake of FV, parental lifetime exposure to FV variety, child's taste sensitivity and child's lifetime exposure to FV variety.

	B	SE B	Beta	T	P	ΔR^2	Adjusted R^2
Step 1						0.257***	0.257
(Constant)	-1.00	1.19		-084	0.404		
Parental intake	0.23	0.05	0.43	4.27	0.0001		
FV exposure (P) [a]	0.01	0.02	0.03	0.28	0.777		
Taste sensitivity	0.16	0.06	0.25	2.52	0.014		
Step 2						0.046*	0.303
(Constant)	0.19	1.23		0.15	0.881		
Parental intake	0.23	0.05	0.43	4.14	0.0001		
FV exposure (P) [a]	0.04	0.03	0.18	1.53	0.129		
Taste sensitivity	0.15	0.07	0.23	2.37	0.020		
FV exposure (ch) [a]	-0.04	0.02	-0.27	-2.23	0.026		

P= parent; ch= child; a= Exposure to variety

3.4.2.3.4. Portions of non-cruciferous vegetables

Finally, the last hierarchical regression analysis was conducted with two steps and the dependent variable of child's 24hour non-cruciferous vegetable intake in portions. The results revealed that at step 1 the predictor variables explained 23.2% of variance in child's non- cruciferous vegetable intake ($F(3,81)=7.84, p<0.001$). At step 2 introducing the new variable of lifetime exposure to FV variety to the model explained an additional 4.8% of the variance. Overall, the model significantly improved with an addition of child's lifetime exposure to FV variety and explained 28.0% of variance in 24hour non-cruciferous vegetable intake in children ($F(4,81)=7.48$, $p<0.001$). The strongest predictor of children's 24hour non-cruciferous vegetable intake was parental FV intake. See Table 3.12 for details.

Table 3.12. Results of a hierarchical regression predicting 24hour intake of portions of non-cruciferous vegetables from parental intake of FV, parental lifetime exposure to FV variety, child's taste sensitivity and child's lifetime exposure to FV variety.

	B	SE B	Beta	T	P	ΔR^2	Adjusted R^2
Step 1						0.232***	0.202
(Constant)	-0.76	1.05		-0.72	0.472		
Parental intake	0.17	0.46	.38	3.72	0.0001		
FV exposure (p) [a]	-0.01	.02	-0.03	-0.28	0.787		
Taste sensitivity	0.15	0.06	0.25	2.54	0.013		
Step 2						0.048*	0.242
(Constant)	.29	1.12		.26	.797		
Parental intake	.17	0.05	.38	3.85	0.0001		
FV exposure (p) [a]	-0.03	0.24	0.13	1.07	.289		
Taste sensitivity	.14	0.06	0.23	2.39	0.19		
FV exposure (ch) [a]	-0.3	.01	-0.27	-2.27	0.026		

Note ch= child; p= parent; a= Exposure to variety

3.4.2.3.5 Intake in portions: summary

In summary, child's lifetime exposure to FV variety was a significant predictor of 24hour intake of portions of FV. Adding the variable of lifetime exposure to FV variety significantly improved the model for predicting child's 24hour intake of portions of FV overall, and separately for vegetables and non-cruciferous vegetables. In contrast, lifetime exposure to FV variety accounted for little variance in 24hour intake of portions of fruit and addition of this variable to the model failed to significantly improve it. Across all four regressions parental FV intake was the strongest predictor of children's 24hour intake of portions of FV, followed by child's lifetime exposure to FV.

3.4.2.3.6 Regression analyses of 24hour variety of FV intake

Next, four hierarchical regressions were conducted in order to establish the amount of variance in 24hour variety of FV consumed, which can be explained by children's lifetime exposure to FV variety. The regression outcomes were 24hour variety of FV overall, and separate variety of fruit, vegetables and non-cruciferous vegetables. In step 1 the covariates identified in the earlier analyses were entered and these were parental 24hour variety of FV, parental lifetime exposure to FV variety, taste sensitivity and child's age. In step 2 child's lifetime exposure to FV variety was entered.

3.4.2.3.7 Variety of FV overall

In the first hierarchical regression, variety of total FV consumed by the child in the last 24 hours was the measurement outcome.

The results showed that at step 1, the predictor variables explained 32.7% of variance in child 24hour variety of FV ($F(4,85)=9.84$, $p<0.001$). At step 2 introducing lifetime exposure to FV variety to the model explained an additional 9.0% of variance. Overall, the model significantly improved with an addition of lifetime exposure to FV variety and explained 41.7% of variance in variety of FV intake in children ($F(5,81)=11.44$, $p<0.001$). The strongest predictor of variety of FV intake in children was parental consumption, followed closely by lifetime exposure to FV variety. See Table 3.13 for details.

Table 3.13. Results of a hierarchical regression predicting 24hour intake of variety of FV from parental variety of FV consumed, parental lifetime exposure to FV variety, child's taste sensitivity and age, and child's lifetime exposure to FV variety.

	B	SE B	Beta	T	P	ΔR^2	Adjusted R^2
Step 1						0.327***	0.327
(Constant)	-0.84	2.40		-0.04	0.972		
Parental intake	0.37	0.08	0.47	4.93	0.0001		
FV exposure (P) [a]	-0.04	0.03	-0.11	-1.16	0.251		
Taste sensitivity	0.10	0.08	0.11	1.23	0.223		
Child's age	0.39	0.28	0.13	1.40	0.166		
Step 2						0.090***	0.417
(Constant)	2.06	2.33		0.88	0.388		
Parental intake	0.39	0.07	0.50	5.48	0.0001		
FV exposure (P) [a]	0.04	0.04	0.10	0.97	0.333		
Taste sensitivity	0.09	0.08	0.10	1.14	0.259		
Child's age	0.38	0.27	0.13	1.45	0.152		
FV exposure (ch) [a]	-0.07	0.02	-0.37	-3.51	0.001		

P= parent; ch= child; a= Exposure to FV variety

3.4.2.3.8 Variety of fruit

Next, a similar analysis was performed, but the dependent variable was variety of fruit consumed by the child in the last 24 hours. The results showed that at step 1, the predictor variables explained a total of 20.3% of variance in child 24hour variety of fruit ($F(4,85)=5.14$, $p=0.001$). At step 2 introducing lifetime exposure to FV variety to the model explained an additional 4.6% of the variance. Overall, the model significantly improved with an addition of lifetime exposure to FV variety and explained 24.9% of variance in variety of fruit intake ($F(5,85)=5.30$, $p<0.001$), with parental intake and child's lifetime exposure to FV variety as significant predictors (Tab. 3.14)

Table 3.14. Results of a hierarchical regression predicting 24hour intake of variety of fruit from parental variety of FV consumed, parental lifetime exposure to FV variety, child's taste sensitivity and age, and child's lifetime exposure to FV variety.

	B	SE B	Beta	T	P	ΔR^2	Adjusted R^2
Step 1						0.203***	0.203
(Constant)	1.25	1.20		1.05	0.299		
Parental intake	0.11	0.04	0.31	2.96	0.004		
FV exposure (P) [a]	-0.04	0.02	-0.24	-2.38	0.020		
Taste sensitivity	0.010	0.04	0.01	0.12	0.905		
Child's age	0.12	0.14	0.09	0.88	0.383		
Step 2						0.046*	0.249
(Constant)	1.95	1.21		1.61	0.111		
Parental intake	0.12	0.04	0.32	3.17	0.002		
FV exposure (P) [a]	-0.01	0.02	-0.09	-0.75	0.457		
Taste sensitivity	0.01	0.04	0.01	0.01	0,989		
Child's age	0.12	0.14	0.09	0.87	0.387		
FV exposure (ch) [a]	-0.03	0.01	-0.26	-2.22	0.030		

P= parent; ch= child; a= Exposure to FV variety

3.4.2.3.9 Variety of vegetables

Next, the dependent variable was variety of vegetables consumed by the child in the last 24hours. The results showed that at step 1, the predictor variables explained a total of 22.5% of variance in variety of vegetables consumed ($F(4,85)=5.89$, $p<0.001$). At step 2 introducing lifetime exposure to FV variety to the model explained an additional 7.2% of the variance. Overall, the model significantly improved with an addition of lifetime exposure to FV variety and explained 29.7% of variance in variety of child 24hour vegetable intake ($F(5,85)=6.74$, $p<0.001$), with parental intake and child lifetime exposure to FV variety being the only significant predictors. See Table 3.15 for details.

Table 3.15. Results of a hierarchical regression predicting 24hour intake of variety of vegetables from parental variety of FV consumed, parental lifetime exposure to FV variety, child's taste sensitivity and age, and child's lifetime exposure to FV variety.

	B	SE B	Beta	T	P	ΔR^2	Adjusted R^2
Step 1						0.225***	0.225
(Constant)	-1.77	1.99		-0.89	0.378		
Parental intake	0.24	0.06	0.38	3.74	0.0001		
FV exposure (P) [a]	-0.01	0.03	-0.02	-0.25	0.806		
Taste sensitivity	0.12	0.07	0.17	1.72	0.090		
Child's age	0.23	0.23	0.10	0.98	0.330		
Step 2						0.072***	0.297
(Constant)	-0.29	1.98		-0.14	0.886		
Parental intake	0.25	0.06	0.41	4.10	0.0001		
FV exposure (P) [a]	0.04	0.03	0.17	1.43	0.162		
Taste sensitivity	0.11	0.07	0.16	1.65	0.103		
Child's age	0.22	0.22	0.10	0.99	0.327		
FV exposure (ch) [a]	-0.05	0.02	-.33	-2.85	0.005		

P= parent; ch= child; a= Exposure to FV variety

3.4.2.3.10 Variety of non-cruciferous vegetables

Finally, the dependent variable was child's 24hour variety of non-cruciferous vegetables consumed. The results showed that at step 1, the predictor variables explained a total of 25.0% of variance in variety of vegetables consumed by the children ($F(4,81)=6.42$, $p<0.001$). At step 2 introducing lifetime exposure to FV variety to the model explained an additional 4.7% of the variance. Overall, the model significantly improved with an addition of lifetime exposure to FV variety and explained 29.7% of variance in variety of vegetable intake ($F(5,81)=6.42$, $p<0.001$), with parental intake and child's lifetime exposure to variety of FV being the only significant predictors (Tab 3.16).

Table 3.16. Results of a hierarchical regression predicting 24hour intake of variety of non-cruciferous vegetables from parental variety of FV consumed, parental lifetime exposure to FV variety, child's taste sensitivity and age, and child's lifetime exposure to FV variety.

	B	SE B	Beta	T	P	ΔR^2	Adjusted R^2
Step 1						0.250***	0.211
(Constant)	-2.59	1.51		-1.71	0.092		
Parental intake	.16	0.05	0.34	3.28	0.002		
FV exposure (P) [a]	-0.01	0.02	-0.04	-0.44	0.664		
Taste sensitivity	0.11	0.06	0.20	2.03	0.046		
Child's age	0.34	0.18	0.19	1.90	.061		
Step 2						0.047*	0.251
(Constant)	-1.63	1.53		-1.06	.290		
Parental intake	.165	.05	.36	3.57	0.001		
FV exposure (P) [a]	0.02	0.02	0.11	0.94	0.351		
Taste sensitivity	0.10	0.05	0.18	1.84	0.068		
Child's age	0.34	0.17	0.19	1.94	0.055		
FV exposure (ch) [a]	-0.03	0.01	-.27	-2.24	0.028		

P= parent; ch= child; a= Exposure to FV variety

3.4.2.3.11 Variety of intake: summary

To summarise, child's lifetime exposure to FV variety was a significant predictor of variety of FV consumed by the children, also when fruit and vegetables were analysed as separate outcome variables. All four models improved significantly with the inclusion of lifetime exposure to FV variety as a predictor. Variety of parental intake was the single strongest contributor to the model followed by child's lifetime exposure to FV variety.

3.4.2.3.12 Summary of regression findings

A summary of regression findings is presented in Table 3.17. It is evident that child's lifetime exposure to FV is a significant contributor to variety of children's FV intake. Lifetime exposure to FV variety explains 24hour total intake of portions of FV and of vegetables, but the unique variance explained by child's lifetime exposure to FV variety on intake of fruit portions was too small to contribute significantly to the model.

Table 3.17 Summary of the regression analyses on 24hour intake of portions and variety of FV.

	Product	Variance explained by model	Unique contribution of exposure to FV variety	Model improved
Portions	Fruit	17.2%	3.6%	No
	Vegetables	30.3%	4.6%	Yes
	Non-cruciferous v.	28.0%	4.8%	Yes
	FV	32.0%	6.8%	Yes
Variety	Fruit	24.9%	4.6%	Yes
	Vegetables	29.7%	7.2%	Yes
	Non-cruciferous v.	29.7%	4.7%	Yes
	FV	41.7%	9.0%	Yes

3.5 Discussion

It was hypothesised that lower lifetime exposure to FV variety would be associated with lower 24hour intake of portions and variety of FV consumed by children. Further, the aim of this study was also to examine whether lifetime exposure to variety of FV would show different associations depending on product type i.e. explore associations with fruit, vegetables and specific groups within FV families such as astringent fruit and cruciferous vegetables. Another aim was to analyse whether exposure to only fruit or only vegetables shows any specific links with FV intake or whether the overall lifetime exposure to various types of FV is associated with intake. The final aim of this study was to establish the variance explained by children's lifetime exposure to FV variety in intake of portions and variety of FV, in models including other known correlates.

The results of this study partially supported the hypotheses. It was demonstrated that children exposed to fewer FV types across their lifetimes were reported to eat fewer portions of FV, and particularly vegetables of non-cruciferous type, in the preceding 24 hours. Interestingly, lifetime exposure to FV variety was not linked with portions of fruit consumed. Contrary to the past findings, lifetime exposure to variety of fruit was not linked with intake of portions of fruit and lifetime exposure to variety of vegetables was not linked with portions of vegetables consumed. It was also demonstrated that children exposed to fewer FV types were reported to consume a more narrow variety of FV, and especially non-cruciferous vegetables. Lifetime exposure to FV variety was shown to be a unique predictor of children’s intake of portions and variety of FV. The amount of variance explained by this contributor was small but consistent for variety of fruit, vegetables and FV in general. It was also small but consistent for portions of vegetables and FV in general, but did not explain intake of portions of fruit.

3.5.1 Lifetime exposure to FV variety and FV intake in portions

Different patterns emerged for exposure to total FV count, and when lifetime exposure was analysed separately for variety of fruit and variety of vegetables. As such, the results will be considered separately to allow detailed interpretation. A model representing the links between lifetime exposure to variety of FV and intake measured in portions is presented in Fig. 3.4.

In the present study, lifetime exposure to variety of FV, used as an index of overall history of exposure to plant based flavours, was associated with 24hour intake of portions of FV, intake of vegetables, particularly of the non-cruciferous type, but did not show significant links with portions of fruit consumed. Past research on the effects of lifetime exposure to variety of FV and intake in children is limited. However, past reports did show that increasing exposure to FV may reduce neophobia levels (Birch et al., 1987) and in this way may promote future acceptance of FV and also may lead to increased intake of specific flavours, at least in the short-term (Mennella et al., 2008).

In this study children who were exposed to more flavours of FV ate more portions of vegetables, especially the non-cruciferous type and in general showed higher 24 hour intake of FV. Interestingly, there was no link between lifetime exposure to FV variety and intake of fruit. We might speculate that intake of fruit would be less affected by exposure compared to vegetables, as fruit are commonly liked more than vegetables (Peracchio et al., 2012). The effects of exposure would be likely to be more differentiated for less palatable products, like vegetables, which was also shown in a study by Barends et al. (2014). Also surprisingly, children who were exposed to more FV flavours ate more non-cruciferous vegetables, but not the cruciferous type. Together those finding suggests that exposure to many different flavours of FV may have less of an effect on intake of highly palatable (fruit) or highly unpalatable (astringent fruit, cruciferous vegetables) flavours. Perhaps exposure to various flavours can make a difference of what could be described as the 'neutral' flavours i.e. non- cruciferous vegetables such as for example carrots. Because astringent fruit and cruciferous vegetables are unique in their sensory properties they may require different types of interventions, as they are inherently more difficult to promote among children, given that they are the least liked

(Jaeger et al., 2011; Bell and Tepper, 2006). Perhaps internal drivers of FV intake, such as bitterness or sweetness perception, play a more substantial role in intake of cruciferous vegetables, and are more difficult to overcome by mere exposure to variety. This issue deserves further attention and will be analysed in the subsequent chapters of this thesis.

The results of the regression analyses further showed that lifetime exposure to FV variety was a significant predictor of intake of FV in general and of vegetables, also the non-cruciferous type, but did not predict intake of fruit. Parental intake was the single strongest predictor of intake, followed by lifetime exposure to FV variety, which from the public health perspective is an important information for parents who want to improve their children's diet. What must be acknowledged is the fact that children with higher levels of neophobia or more fussy may be showing higher rejection rates, thus reducing the opportunities for higher exposure. Neophobia or fussiness levels were not measured in this study which is a limitation, however children with neophobia or characterised as fussy typically show higher taste/smell sensitivity levels and taste/smell sensitivity in this sample was not linked with FV exposure to variety.

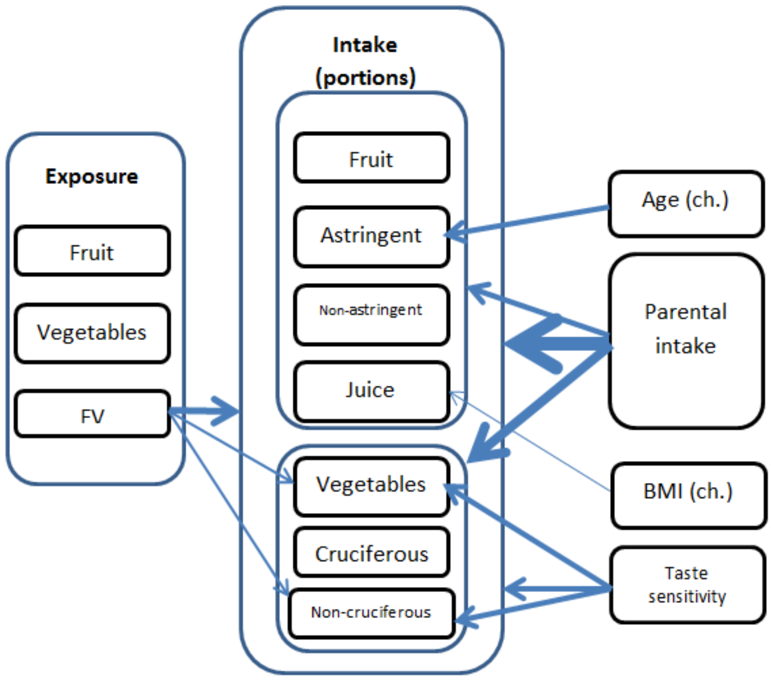

Fig. 3.4 A model representing the links between lifetime exposure to FV variety and children's 24hour intake of FV measured in portions. Thickness of the arrows represents the strength of the relationship.

3.5.2 Lifetime exposure to variety of fruit and variety of vegetables and intake in portions

Furthermore, when lifetime exposure to FV variety was separated into exposure to variety of fruit and vegetables as separate categories, it was evident that contrary to past literature, exposure to variety of fruit was not related to intake of portions of fruit, and exposure to variety of vegetables was not related to intake of portions of vegetables. The associations were also not found for subcategories of FV. Reinaerts et al. (2007) showed that exposure to variety of fruit was a predictor of intake of fruit and exposure to variety of vegetables was a predictor of vegetable intake, however the methodology in that study did not utilise an optimal measure of lifetime exposure to variety of FV, as lifetime exposure to only a limited number of products (29 items) was measured. The present study measured lifetime exposure with a more thorough method using a comprehensive list of locally available FV, which might explain differences in obtained results. In this study exposure was conceptualised as experience of a wide variety of different products and allowed for distinguishing between people with various levels of familiarity with many different or rarely consumed FV (e.g. Chinese cabbage or fresh figs). In Reinaerts et al. study, inclusion of only a small group of the most popular products did not allow for differentiation between people who ate a wide variety of non-popular products and those who only ate a high variety of popular products, inherently categorising them as the same group.

The results of the present study suggest that rather than focusing on exposure to variety of fruit and vegetables separately, the overall experience of variety of FV flavours seems to be related to intake of quantity of FV consumed by children. This is evident from the fact that, contrary to what would be expected based on past findings, exposure to variety of fruit did not correlate with portions of fruit consumed, and exposure to variety of vegetables did not correlate with portions of vegetables consumed. On the contrary, overall exposure to FV variety correlated with portions of vegetables and FV consumed. Therefore rather than looking at separate effects of fruit on intake of fruit, it seems more justified to look at the overall experience of flavour diversity on intake of FV. This is consistent with earlier research on exposure to flavours, which shows that children can generalise experience of flavours to other flavours, and exposing the child to a vegetable flavour of one kind may affect acceptance not only of that vegetable, but also of other vegetables with similar properties (Forestell & Mennella, 2007).

3.5.3 Lifetime exposure to FV variety and variety of FV consumed

Lifetime exposure to FV variety showed an even stronger association with intake of a greater variety of FV, compared to intake measured in portions. The relationship between lifetime exposure to FV variety and variety of FV consumed is represented in Fig 3.5. This shows that exposing children to a wide range of different FV may be associated with a greater acceptance of various fruit and vegetables and demonstrates as a more varied daily diet. In contrast to intake measured in portions, exposure to more types of fruit was linked with greater variety of fruit consumed. Also exposure to more types of vegetables was linked with variety of vegetables consumed. It seems that to increase children's intake of portions of FV, exposing them to diverse flavours of FV would suffice, while in order to promote acceptance of a wider range of either fruit or vegetables parents should expose children to flavours of similar type. Alternatively, what needs to be considered is the fact that variety of FV at home depends on the parents and so parents who do not provide the opportunities for intake of higher variety of FV will not have children who eat a varied diet. Lifetime exposure to diverse types of FV and variety of intake are likely to be related to home availability, which unfortunately was not measured in this study. This is an important limitation, as in order to fully understand the effects of lifetime exposure to variety of FV on FV intake, home availability should be controlled for and ideally tested for moderation effects on the link between lifetime exposure to FV variety and intake of FV.

As demonstrated by the results of regression analyses, the strongest model explaining the greatest amount of variance in 24 hour FV variety was the one in which FV were measured together. The weakest model explained intake of variety of fruit, similarly to regressions looking at intake in portions. Lifetime exposure to FV variety explained higher proportion of child 24hour variety of FV, than that of portions consumed. Again, only a small proportion of variance of variety of fruit intake was explained by exposure to FV variety, supporting the idea that what is liked is less affected by external factors.

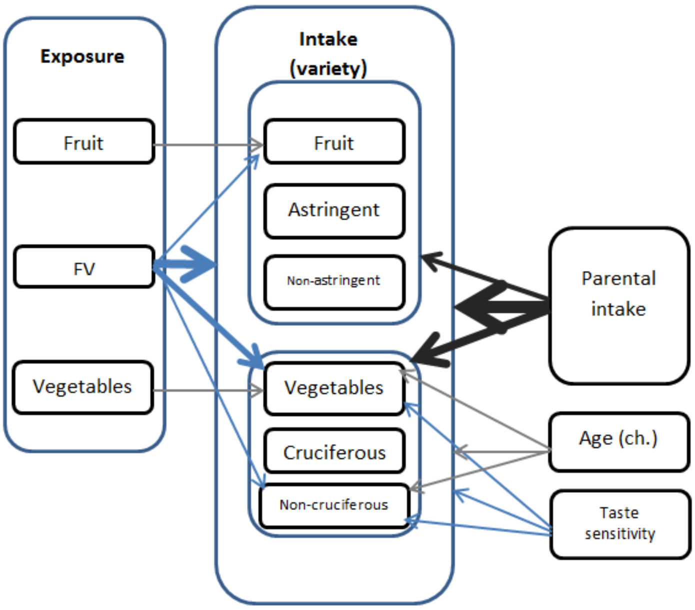

Fig.3.5 Model representing the relationship between exposure to FV variety and intake of variety of FV. Thickness of the arrows represents the strength of the association.

3.5.4. Limitations

This study had several limitations. Firstly, reported intake of FV seemed unusually high, indicating issues with the measure used. It seemed that parents inaccurately reported the number of portions that the child consumed, which resulted in higher intake data. Data on intake from a larger sample of days would provide a more reliable view of the actual diet and consideration should be given to using a food diary rather than a recall questionnaire given the possibility of inaccurate reports. Another limitation was lack of further control variables used, such as measurements of home availability or lack of more specific socio-demographic data. Also, the study would benefit particularly from a measure of child neophobia, as exposure data may have been affected by children's neophobia, because the fact the child never tried a given product may have resulted from their rejection or refusal to try the product, which may have been offered to them. This is particularly problematic given that in this particular sample, taste sensitivity was one of the correlates of FV intake. Also, in the future, it would be of great benefit to incorporate another measure of exposure and ask parents to mark separately the products the child never tried and the products that the child never tried but was offered. Also it would be beneficial to collect information on which products the child consumed on a regular basis and which were rarely consumed or which were tasted only once. Also information on the general diet of children would provide a more comprehensive evaluation of dietary patterns which may be related to exposure and intake of FV.

3.5.5 Summary

This study demonstrated that lifetime exposure to variety of FV is linked with children's intake of both portions and variety of FV. Lifetime exposure to different types of FV is a small but consistent contributor to intake of FV and explains additional variance over and above that explained by parental intake. Exposure to diverse FV explains intake of FV in general, and vegetables separately, but intake of fruit seems to be less dependent on lifetime exposure to different types of FV or their subcategories. Exposure to variety is also linked to intake of non-cruciferous vegetables, but cruciferous vegetables or astringent fruit intake did not show any associations with exposure variety. Similarly, fruit intake did not show associations with lifetime exposure to FV variety. The variety of FV consumed by children seems to show more substantial associations with exposure to FV variety, than the number of consumed portions. While causation cannot be implied from the results, data seems to be consistent with the idea that exposure to greater diversity of flavours predisposes to greater acceptance of flavours, particularly of vegetables. It was also suggested that highly liked flavours like fruits and highly disliked flavours like cruciferous vegetables or astringent fruit are less likely to be affected by exposure due to their strongly disliked sensory properties.

While lifetime exposure to FV variety seems to be linked with intake of FV, that contribution is small. Mere exposure to diverse flavours of FV is evidently important for intake of FV, but as demonstrated in this study, parental intake seems to be the stronger influence on children's intake of FV. Additional home environment variables need to be further considered to understand contribution of other family factors on intake of FV, such as for example parental feeding practices, which will be discussed in subsequent chapters of this thesis. Also individual differences in perception of FV flavours would provide more information why there is only a weak link between exposing children to diverse FV and their intake of FV. There were several limitations in this study, which are discussed in Chapter VII.

Chapter IV
Liking of fruit and vegetables and reported intake in toddlers. Do parental feeding practices moderate this relationship?

4.1 Abstract

This study examined the relationship between relative liking of FV, the use of selected parental feeding practices and 24hour intake of FV in toddlers. It was hypothesised that liking of FV would be correlated with intake of FV. It was also hypothesised that higher levels of teaching, involvement and encouragement of balance and variety (BV) would be associated with higher liking and intake of FV in children, while higher parental control would be associated with lower liking and intake of FV. Further, moderating effects of parental feeding practices on the relationship between liking and intake of FV were analysed. The results showed that while controlling for other internal and external factors, children's relative liking of fruit was linked to their intake of non-astringent fruit, and liking of vegetables was positively linked to intake of cruciferous vegetables. Parental control moderated the link between liking and intake of fruit. Parents with lower levels of control had children whose liking and intake of FV were positively associated. The remaining parental feeding practices did not moderate the relationship between liking and intake of FV.

4.2. Introduction

One of the external correlates previously analysed in the context of children's FV intake is family environment. A key element of the family environment are the parents, and not surprisingly one of the most researched and consistently reported correlates of children's FV intake is parental FV consumption (e.g. Coulthard and Blissett, 2009; Reinaerts et al., 2007; Bere & Klepp, 2004; Reinaerts et al., 2007b). This has also been supported by the results presented in the previous chapter.

While there is substantial evidence that child's and parental intake of FV are closely linked, less is known about the effects of parental feeding strategies on children's FV intake. Parents typically use a number of feeding strategies in order to introduce FV to children's diet (Blissett et al., 2012). While there is evidence that some of them are successful (e.g. non-food rewards; Horne et al. 2011), some have been also shown to be counterproductive (e.g. pressure; Galloway et al., 2006) and some have been relatively unexplored (e.g. teaching; Blissett et al., 2012). Parental control, as a feeding strategy, has in the past been shown to have a negative effect on child's eating behaviour, with children of the mothers who use more control over their children's feeding, consuming less FV (Birch, 1999). Still, authoritative feeding style characterised by moderate levels of parental control, has been linked with increased intake of FV (Patrick et al., 2005).

There are also some promising reports showing that involving children in meal planning and preparation may result in better diet quality and higher intake of FV (Chu et al., 2014; Gross et al., 2010), however this effect has not been directly researched in the population of toddlers. It has also been shown that teaching children about nutritional value of food or about healthy eating via hidden messages in storybooks (e.g. repeated reinforcing messages about an unknown vegetable added to a story plot) may aid novel food introduction (Byrne & Nitzke, 2002) or enhance intake of a known product (de Droog et al., 2014). However, research on the effects of teaching about healthy eating and nutritional value of FV has not been explored in great detail before, despite the fact that parents often spontaneously use teaching as a feeding strategy, which has been a successful method for aiding contact with a novel fruit (Blissett et al. 2012).

Musher-Eizenman and Holub (2007) created a feeding strategies questionnaire (Comprehensive Feeding Practices Questionnaire; CFPQ) in which they proposed a novel feeding strategy called Encouraging Balance and Variety (BV), which was suggested to aid intake of FV. This strategy is a combination of modelling the healthy behaviour and providing variety of healthy food options in the home environment. Effects of this feeding strategy have not been analysed in the past, but given the previously reported effects of both modelling (Blissett et al., Unpublished) and home availability (Pearson et al., 2008), it might show positive effects on intake of FV in toddlers.

For the majority of foods, the simple premise is that what is liked is consumed, and what is not liked is avoided. Certain external factors may alter this relationship, as even the liked things will not be consumed if they are not available at home, and certain disliked products might be consumed if the child is forced to consume them, or is offered a reward for eating (Blissett et al., 2012). Past research has shown that liking of FV predicts intake. Wind et al. (2006) showed that in school-age children, liking of FV, among other variables, significantly predicted their intake. However, in regression analysis, liking explained less variance in FV intake than availability (home and in social places). Chu et al. (2014) reported that children who liked a given fruit or vegetable were more likely to report eating it at least once a week, compared to children who reported dislike for that fruit or vegetable. Furthermore, Gibson, Wardle and Watts (1998) showed that children's vegetable liking was an independent predictor of vegetable consumption, which was not shown for fruit intake, for which maternal feeding practices and maternal consumption were better predictors. Feeney et al. (2014) showed that liking was the best predictor for cruciferous vegetable intake in children.

Interestingly, Hartvig et al. (2015) showed that intake is not necessarily related to liking. In their study on astringent juice liking and intake, they attempted to increase intake of astringent juices among children via repeated exposure. During the 6 month follow up they documented an increase in intake of the astringent juices, without an increase in liking. Subsequent analysis revealed that a minor increase in liking was evident for children who initially disliked the juices, however increases in intake among the initial likers or initially neutral children were not associated with increased liking. This study demonstrates that the relationship between liking and intake of FV is not as straightforward as intuitively might be considered. It should be noted that past studies examining liking and intake of FV focused on school-age children, so they cannot be generalised to toddlers. Furthermore, even though liking has been consistently shown to be a predictor of intake, variance explained by liking tends to be consistently small (Baranowski et al. 1999).

The concept of liking and particularly the measurement of liking is not without problems. Studies on liking and intake of FV have mainly focused on predicting intake of a particular fruit or vegetable, from liking of that particular fruit or vegetable (Chu et al., 2014). Furthermore, the concept of measuring individual differences in liking is also complicated, because liking is relative and depends on the individual's sensory world (Bartoshuk, 2004). Liking of any kind of products can be compared to a universal liking from a different sensory modality, in order to allow for comparison between participants with regards to the magnitude of the liking score (Bartoshuk, 2004), but this is still not a common practice.

As demonstrated above, past research showed that parental feeding practices may affect intake of FV in children. At the same time, there are mixed reports on the association between liking and intake of FV in children, and data from toddlers is scarce. For that reason the link between liking and intake of FV in toddlers should be analysed and further assessed in the context of parental feeding strategies. Perhaps parental feeding strategies alter the relationship between child's liking and intake of FV, which would explain why that link is not necessarily linear. The parental feeding practices that will be analysed are encouragement of BV, teaching and involvement, because little is known about these practices to date and there is no data from the population of toddlers. Also the effects of parental control will be examined to clarify its role in intake of FV. Furthermore, as within the FV family there are unique subgroups of products which are characterised by strong sensory properties, their intake should be analysed separately from the entire group of FV. For that reason, astringent and non-astringent fruit, and cruciferous and non-cruciferous vegetables will be examined separately.

The research questions that remain to be answered are whether relative liking of FV is correlated with 24hour intake of FV and intake of specific subgroups of FV; whether the use of parental feeding practices is associated with children's intake of FV and their subgroups; and whether parental feeding practices affect the relationship between relative liking and 24hour intake of FV in toddlers. Based on the past reports, it was hypothesised that children's relative liking of fruit will be correlated with 24hour intake of fruit and relative liking of vegetables will be correlated with 24hour intake of vegetables, but in accord with past reports these relationships are expected to be weak. It was also hypothesised that positive parental feeding practices such as encouragement of balance and variety, involvement and teaching will be positively correlated with intake of FV and parental control will be negatively linked to 24hour intake of FV. It is also hypothesised that parental feeding practices will moderate the relationship between children's liking and intake of FV. To be more precise, it is predicted that where parents employ high levels of teaching, involvement and encouragement of balance and variety, there will be a positive link between children's liking and intake of FV. Also it is predicted that for parents who show low levels of control, children's liking and intake of FV will be positively linked. Those analyses will be conducted while controlling for a number of possible covariates which in the past have been linked to liking and intake of FV.

4.3 Methodology

4.3.1 Participants

Data from 101 parents were used for the analyses. Information on recruitment and procedure is summarised in Chapter II. There were 41 girls and 60 boys with a mean age of M=29.4 (SD= 4.75) months. The data were reported by mothers, whose mean age was M=35.17 (SD=5.07) years.

4.3.2 Materials and Measures

4.3.2.1 PALS

PALS was used to examine liking of FV in the sample (Peracchio et al., 2012; see Appendix A-11). Details on the measure are summarised in Chapter II.

4.3.2.2 FV intake

Fruit and Vegetable intake of children and their parents was tested with a Guided One Day Dietary Recall measure (Robinson et al., 2011; see Appendix A-9). For details refer to chapter II.

4.3.2.3 Adiposity

Children's adiposity was expressed in BMI centiles and WHtR. Higher WHtR value is indicative of greater central adiposity. For details on measurement procedure and conversion refer to Chapter II.

4.3.2.4 Sensory sensitivity

To assess general sensory sensitivity of a child, parents were asked to complete the Short Sensory Profile questionnaire (SSP; Dunn, 1999; see Appendix A-7). For details refer to Chapter II. Higher scores indicate more typical processing.

4.3.2.5 Demographics questionnaire

A demographic questionnaire was used which asked about child's DOB, gender, breastfeeding, duration of exclusive breastfeeding, age of weaning, maternal age, maternal education and annual family income (see Appendix A-14).

4.3.2.6 CFPQ

The Comprehensive Feeding Practices Questionnaire (CFPQ; Musher-Eizenman & Holub, 2007; see Appendix A-10) was used to examine parental feeding practices. For the subscales on encouragement of BV, teaching and involvement higher scores indicate greater frequency of behaviours. Control in this questionnaire was conceptualised more in terms of permissive parental style rather than pressure and restriction which are typically used to describe the feeding practice of control. For the control subscale, lower scores indicate higher parental control over the child's feeding and higher scores indicate greater degree of child's independence over their own feeding. For details refer to Chapter II.

4.3.2.7 Neophobia

The Food Neophobia Scale (Pliner & Hobden, 1992; see Appendix A-8) was used to control for possible neophobic tendencies. Parents were asked to report their own neophobia, using the same scale as for children, with questions worded to reflect their own behaviours. Higher scores indicate higher degree of neophobia. For details refer to Chapter II.

4.4 Results

4.4.1 Descriptive Statistics and evaluation of covariates

4.4.1.1 Liking

Relative liking of FV is summarised in Table 4.1. The results showed that fruit were liked more than vegetables. Mean relative liking of fruit on the VAS scale was equivalent to 'Really likes it', while mean relative liking of vegetables on the VAS scale was equivalent to 'Likes it'. Liking of FV showed normal distribution (KS; $p>0.05$). The precise distribution of liking scores, with approximate equivalent to the relative liking value presented on the smiley face scale, is presented in Table 4.2.

Table 4.1 Descriptive data on relative liking of FV as measured by PALS: min and max liking scores in the sample, mean values and SD.

	Min	Max	Mean (SD)
Fruit	-2.54	6.50	3.73 (1.91)
Vegetables	-3.27	6.39	2.21 (1.87)

Table 4.2 Distribution of relative liking scores of fruit and vegetables across the PALS scale, with grouped value representative of the smiley face equivalent.

	Group	Mean liking score (SD)	Number of participants (per cent)
Fruit	Loves it	5.66 (0.47)	33 (32.7%)
	Really likes it	3.89 (0.49)	39 (38.6%)
	Likes it	2.07 (0.56)	21 (20.7%)
	Neutral	0.23 (0.53)	5 (5%)
	Dislikes it	-2.04 (0.43)	3 (3%)
	Really dislikes it	n/a	0
	Hates it	n/a	0
Vegetables	Loves it	5.43 (0.63)	8 (7.9%)
	Really likes it	3.83 (0.57)	28 (27.7%)
	Likes it	1.89 (0.54)	40 (39.6%)
	Neutral	0.33 (0.52)	20 (19.8%)
	Dislikes it	-1.60 (0.63)	4 (4%)
	Really dislikes it	-3.27	1 (1%)
	Hates it	n/a	0

Relative liking of FV was correlated with various sample characteristics (see Table 4.3) to establish which of these were necessary to include as covariates in inferential analyses. The results showed that more neophobic children and children from higher SES were reported to show lower liking of both fruit and vegetables. Child's age was negatively correlated with liking of vegetables. Children of mothers with higher BMI showed higher liking of vegetables. Greater child's adiposity (WHtR) was positively associated with liking of vegetables. Breastfeeding duration, weaning age, maternal age and maternal neophobia were not related to liking of FV. For that reason inferential analyses of fruit liking were adjusted for child's neophobia and household annual income and inferential analyses of vegetable liking were adjusted for child's neophobia, child's age, maternal BMI, household annual income and child's WHtR.

Table 4.3 Relationship between FV liking and sample characteristics (Pearson's r).

	Liking	
	Fruit	Vegetables
Neophobia (Child)	-.32***	-.52***
Age	-.03	-.21*
Breastfeeding	.14	.10
Weaning age	.12	.05
Mother's age	-.08	-.15
BMI (mother)	.06	.20*
Neophobia (mother)	.02	-.08
Income	-.21*	-.25*
BMI	.10	.13
WHtR	.11	.23*
Maternal intake	-.03	.15

*p<0.05, ***p<0.001

4.4.1.2 Child's FV intake

The range of reported child's intake of FV over the preceding 24 hour period was between 0-11 portions. Parents did not seem to report intake of fruit juice unless it was a part of a meal, so intake of juice was excluded from the analyses due to a small mean reported intake (M=0.06 portion a day). Intake of FV or their subcategories all violated the assumption of normality (KS<0.05). Mean values and SE of children's and maternal reported intake of FV over the 24 hour period are presented in Table 4.4. Child's 24hour intake of FV showed association with maternal intake, therefore maternal intake will be controlled for in inferential analyses.

Table 4.4 Mean number of portions and SE (in brackets), of fruit and vegetables reported over the 24 hour period for parents and children. Relationship between maternal and child's intake reported as r-value (Spearman's rho).

	Child	Parent	r-value
Fruit Total	1.51 (0.12)	0.94 (0.13)	.376***
Astringent	0.34 (0.05)	0.08 (0.03)	.331**
Non-astringent	1.17 (0.09)	0.86 (0.12)	.337***
Vegetables Total	1.45 (0.11)	1.91 (0.18)	.327**
Cruciferous	0.14 (0.03)	0.22 (0.06)	.218
Non-cruciferous	1.28 (0.13)	1.97 (0.33)	.231*
FV (total)	2.96 (0.17)	2.85 (0.21)	.359***

*p<0.05, **p<0.01, ***p<0.001

Further, 24hour intake of FV was correlated with various sample characteristics, which are summarised in Table 4.5. The results showed that children of older mothers ate fewer cruciferous vegetables. Children of mothers with higher neophobia rates ate less fruit, both astringent and non-astringent. Annual family income was positively correlated with intake of fruit and negatively correlated with intake of vegetables. Child's neophobia, child's age, breastfeeding duration, weaning age and maternal BMI were not correlated with intake of FV.

For that reason several characteristics will be used as covariates in inferential analyses. In analyses of fruit intake, maternal neophobia and household annual income will be controlled for. Additionally, analyses of cruciferous vegetable intake will be adjusted for income and maternal age.

Table 4.5 Relationship between intake of FV and sample characteristics (Spearman's rho).

	Intake (portions)					
	Fruit	Astrin.	Non-astr	Veg.	Crucif.	Non-crucif.
Neophobia (Ch.)	.14	-.08	.16	.01	-.09	.02
Age	.10	-.01	.05	.06	-.04	.02
Breastfeeding	-.13	-.03	-.10	-.11	.12	.10
Weaning age	-.09	-.12	.03	.05	-.03	-.01
Age (m.)	.11	.17	.07	-.12	-.25*	-.09
BMI (m.)	-.15	.01	-.16	-.05	-.08	-.06
Neophobia (m.)	-.28**	-.26**	-.20*	-.03	.05	-.01
Income	.23*	.17	.11	-.10	-.22*	-.10
BMI (m.)	-.06	.05	-.10	.04	-.02	.06
WHtR (ch.)	-.10	-.01	-.12	.06	.02	.08

Astrin= Astringent; non-Astr= non-astringent; veg= vegetables; Crucif= cruciferous vegetables; Non-crucif= non-cruciferous vegetables; m= mother; ch=child; *p<0.05, **p<0.01

4.4.1.3 CFPQ

Maternal feeding practices were subsequently divided into low and high groups based on median splits, so they can be later used in moderation analyses. The median was established at M= 12.0 for Control, M=11.0 for Encouraging BV, M= 11.0 for Involvement and at M= 8.0 for Teaching. Frequencies, means and SE of means of subdivided groups are presented in Table 4.6. As control had inverse scoring, lower value is associated with higher maternal control.

Table 4.6 Frequencies, mean values and SE of children's fruit liking for mothers who were described as low or high in feeding behaviours.

		Frequency	Mean	SE
Control	Low	44	14.80	0.25
	High	56	10.27	0.21
BV	Low	57	9.46	0.21
	High	43	13.89	0.29
Involvement	Low	54	9.50	0.26
	High	46	12.70	0.13
Teaching	Low	49	6.47	0.22
	High	48	9.98	0.16

BV=Encouragement of balance and variety

4.4.1.4 SSP

Data from SSP were used to assess sensitivity of children in taste/smell, tactile and audio/visual domain. Summary data are presented in Table 4.7. Sensory sensitivity was not correlated with liking or intake of FV or their subcategories and therefore will not be used as covariate in inferential analyses.

Table 4.7. Relationship between sensory sensitivity in various domains and liking and intake of FV and their subcategories (Pearson's r).

		Tactile	Taste/Smell	Audio/Visual
Liking	Fruit	-.03	.12	-.09
	Vegetables	.01	.08	.09
Intake	Fruit	.11	.12	.-02
	Astringent	.16	-.02	.12
	Non-astringent	.03	-.02	.08
	Vegetables	-.05	.02	-.03
	Cruciferous	-.01	.06	-.09
	Non-cruciferous	-.03	.05	-.02

4.4.2 Inferential analyses

4.4.2.1 Liking and intake

To test the hypothesis that liking of FV will be correlated with intake of FV, a series of one-tailed partial correlations controlling for covariates which emerged in preliminary analyses were conducted. In the analysis of fruit intake the factors controlled for were: child's neophobia, income level, maternal neophobia and maternal intake of fruit.

Liking of fruit was not correlated with intake of fruit or astringent fruit. Liking of fruit was correlated with intake of non-astringent fruit (see Table 4.8).

Table 4.8 One-tailed partial correlations between liking of fruit and intake of fruit, controlling for covariates.

		Fruit Liking
	Fruit	.16
Intake	Astringent	-.02
	Non-astringent	.22*

*p<0.05

The factors controlled for in the analysis of the relationship between vegetable liking and intake were: child's neophobia, child's age, mother's BMI, income, child's WHtR, mother's age and mother's intake. Liking of vegetables was correlated with intake of cruciferous vegetables and showed strong trend for association with vegetables intake (see Table 4.9).

Table 4.9 One-tailed partial correlations between liking of vegetables and intake, controlling for covariates.

		Vegetable Liking
	Vegetables	.21[a]
Intake	Cruciferous	.27*
	Non-cruciferous	.14

a p=0.053, *p<0.05

4.4.2.2 Feeding practices and liking of FV

To test the hypothesis that parental feeding practices will be linked with children's liking of FV a series of t-tests were conducted. Parents were divided into high and low levels of different feeding practices based on a median split.

Table 4.10 summarises the results. It was evident that parents who encouraged the child to be involved in meal planning and preparation had children who liked fruit more. Parents who encouraged BV in the home setting had children who liked vegetables more. No other feeding practices were associated with liking of FV.

Table 4.10. Group differences between parents low and high in feeding strategies in children's liking of FV.

		Low	High	T	p
Fruit	Control	3.53	3.86	0.86	0.394
	BV	3.48	4.04	-1.44	0.152
	Involvement	3.12	4.34	-3.31	0.001
	Teaching	3.62	3.86	-0.62	0.536
Vegetables	Control	1.90	2.44	1.42	0.159
	BV	1.81	2.71	-2.42	0.017
	Involvement	2.04	2.39	-0.92	0.359
	Teaching	2.11	2.36	-0.65	0.518

Note BV refers to Encouragement of Balance and Variety

4.4.2.3 Feeding practices and intake of FV

To test the hypothesis that parental feeding practices will be linked with children's intake of FV a series of Mann Whitney U tests were conducted. Parents were divided into high and low levels of different feeding practices based on a median split. Non-parametric Mann Whitney U test was used as intake of FV violated the assumptions of normality. Differences between parents high and low in feeding practices have been presented in Table 4.11 for fruit and Table 4.12 for vegetable intake. There were no differences between parents who used high or low levels of feeding practices, except that parents who showed high levels of teaching had children who ate significantly less cruciferous vegetables, compared to parents who showed low levels of teaching.

Table 4.11 Differences in children's fruit intake between children of parents with high and low levels of feeding practices (Mann Whitney U test). Mean values and SD are reported per group.

		Low	High	U	P
Fruit	Control	1.38 (0.97)	1.63 (1.24)	925.0	.353
	BV	1.59 (1.28)	1.43 (0.93)	1034.0	.926
	Involvement	1.58 (1.28)	1.45 (0.95)	1043.0	.917
	Teaching	1.48 (1.19)	1.53 (1.12)	938.50	.670
Astringent	Control	0.33 (0.51)	0.33 (0.57)	1006.50	.747
	BV	0.34 (0.57)	0.31 (0.52)	1044.0	.989
	Involvement	0.33 (0.62)	0.33 (0.47)	981.0	.474
	Teaching	0.34 (0.55)	0.33 (0.56)	984.50	.964
Nonastringent	Control	1.05 (0.82)	1.30 (0.98)	895.0	.234
	BV	1.25 (1.02)	1.10 (0.77)	1008.0	.759
	Involvement	1.25 (1.02)	1.12 (0.79)	1004.50	.675
	Teaching	1.14 (0.95)	1.20 (0.90)	942.50	.690

Note BV refers to Encouragement of Balance and Variety

Table 4.12 Differences in children's vegetable intake between children of parents with high and low levels of feeding practices (Mann Whitney U test). Mean values and SD are reported per group.

		Low	High	U	P
Vegetables	Control	1.60 (1.01)	1.35 (1.12)	861.50	.154
	BV	1.47(1.19)	1.45 (1.00)	1027.50	.886
	Involvement	1.53 (1.26)	1.38 (0.91)	1055.50	.997
	Teaching	1.62 (1.25)	1.33 (0.96)	877.0	.352
Cruciferous	Control	0.17 (0.37)	0.12 (0.31)	910.0	.569
	BV	0.11 (0.29)	0.18 (0.38)	893.0	.475
	Involvement	0.10 (0.28)	0.20 (0.38)	850.50	.159
	Teaching	0.26 (0.43)	0.03 (0.12)	696.0	0.006
Noncruciferous	Control	1.42 (1.01)	1.18 (1.06)	741.50	0.093
	BV	1.34 (1.17)	1.22 (1.00)	887.50	.745
	Involvement	1.40 (1.28)	1.16 (0.84)	901.50	.721
	Teaching	1.35 (1.20)	1.27 (1.00)	878.50	.975

Note BV refers to Encouragement of Balance and Variety

4.4.2.4 Liking, parental feeding practices and FV intake

To test the hypothesis that feeding practices moderate the relationship between relative liking and intake of FV a series of moderated regressions were conducted, controlling for covariates which emerged in the preliminary analyses. As outcome variables, only fruit and vegetables without the subdivisions were considered, as conducting separate analyses on subdivided FV would result in additional 16 moderated analyses, thus creating potential problems with statistical interpretation due to the large amount of tests on a relatively small data set. This strategy of focusing on general FV count without conducting separate regressions on subdivided FV complies with the main assumption of PALS which was not validated on intake of subdivided FV groups, such as astringent fruit or cruciferous vegetables.

4.4.2.4.1 Fruit

For analyses concerning potential moderators of the relationship between relative liking and 24hour intake of fruit, child's neophobia, income level, maternal neophobia and maternal intake of fruit were used as covariates, and parental feeding practices of Control, Involvement, Teaching and Encouraging BV were tested for moderation.

There were no main effects of parental control or child's liking of fruit on intake of fruit. Parental control was a significant moderator of the relationship between liking of fruit and fruit intake (Table 4.13). Subsequent simple slopes analysis revealed that when parental control was low there was a significant positive relationship between liking of fruit and intake of fruit ($b= 0.21$, 95% CI [0.05, 0.36], $t=2.72$, $p=0.008$). When parental control was high, there was a non-significant negative relationship between liking of fruit and intake of fruit ($b=-0.028$, 95% CI [-0.17, 0.11], $t=-0.38$, $p=0.704$). Fig 4.1. illustrates this association. Maternal neophobia and intake were the only other significant contributors to the model. Maternal intake was the single most substantial contributor. The model overall explained 32% of variance ($F(7, 69)= 3.86$, $p<0.001$).

Table 4.13 Summary of results of moderated regression analysis: parental control as a moderator of the relationship between liking of fruit and intake of fruit, controlling for child neophobia, maternal neophobia, maternal intake of fruit and family annual income.

Model variables	B	SE_b	T	P-value	R^2	Adjusted R^2
Predictor variables						
(Constant)	1.16	0.60	1.95	.055		
Covariates						
Neophobia child	0.02	0.01	1.52	.133		
Maternal neophobia	-0.03	0.01	-2.25	.027		
Intake mother	0.36	0.12	3.05	.003		
Income	0.04	0.10	0.37	.716		
Main effects						
Liking	0.07	0.05	1.36	.178		
Control	-0.14	0.28	-0.50	.616		
Interaction						
Liking x control	0.24	0.11	2.620	.003		
Model					.566	.320***

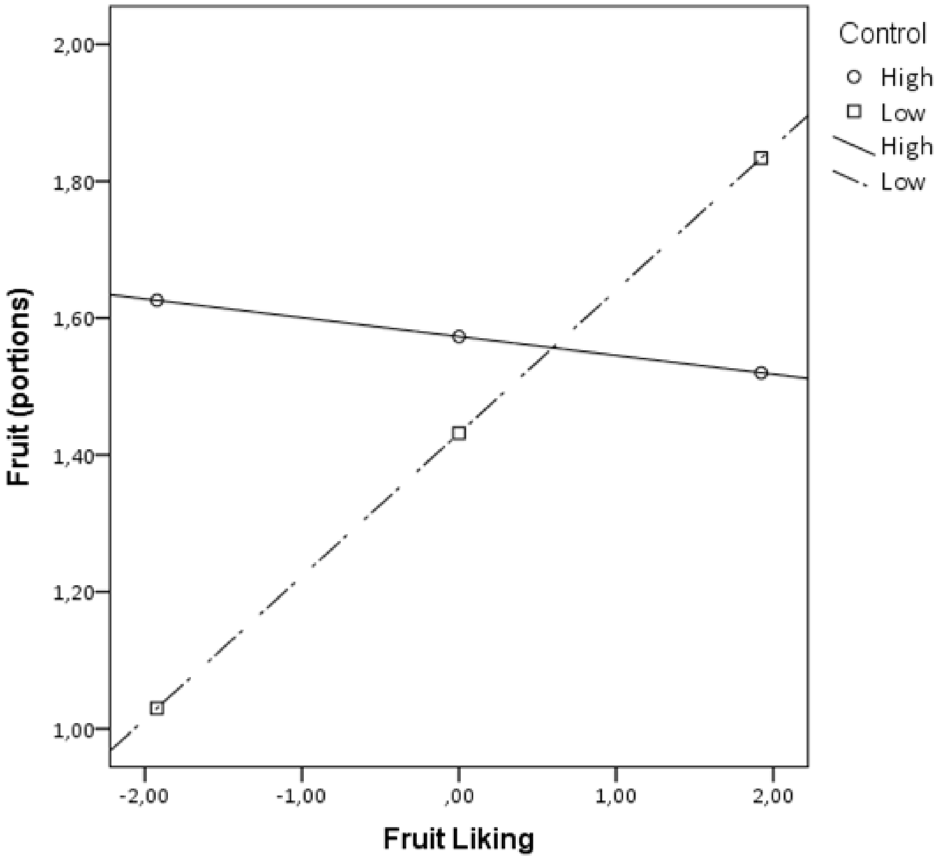

Fig 4.1. Moderating effects of parental control on the relationship between relative liking and 24hour intake of fruit.

Next, looking at the moderating effects of parental involvement on the relationship between relative liking of fruit and 24hour fruit intake, there was no significant interaction between relative liking and involvement on 24hour intake of fruit. Maternal neophobia and intake were the only significant contributors to the model, with maternal intake being the more substantial one. Overall the model explained 31.6% of variance ($F(7,69)= 3.30$, $p<0.01$). Table summarising the results is presented in the Appendix C-1.

There was also no significant interaction between parental teaching and relative liking of fruit, on 24hour intake of fruit. Maternal neophobia and intake were the only significant contributors to the model, with maternal intake being the more substantial one. Overall, the model explained 28.7% of variance in 24hour intake of fruit ($F(7,69)= 3.10$, $p<0.01$). Table summarising the results is presented in the Appendix C-2.

Subsequent analysis revealed that parental encouragement of BV did not moderate the relationship between relative liking of fruit and 24hour intake of fruit. Maternal neophobia and intake were again the only significant contributors to the model. Overall, the model explained 29.1% of variance in fruit intake ($F(7, 69)= 3.16$, $p<0.01$). Table summarising the results is presented in the Appendix C-3.

4.4.2.4.2 Vegetables

Analyses were replicated for 24hour intake of vegetables. To test the hypothesis that parental feeding practices moderate the relationship between relative liking and 24hour intake of vegetables a series of moderated regressions were conducted, controlling for covariates which emerged in the preliminary analyses. The covariates used were neophobia, child age, WHtR, maternal age, maternal BMI, maternal intake of vegetables and annual family income. Moderating effects of Control, Involvement, Teaching and Encouraging BV were tested.

Moderated regression analysis, controlling for covariates, revealed no interaction between Encouraging BV and relative liking of vegetables on 24hour intake of vegetables. Maternal intake and child's relative liking were the only significant contributors to the model, with maternal intake being the more substantial one. Overall, the model explained 39.6% of variance in intake of vegetables ($F(10, 57)= 3.84$, $p<0.001$). Table summarising the results is presented in the Appendix C-4.

There was also no interaction between control and child's relative liking of vegetables on child's 24hour intake of vegetables. Maternal intake was the only significant contributor to the model explaining child's 24hour intake of vegetables. Overall, the model explained 38.9% of variance ($F(10, 57)= 3.35$, $p<0.01$). Table summarising the results is presented in the Appendix C-5.

There was also no moderating effect of Involvement on the relationship between child's relative liking and 24hour intake of vegetables. Again parental intake was the only significant contributor to the model. Overall the model explained 38.3% of variance in vegetable intake ($F(10, 57)= 3.71$, $p<0.001$) (see Table 19). Table summarising the results is presented in the Appendix C-6.

Finally, there was no interaction between Teaching and child's relative liking of vegetables on 24hour intake of vegetables. Maternal intake was the only significant contributor to the model. Overall the model explained 38.5% of variance in vegetable intake ($F(10, 57)= 4.54$, $p<0.001$). Table summarising the results is presented in the Appendix C-7.

4.5 Discussion

This study looked at the relationship between relative liking of FV and 24hour FV intake in toddlers, while controlling for a number of internal and external correlates. This study also looked at whether the use of selected parental feeding practices is associated with relative liking and 24hour intake of FV. Additionally, moderating effects of selected parental feeding practices on the relationship between child's relative liking and 24hour FV intake were analysed.

The results showed that in toddlers, relative liking of fruit and 24hour intake of fruit were not correlated, but relative liking of fruit was correlated with intake of only non-astringent fruit. Relative liking of vegetables showed a positive relationship with intake of cruciferous vegetables, and showed a trend that just missed significance with intake of vegetables in general. The results revealed that parents who involved their children in meal planning and preparation had children who were reported to like fruit more. Parents who encouraged balance and variety at home had children who were reported to like vegetables more. Control or Teaching did not show associations with liking of FV, but parents who used more Teaching had children who ate fewer cruciferous vegetables. Balance and variety, Involvement or Control did not show relationships with children's 24hour intake of FV. Parental feeding practices such as Encouragement of BV, Teaching and Involvement did not moderate the relationship between liking of fruit and intake of fruit. However, Control moderated the link between child's relative liking and intake of fruit. Where parental control was low, liking and intake of fruit were correlated; children who did not like fruit did not eat much fruit, and those children who liked fruit ate larger amounts of it. In contrast, when parental control was high, there was not a relationship between child liking and intake; those children who did not like fruit ate around the same amount of fruit as those who liked it. Parental feeding strategies did not moderate the relationship between liking and intake of vegetables. A model representing the results of this study is presented in Fig. 4.2.

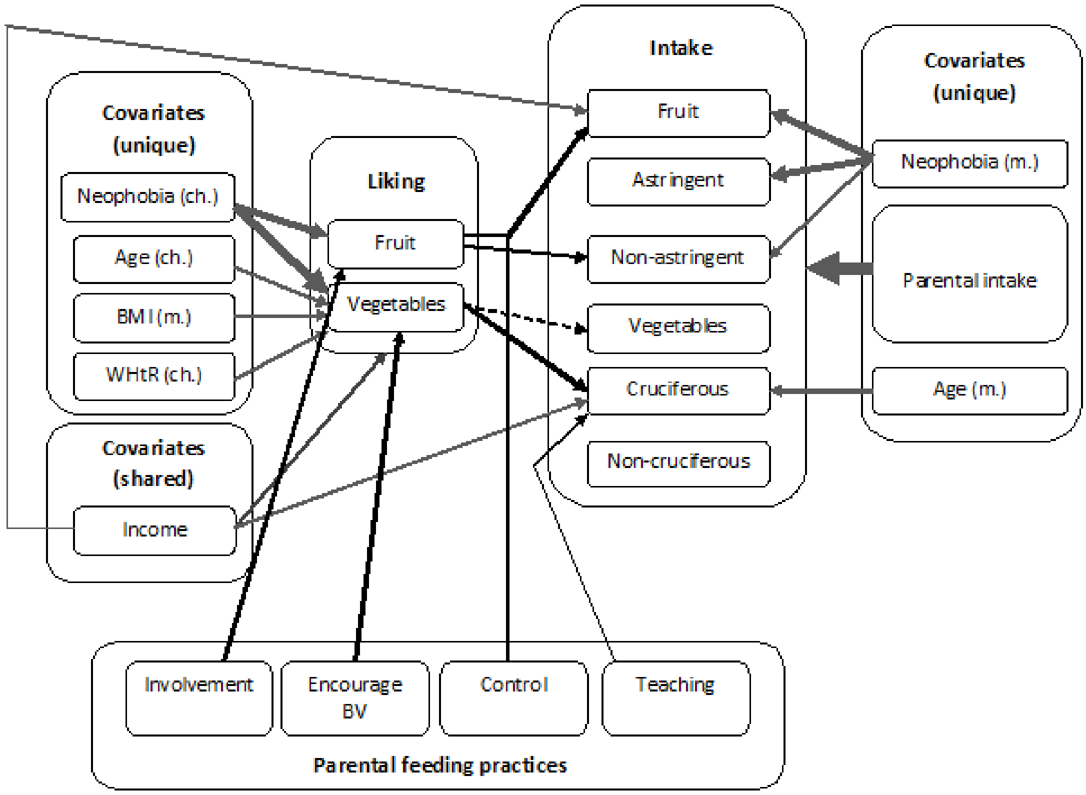

Fig. 4.2. Model depicts the relationships between relative liking, parental feeding practices and 24hour intake of FV. Covariates are included in the model. Thickness of the arrows indicates the strength of the association. Dotted arrow represents the association that showed a strong trend but missed significance. Black arrows represent the associations which tested hypotheses, dark grey arrows represent covariates.

4.5.1 Relative liking and 24hour intake

In this study of toddlers, relative liking of fruit was not linked to reported intake of fruit in general, but did show a positive association with intake of non-astringent fruit. Relative liking of vegetables was linked to reported intake of cruciferous vegetables, and showed a trend that missed significance for a link with vegetables in general.

Those results do not support the majority of past research on liking and intake of FV in children. Past studies have consistently reported liking as predictor of intake of FV in children, however the variance of FV intake explained by liking has consistently been reported to be small (Baranowski et al., 1999), indicating that while liking contributes to intake, there are other factors which are more substantial. It should be however noted that past studies that looked at liking and intake of FV in children were conducted on older samples of school-age children, who might face different barriers to eating FV, compared to toddlers whose diet is almost completely dependent on their caregivers. Furthermore, this study utilised a novel measure of liking which is assessed relative to the strongest liking of any kind and places the FV liking scores in the context of all the other liked and disliked foods and non-foods. Conceptualisation of liking in this study is therefore different from other studies of similar type. Studies on adult populations show that palatability of foods is not necessarily related to quantity consumed or to portion size. Wilkinson et al. (2012) demonstrated that adults selected portion size of the meal based on the expected satiety, and actual and expected liking were poor predictors of the actual intake. As fruit and vegetables are generally low in energy, at least relative to non-FV foods, perhaps the unique contribution of palatability to the actual intake of FV is less substantial compared to expected satiety. In other words, in low energy foods such as FV, liking may be less important for intake than expected satiety. Liking may be more important for selection of the different types of fruit or vegetables rather than the actual quantity consumed. This would explain why despite 92% of children liking fruit, there are still large individual differences in the actual quantity of fruit consumed and despite high reported liking, they consume little of it. As FV are generally low in energy, they carry small expected satiety value and that is why they may not be consumed in sufficient quantity despite being liked.

Relative liking of fruit was weakly correlated with 24hour intake of non-astringent fruit, which indicates that children who like fruit consume more of it, but that increased intake is exclusive to fruit which do not have strong sensory properties. This finding supports the main aim of this thesis and shows that in order to fully understand intake of FV in children, fruit should not be considered as a uniform construct, but should be assessed with appreciation of different drivers of fruit that differ in sensory properties. As such, astringent and non-astringent fruit should be analysed separately due to different correlates that guide their intake in children. The results presented in this study suggest that general liking of fruit is weakly related only to non-astringent fruit intake, and general liking of fruit does not translate to consumption of astringent fruit. However, past research did show that children's liking for different FV is proportional to their energy density. FV with higher energy density are generally more liked than low-energy FV (Gibson & Wardle, 2003). For that reason it is somewhat not surprising that in this study liking of fruit was linked with intake of non-astringent fruit only, as astringent fruit are lower in energy compared to non-astringent fruit, and that difference is quite substantial. Non-astringent fruit are less uniform in energy, as they include high energy bananas (89kcal/100g) and low-energy melon (34kcal/100g), while astringent fruit are generally low in energy and are more uniform in energy density (with a few exceptions for example blackberries (43kcal/100g), pineapple (50kcal/100g) and raspberries (52kcal/100g). For that reason liking of fruit may be better linked to intake of non-astringent fruit, as astringent fruit, as well as being irritant, are also disadvantaged as they are lower in energy density. Studies on animals indicate that energy content of FV is predictive of their liking and more so than their sweetness measured by total carbohydrate content. Laska, Salzar and Luna (2000) demonstrated that spider monkeys chose different FV based on their total energy content, independent of carbohydrate, lipid or protein content, in a test which included astringent fruit too. Astringent pineapple was chosen over a non-astringent melon or tomato, as it is characterised by higher energy density. This indicates that perhaps it is of evolutionary advantage for humans to develop preference for energy dense FV. For that reason general liking of fruit might not be correlated with liking of astringent fruit, as even children who like fruit in general (in this study 92%) would not perhaps develop liking of low-energy astringent fruit. This does suggest that PALS scale might not be an appropriate measure of liking of all types of fruit.

Despite the fact that a number of different covariates were analysed, there still remain other factors which were not controlled for, such as home availability which has been shown to be a major contributor to FV intake in children but which was not analysed in this study. The majority of children in the sample liked fruit and the mean liking score was representative of ‘really likes it’ and showed small variance, which might also indicate that small differences in liking scores would not result in a meaningful and measurable difference in the intake of fruit. There are no theoretical premises to expect meaningful differences in intake of FV between children who ‘like fruit’ and those who ‘really like fruit’. As only 5% of the sample reported the liking score equivalent to neutral and 3% disliked fruit, it was not possible to make comparisons between groups with clearly different liking scores, representative of truly different attitudes towards fruit. Larger sample size would perhaps result in larger group differences representative of different preferences. This ceiling effect in liking would also explain why FV liking in this sample was not correlated with children’s sensory sensitivity. Furthermore, it was evident from preliminary analyses that neophobia levels were negatively associated with liking of FV, and yet neophobia was not linked to 24hour intake of portions of FV. This suggests that children might only be eating familiar and liked fruits, and as such levels of overall FV liking would not correspond to the actual differences in intake. It was also unusual that in this generally affluent sample income was negatively linked with liking of FV. This is not consistent with past research which generally shows that children of higher SES like FV more (Pechey et al., 2015), however the opposite has also been reported (Feeney et al., 2014). This is likely related to the recruitment in the present study. This study was a part of a larger project on introduction of novel fruit to toddlers. Parents during the recruitment were informed that the main purpose of the study is to test whether parental feeding practices affect the acceptance of novel fruit in children. It is likely that the parents of the more fussy children who find it problematic to introduce new FV to their children's diet were more likely to take part in this project due to personal interest in the topic, which would be reflected in both lower liking of FV or perceived lower liking of FV by the parents. Perhaps parents of higher SES with the more fussy children were more likely to be involved in this project which would explain the negative association between income and FV liking. Alternatively, past research, as summarised in Chapter I, did show that different proxies of SES such as Education or Income show different links to FV intake, so perhaps a different choice of SES have resulted in different findings. The characteristics of the sample may have also contributed to the unusual finding that, while trending in the expected direction, children's sensory sensitivity was not linked with their intake of FV.

Liking scores for vegetables showed greater variance and a larger proportion of the sample reported a liking score equivalent to neutral or dislike (approximately

25%) indicating larger group differences and thus showing a quantifiable difference in liking between individuals. Despite this, there was no relationship between relative liking of vegetables and intake of vegetables overall, but there were differences in the intake of cruciferous vegetables. As with fruit, liking might not be related to intake of vegetables overall because children may be offered and are eating primarily liked and accepted vegetables. This means that the general liking score would show lower correspondence with intake, because even children who generally dislike vegetables may be consuming a small portion of the types that they do accept. However, the results suggest that general liking of vegetables is positively associated with the intake of the most disliked of the vegetables types i.e. the cruciferous family. Perhaps children who have greater liking for vegetables are more accepting of those characterised by bitter properties. Consistent with past findings (e.g. Baranowski et al., 1999) this link is however modest. However, even within the cruciferous family there might be some individual vegetables that the children like, perhaps because they were often exposed to them. Such an example would be broccoli, which is a commonly consumed vegetable in the UK and in this sample was one of the most common vegetables consumed by over 25% of children.

As with fruit, children who were reported to like vegetables more were not reported to eat more portions of it, possibly again because liking might not be the most substantial contributor to the portion consumed, but expected satiety might be a better predictor. However, children who in general like vegetables may be more likely to be accepting of the more bitter cruciferous vegetables. Liking would not be correlated with quantity of vegetables consumed as even children who dislike vegetables may be consuming the energy-dense vegetables hence further research is needed to explore the types of vegetables and energy density of vegetables consumed by vegetable likers and dislikers.

Furthermore, the preliminary analyses showed that different internal and external factors were associated with both liking and intake of FV. For intake, the factors that were linked were centred around the mother i.e. maternal age, maternal neophobia and family income. For children's liking of FV, the factors were centred more around the child, including child's neophobia, age and WHtR, with only two external correlates (maternal BMI and family income). This suggests that liking might be more driven by internal factors while the intake seems to be influenced by external factors, at least in this young age group. This might suggest that the lack of clear links between liking and intake in this age group may be affected by external drivers over which the child has no control, such as parental control. The link between liking and intake may therefore strengthen in the later stages of development when the child might exert more control over their own diet.

4.5.2 Feeding practices

Selected feeding practices tested in this study partially supported the hypotheses. Contrary to what was predicted, only the use of involvement and encouraging balance and variety showed positive links with the child's FV liking. The use of teaching showed the opposite effect to what was predicted and resulted in lower intake of cruciferous vegetables, while the use of control as a feeding strategy did not show any associations with intake or liking.

The results show that parents who involve children in meal planning and preparation at a very young age have children who show higher liking of fruit.

Interestingly, such involving has no relationship with liking of vegetables, but what shows impact on liking of vegetables is providing an environment which encourages balance and variety of different products. Surprisingly none of the feeding practices was associated with higher FV intake. What is most interesting is that teaching about healthy eating was actually associated with a lower intake of cruciferous vegetables. Perhaps children perceive higher levels of teaching as verbal coercion which would explain lower levels of intake of cruciferous vegetables, as coercion has been reported to have a negative impact on FV intake (Wolfenden et al., 2014). Alternatively, the directionality of this effect is unknown and parents who use high degree of teaching may do so as response to low cruciferous intake in children, as a method of encouragement, so the direction of this link requires further research. This is the same issue which arose in the previous chapter, where it was under question whether lifetime exposure to FV is restricted by child's refusal to try FV. Perhaps teaching would be more effective in older children who are better able to understand the importance of a healthy diet. While the results of this study do not seem very optimistic as to the effectiveness of positive feeding strategies on FV intake, it must be noted that the sample was very young and effects may demonstrate at later stages of development.

4.5.3 Liking, parental feeding practices and FV intake

The second part of the study looked at the moderating effects of parental feeding practices on the relationship between liking and intake of FV in toddlers. The results surprisingly showed that parental feeding practices did not moderate this relationship, with the exception that parental control moderated the link between liking and intake of fruit.

In this study, three positive feeding practices were tested i.e. encouragement of balance and variety, teaching and involvement and one negative practice of parental control. Only the negative feeding practice affected the link between liking and intake of fruit. Parents who reported low control over child's eating had children who showed a positive relationship between liking and intake. Past studies often report negative effects of parental control on liking and intake of FV (Wardle et al., 2005), which however was not seen in this study, perhaps because a different measure of control was used, which focussed more on the amount of control over eating relinquished to the child rather than the use of pressure or restriction. The results of this study indicate that when parents use less control over eating, children who like fruit eat more of it and those who show lower liking of fruit eat less fruit. Parents who are more controlling have children who eat more fruit in general, whether it corresponds to their liking or not. This could be because more controlling parents use coercion, or because they ensure that the child eats sufficient amount of the fruit that they strongly like, even if it would mean poorer variety of diet. Less controlling parents allow more autonomy in intake of fruit, which means that children who show lower liking of fruit, might not be eating sufficient amount. While short term effects of parental control demonstrated in this study indicate positive effects on intake of fruit, long-term effects as reported in past research may be harmful (Wardle et al., 2005).

Surprisingly, positive feeding practices did not moderate the link between liking and intake of FV. There is a gap in literature on the effects of those positive feeding practices on FV intake in children, particularly in toddlers. It was expected that parents who use positive feeding practices i.e. who teach their children about healthy eating, who provide variety of FV in the home setting and who involve children in the food preparation, would have children whose liking of FV corresponds to intake, especially by creating positive mealtime environment. This however was not the case. On the contrary, the results showed that intake of FV in toddlers is dependent not on the actual liking and positive feeding practices, but most consistently on parental intake of FV. Parental intake of FV was the single most consistent predictor of intake in children, explaining more than 36% of variance in intake. This supports past research on intake of FV in children (Blissett et al., 2012).

Past studies show some indications that, at least in the older children, positive feeding practices result in higher intake of FV (Blissett et al., 2012; Blissett et al., Unpublished). This study initially showed that higher involvement was linked to liking of fruit and encouragement of BV was positively associated with intake of vegetables. However, in the hierarchical regression analyses which employed various covariates, those effects disappeared, indicating that in this age group the strongest predictor of FV intake in children is not what parents do, but what parents eat.

4.5.4 Limitations

There were several limitations in this study. Firstly, the 24 hour dietary recall was used as a measure of FV intake. Many parents did not report accurate dietary intake with the inclusion of measures or portion sizes and they were removed from the analyses. Perhaps a 3 or 7 day diary with an appropriate training would result in more accurate reporting. Also, collecting dietary data from a larger selection of days would provide more information on the intake of subcategories of FV i.e. cruciferous vegetables and astringent fruit, the intake of which in this sample was extremely limited. Further, the study utilised a large number of measures and larger sample size would allow for further subdivision of FV into subcategories and looking for moderating effects on the subgroups of FV intake. Also, the PALS liking scale contained smiley faces on top of visual scales, which may have swayed the parents to mark the liking consistent with the facial equivalent, thus violating the principle of VAS methodology. Furthermore, PALS is a relatively new instrument for measuring liking and has not been yet validated in the British sample. While there are no indications that PALS should not be used in non-American samples, several items of PALS have been more typical for American than British diet (e.g. melon). The suitability of PALS for this young UK sample needs further validation. Also an alternative neophobia measure might have been more suitable for this sample, as some of the measure questions seemed inappropriate for the use with 2-3 year olds e.g. question referring to child's liking of eating in ethnic restaurants. Finally, this was a highly affluent sample, with high income and high educational level, so the results are not representative of the population.

4.5.5 Summary

This study looked at the relationship between liking and intake of FV in toddlers, while controlling for a large number of internal and external components. This study also analysed potential moderating effects of parental feeding practices on this relationship. The results showed that in toddlers, there is no link between liking and intake of fruit, and no link between liking and intake of vegetables overall. This study showed that children who like fruit more eat more of non-astringent fruit and children who like vegetables more eat more of cruciferous vegetables. This study also demonstrated that positive feeding practices do not moderate the relationship between liking and intake of FV. However, a negative feeding practice of parental control does affect the relationship between liking and intake of fruit. Highly controlling parents have children who eat the same amount of fruit independent of liking, and parents with low levels of control have children whose intake of fruit corresponds to fruit liking. Perhaps low levels of parental control are associated with greater facilitation of fruit intake for those children whose liking for fruits is naturally high. It seems therefore that in younger children liking does not necessarily correspond with intake, perhaps because external covariates disturb what might be seen as a natural link. However, another interesting factor that remains to be explored is why certain children show higher liking for FV than others. Internal predispositions to higher liking of FV will be explored in the subsequent chapters of this thesis.

Chapter V
Effects of otitis media exposure on children's adiposity and fruit and vegetable intake.

5.1 Abstract

Previous research has shown that viruses causing middle ear infections (*Otitis media;* OM) may impair the chorda tympani nerve (CT). CT damage has been linked with increased BMI in children and lower liking of fruit and vegetables (FV). The present studies hypothesised that in line with research on CT damage, children exposed to OM would have higher adiposity and would eat fewer FV, compared to controls. Two studies were conducted on different age groups to test the hypotheses. Study I was conducted on 5-9 years old children. The results showed that children with OM history had higher adiposity than the controls, and children with multiple history of OM had higher adiposity than children with single OM exposure. Children with a history of OM consumed significantly more portions of fruit juice, but not portions of FV. Children with history of OM consumed a higher variety of vegetables, and more specifically non-cruciferous vegetables. Study II: was conducted on 2-3 years old children. The results showed that children with a history of OM did not differ in BMI centiles from the controls, but girls with OM had higher WHtR ratio than girls without OM history. This effect was not seen in boys. There were no differences in FV intake between the children with OM history and controls. It was concluded that OM history may predispose to higher adiposity and differences in FV intake in older children who can make more independent feeding decisions.

5.2 Introduction

Otitis media (OM) or middle ear infection is one of the most common childhood infections, with the highest occurrence rate between 6-24 months of age (Haggard, 2011). Prevalence rates differ between studies but it has been estimated that as many as 60% of children would have at least 1 episode of OM by the age of 1 (Leibovitz and Greenberg, 2004), and 90% by the age of 2 (McConaghy, 2001). The most commonly reported risk factors for OM include attending day care (Rovers et al., 1999), passive smoking (Etzel et al., 1992*),* large number of siblings (Zhang et al., 2014), older siblings, young maternal age, male gender (MacIntyre et al., 2010), lower socio-economic status (Auinger, Lanphear, Kalkwarf & Mansour, 2003) and air pollution (Brauer et al., 2006). Prevalence of OM has also been reported to be higher in bottle-fed as opposed to breastfed children (Auinger et al., 2003).

OM exposure has been discussed in the context of taste alterations and changes to oral somatosensation via the chorda tympani (CT) nerve. The CT together with the trigeminal nerve innervate taste buds in fungiform papillae on the anterior two thirds of the tongue (Peracchio et al., 2012). The posterior part of the tongue is innervated by the glossopharyngeal nerve. While CT carries information about taste, the trigeminal nerve transduces somatosensory information (Prutkin et al., 2000). The CT is vulnerable to damage as it separates from the lingual nerve and travels through the middle ear where it is exposed to viruses that cause OM (Bartoshuk et al., 2012).

Past research, although limited, has shown that OM history is related to perception of flavour. The first account of alterations of taste in a group of 50 patients with history of severe OM were reported by Urbantschitsch in 1876 (as cited in Bartoshuk, 1996) who noted two mutually exclusive phenomena related to OM, either increased or decreased taste acuity in different patients. Bartoshuk (1996) explained this with a release of inhibition model, in which damage to CT would release the normally present inhibition of the glossopharyngeal (GP) nerve and in this way would enhance taste information carried by the GP nerve. In this study, patients with OM history rated salt, sucrose and citric acid (also an irritant) as more intense than the controls. The bitter compound quinine showed a trend for higher intensity but did not reach significance, however interestingly, another bitter compound 6-n-propylthiouracil (PROP) was rated as more intensely bitter by the OM subjects. However, some participants showed decreased taste acuity for the same tastants. Bartoshuk (2012) concluded that damage to one taste nerve results in increase of taste sensations via release of inhibition (more intense sensation) while damage to two taste nerves results in decrease of taste sensation (less intense taste). This study showed that OM might affect taste acuity for different flavours possibly via the CT and GP nerves. Changes in sensory perception of different foods and changed acuity of flavour perception might therefore affect preference or liking of certain groups of foods.

The alterations in flavour perception linked to OM history have further inspired research on the link between OM history and food preferences. Arsenault et al. (2004) showed that more severe histories of OM were linked to increased consumption of sweet foods and decreased consumption of vegetables in children, possibly due to higher perceived intensity of sweet compounds which might be more pleasurable to children with OM history. Snyder, Duffy, Chapo, Cobbett and Bartoshuk (2003a,b) demonstrated that OM might alter the normally age-dependent food preferences differently in men and women. They showed that in adult women with history of OM there was no age-dependent decrease in preference for highly sweet foods. At the same time they noted an increase in preference for high fat foods in men with a history of OM. This study did not however measure intake of FV.

Bartoshuk (2012) showed that in a questionnaire study OM patients reported increased preference for sweet-fat foods, possibly due to intensification of tactile food properties such as increased creaminess of fats and intensification of taste sensations such as increased perception of sweetness, which supports Snyder's et al. (2003a,b) and Arsenault's et al. (2004) findings. Also Peracchio et al. (2012) in a recent study on OM and food preferences in children between 3 and 5 years old, showed that pre-schoolers with OM history had lower liking of fruit and vegetables. At the same time boys with OM history were more likely to choose high fat sweet foods over other pleasurable non-food activities, showing increased pleasure from this group of foods. The decreased liking of FV in this study may be explained with the release of inhibition model, as bitter compounds present in some vegetables such as cruciferous vegetables may be perceived as more intensely bitter by children with a possible damage to CT nerve through OM exposure.

Past studies noted increased adiposity among children with OM history, which they explained with OM-related changed perception of flavours and different liking of energy dense foods and FV. In the above mentioned study by Snyder et al. (2003a, b) participants with a history of OM were reported to have a higher BMI compared to controls and those differences were found for both males and females. Also Peracchio et al. (2012) found that children between 3 and 5 years old with the highest exposure to OM had higher BMI than the controls, indicating that the number of exposures may be of great importance for dietary preferences associated with overweight. Further evidence comes from Kim et al. (2007) who demonstrated that in 2-

7 year olds those with a history of OM with effusion had significantly higher BMI compared to controls. Nelson et al. (2011) later showed that, in a prospective cohort study of 538 infants up to 2 years old, infants with preceding tympanostomy tube treatment (performed in severe OM cases which do not respond to antibiotic treatment) were more likely to be overweight or obese at 2 years of age. Contrary to expected, Seaberg et al. (2010) in a study of 142 children between 5-18 years old failed to show the link between CT function and OM history, and they did not find a relationship between OM history and BMI. However, their study used an electrogustometer to measure CT function, which does not measure neural responsiveness to tastants, but rather a general neural acuity to signalling thresholds, which is a poor indicator of taste sensitivity.

Previous studies have not examined OM history in relation to the actual intake of FV in children, and the majority of studies have focused on liking or intake of energy dense foods, due to the reported risk for adiposity in children with OM history. Damage to CT as a result of OM could possibly have a detrimental effect on intake of FV. Due to possible intensification of somatosensation of unpalatable bitter or irritant compounds, astringent fruit and cruciferous vegetables, would therefore be most likely to be rejected. Possible effects of OM on FV intake may be demonstrated not only in the number of portions of FV consumed, but also in the variety of FV consumed. Further, given the previously reported effects of OM on high-energy food preferences and adiposity, for comparative reasons the current studies aimed to also look at the effects of past history of OM on adiposity in children of different age groups. All variables would be analysed while controlling for a number of variables previously shown to be associated with adiposity and FV intake in children.

It was hypothesised that, in line with past research, children with history of OM would show higher levels of adiposity in comparison to children without OM exposure and a higher number of OM episodes would predispose to greater adiposity. Further, it was hypothesised that children with OM history would eat fewer FV and lower variety of FV compared to controls. The effects would be expected to be particularly strong for astringent fruit and cruciferous vegetables. Given that the peak of OM incidents is between 6-24 months, early onset effects of OM on FV intake and adiposity will be measured in a sample of 2-3 year olds, and possible late onset effects will be examined in an older sample of 5-9 year olds. As the previous study by Peracchio et al. (2012) measured the effects of OM on weight in 3-5 year olds, these studies were conducted on two samples of previously unexamined age ranges.

5.3. Study I

5.3.1 Methodology

5.3.1.1 Participants

The participants of this study were 99 children (50 boys and 49 girls). Data of 96 children were used in the analyses (49 boys and 46 girls) as 2 parents did not provide information on OM history and 2 children did not consent to being weighed. The mean age of the sample was M=7.20 (SD=1.31) years old. Parental mean age was M=38.91 (SD= 9.52) years old.

5.3.1.2 Materials and Measures

5.3.1.2.1 Otitis media

Information on OM was included in the general demographics questionnaire (see Appendix A-13; details in Chapter II). Parents were requested to state whether their child has ever been diagnosed with an infection of the middle ear. Parents were given three options: yes, no and I'm not sure. Those parents who confirmed a history of the middle ear infection were asked to state the number of times the child was diagnosed.

5.3.1.2.2 Sensory sensitivity

To assess general sensory sensitivity of a child, parents were asked to complete the Short Sensory Profile questionnaire (SSP; Dunn, 1999; see Appendix A-7). Higher scores indicate more typical sensory processing. Details are summarised in Chapter II.

5.3.1.2.3 Adiposity

Weight was expressed as BMI centiles. For details on procedure and conversion see Chapter II. BMI centiles were used to create weight categories, which split children to healthy weight and overweight/obese categories based on the BMI centile cut-offs as recommended by National Obesity Observatory (NHS, 2011), at 85th centile indicating overweight and above 95th centile indicating obese.

5.3.1.2.4 Fruit and Vegetables

FV consumption over the past 24 hours was reported by the parents who completed a measure designed specifically for this study (see Appendix A-12; details are summarised in Chapter II).

5.3.2 Results

5.3.2.1 Descriptive analyses and evaluation of potential covariates

5.3.2.1.1 Adiposity

Children's BMI z-scores (M=0.22, SE=0.11) and corresponding BMI centiles (M= 54.77, SE= 2.97) were normally distributed (KS; p>0.05). Children were split into two groups, healthy weight (n=75) and overweight/obese (n= 20). Due to the small sample for the purpose of these analyses overweight (n=10) and obese (n=10) children were classified as one group, which will be referred to as Overweight.

5.3.2.1.2 Otitis media

Out of 95 children, 25 children (26.3%) were reported to have a history of OM, with the range of lifetime occurrence between 1-12 times, compared to 70 children (73.7%) whose parents did not report OM history. Further, 11 children were reported to have experienced a single OM episode, and 13 to have had more than 1 episode. One parent who reported OM history did not specify the number of episodes. OM sufferers and controls did not differ in age (Mann Whitney U; U= 842.50, p>0.05) or parental age (U= 678.00, p>0.05), and did not differ by gender ($\aleph^2$= 1.08, p>0.05). OM sufferers with a single reported episode did not differ from children with the multiple reported episodes in age (U= 81.50, p>0.05) or parental age (U= 75.00, p>0.05). They also did not differ by gender ($\aleph^2$= 0.54, p>0.05).

5.3.2.1.3 FV intake in portions

Mean FV intake of children and parents and the relationship between them, is reported in Table 5.1 and follows the same over-reporting exclusion criteria as presented in Chapter III (section 3.4.1.1). FV intake did not show normal distribution (KS; $p<0.05$). There were no gender differences in intake of FV, or their subdivisions (see Appendix B-1).

Table 5.1. Mean number of portions and SE (in brackets) of fruit and vegetables reported over the 24 hour period for parents and their children, and the relationship between intake in the parent-child dyads (Spearman's rho).

	Child	Parent	Correlation (r)
Fruit	2.70 (0.21)	3.19 (0.28)	0.26**
Astringent	0.59 (0.09)	0.53 (0.08)	0.47***
Non-astringent	2.11 (0.18)	2.67 (0.23)	0.20*
Juice	0.96 (0.1)	0.51(0.07)	0.23*
Vegetables	3.03 (0.26)	4.25 (0.38)	0.55***
Cruciferous	0.43 (0.07)	0.63 (0.10)	0.67***
Non-cruciferous	2.60 (0.24)	3.63 (0.33)	0.53***
FV (total)	5.74 (0.39)	7.45 (0.54)	0.47***

*<0.05 **<0.01; ***<0.001

5.3.2.1.4 FV intake in variety

Mean values of reported variety for child and the parents, and the relationship between them are presented in Table 5.2. Variety of FV did not show normal distribution (KS; $p<0.05$). There were no gender differences in variety of FV consumed (see Appendix B-2).

Table 5.2. Mean reported variety (SE in brackets) of FV consumed over 24hour period by children and their parents and the relationship between adult and child consumed variety (Spearman's r).

	Child	Parent	Correlation (r)
Fruit	2.48 (0.19)	2.91 (0.25)	0.30***
Astringent	0.56 (0.07)	0.52 (0.07)	0.47***
Non-astringent	1.92 (0.16)	2.40 (0.20)	0.24*
Vegetables	2.78 (0.25)	4.14 (0.37)	0.60***
Cruciferous	0.41 (0.06)	0.58 (0.08)	0.64***
Non-cruciferous	2.39 (0.25)	3.56 (0.33)	0.58***
FV (total)	5.91 (0.37)	7.05 (0.53)	0.51***

*p<0.05; ***p<0.001

5.3.2.1.5 Short Sensory Profile

Data from the SSP were used to assess sensitivity of children across the three domains. The mean scores of the total sample and separate scores of children with OM history and the controls are summarised in Table 5.3.

Children with history of OM did not differ from the controls in sensory sensitivity in taste/smell ($U=748.5$, $p>0.05$), tactile ($U=862.5$, $p>0.05$) or audio/visual domain ($U= 673.5$, $p>0.05$; refer to Table 5.3). Children with multiple history of OM did not differ from children with single exposure in sensory sensitivity in taste/smell ($U= 63.5$, $p>0.05$), tactile ($U=52.5$, $p>0.05$) or audio/visual ($U=59.5$, $p>0.05$) domain.

Sensory sensitivity data were further correlated with BMI centiles, OM frequency and a number of portions and variety of FV in the sample (see Table 5.4). BMI centiles were not associated with sensory sensitivity. Only taste sensitivity showed relationship to both the number of portions consumed and variety of vegetables consumed.

Table 5.3. Mean and SE of sensory sensitivity in three domains displayed for the total sample and separately for children with OM history and the controls.

	Tactile (0-35)	Taste/Smell (0-20)	Audio/Visual (0-25)
Total sample	30.43 (0.39)	15.95 (0.45)	21.92 (0.27)
Otitis media	30.78 (0.79)	15.27 (1.12)	21.43 (0.57)
Single	31.36 (1.04)	14.64 (1.45)	21.45 (0.82)
Multiple	30.36 (1.31)	15.60 (1.92)	21.36 (0.88)
Control condition	30.32 (0.45)	16.16 (0.47)	22.09 (0.31)

Note Minimum and maximum possible score per domain given in brackets.

Table 5.4 Relationships between sensory sensitivity in various domains, BMI centiles and portions and variety of FV in the sample (Spearman's rho).

		Sensory sensitivity		
		Taste	Tactile	Audio/Visual
	BMI centile	0.13	0.13	0.16
	OM frequency	0.03	0.09	-0.05
Portions	Fruit	0.14	0.04	0.09
	Astringent	0.13	-0.01	0.19
	Non-astringent	0.13	0.01	0.05
	Juice	-0.15	0.06	0.05
	Vegetables	0.28**	0.02	0.19
	Cruciferous	0.07	0.03	0.02
	Non-cruciferous	0.29**	-0.12	0.19
	FV Total	0.28**	0.06	0.17
Variety	Fruit	0.12	-0.01	0.04
	Astringent	0.11	-0.04	0.12
	Non-astringent	0.12	-0.03	-0.03
	Vegetables	0.23*	0.06	0.12
	Cruciferous	0.09	-0.16	0.02
	Non-cruciferous	0.24*	-0.03	0.13
	FV Total	0.20*	-0.05	0.12

* $p < 0.05$; ** $p < 0.01$

5.3.2.2 Inferential analyses

In order to test the hypotheses a number of statistical procedures were used. Preliminary data analyses (above) identified potential confounders, which were used as covariates. Statistical procedures and covariates have been summarised in Table 5.5.

Table 5.5 Summary of covariates which will be used in inferential analyses, based on the results of descriptive statistics.

	Analyses examining	Statistical Test	Covariates
	BMI	Mann-Whitney U	n/a
Portions	Fruit Vegetables	MANCOVA	Parental intake (portions) Taste sensitivity
	Astringent, Non-astringent fruit Cruciferous Non-cruciferous veg.	MANCOVA	Parental intake (portions) Taste sensitivity
Variety	Fruit Vegetables	MANCOVA	Parental intake (variety) Taste sensitivity
	Astringent, Non-astringent fruit Cruciferous Non-cruciferous veg.	MANCOVA	Parental intake (variety) Taste sensitivity

5.3.2.2.1 Otitis media and weight

To test the hypothesis that children with OM history would have higher adiposity than the controls without OM history, a Mann-Whitney U test was run. Children whose parents reported OM history had significantly higher BMI centiles compared to controls (Mann Whitney U; U=1.17, n=95, p=0.012; see Fig 5.1). The mean BMI centiles of children with OM history were established at M=67.15 (SD=28.94), compared to the mean of M=50.20 (SD=28.17) in children without a history of OM.

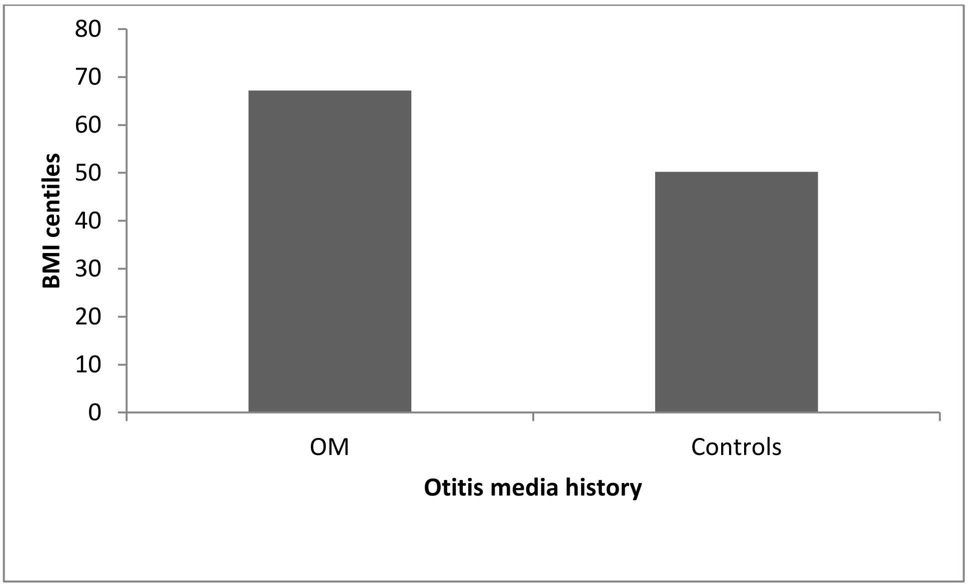

Fig.5.1 Mean BMI centiles of children with OM history and the controls without the history of OM.

When the OM group was further split into Single and Multiple episodes of OM, children in the Multiple occurrence condition were significantly heavier than children in the single occurrence condition (U=112.0, p=0.018). The mean BMI centiles of children with a history of a single episode were established at M= 52.01 (SD=28.04) compared to the mean of M= 77.47 (SD=24.63) for children with the history of multiple episodes of OM (Fig. 5.2.).

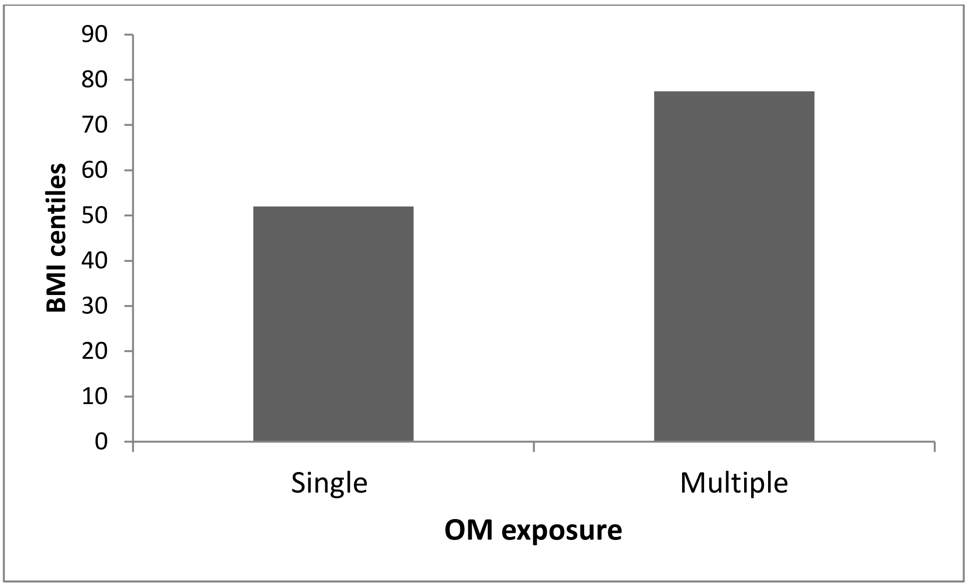

Fig.5.2 Mean BMI centiles of children with a history of a single episode of OM compared to children with a multiple history of OM.

Analysis of likelihood ($\aleph^2$) further showed that children with OM history were significantly more likely to be in the overweight group ($\aleph^2$(1, N=95)=4.56, p=0.03; 45.0%), and children with multiple history of OM were significantly more likely to be overweight compared to children with single episode of OM ($\aleph^2$(1, N=24)= 5.37, p= 0.02; 87.5%).

5.3.2.2.2 Otitis media and FV intake

FV portions

In order to analyse differences between children with OM history and the controls two MANCOVAs were carried out, controlling for parental intake of FV and sensory sensitivity in taste (for vegetables and non-cruciferous vegetable intake). MANCOVA test was appropriate given a large number of dependent variables. Two MANCOVAs were carried out as the dependent variables in the second MANCOVA were the subset of the dependent variables from the first MANCOVA and as such showed high multicollinearity. The dependent variables in first MANCOVA were fruit and vegetables. The dependent variables in the second MANCOVA were sub-divisions of FV: non-astringent fruit, astringent fruit, fruit juice, cruciferous and non-cruciferous vegetables. MANCOVA was appropriate as assumption of variance-covariance matrices was not violated as indicated by Box's M test ($p>0.05$). The assumption of equality of error variances was not violated either ($p>0.05$).

Using Pillai's trace there was no significant difference between OM group and the controls on the dependent variables of intake of portions of fruit and vegetables ($V=0.03$, $F(2,86)=1.38$, $p=0.256$). Further, using Pillai's trace there was no significant difference between the groups on the dependent variables of intake of portions of astringent, non-astringent fruit, fruit juice, cruciferous and non-cruciferous vegetables ($V=0.09$, $F(5,83)=1.71$, $p=0.141$). However, separate univariate analyses showed a significant difference in intake of fruit juice between the two groups. The results of the univariate tests need to be interpreted with caution, given the lack of multivariate differences. The results are summarised in Table 5 below.

Table 5.6 Differences in reported intake of portions of FV of children with and without a history of OM, controlling for parental FV intake and taste sensitivity.

	OM history		Controls		F-value	p-value
Portions	M	SD	M	SD		
Fruit	2.26	2.16	2.82	1.97	0.52	0.473
Non-astringent	2.43	1.92	2.74	1.61	0.09	0.770
Astringent	0.47	0.79	0.71	0.93	0.75	0.389
Fruit juice	1.35	1.27	0.86	0.81	5.87	0.018
Vegetables	3.30	2.90	3.07	2.67	1.84	0.179
Cruciferous	0.57	0.84	0.43	0.71	1.21	0.275
Non-cruciferous	2.74	2.41	2.65	2.37	1.33	0.252

FV variety

The same analyses were carried out using variety of FV consumed as the dependent variable, in order to test the hypothesis that children with OM will consume a narrower variety of FV compared to controls. Two MANCOVAs were again carried out. The first MANCOVA used variety of fruit and vegetables as dependent variables, and the second used subdivisions of FV (astringent and non-astringent fruit, and cruciferous and non-cruciferous vegetables) as dependent variables. Maternal variety of FV consumed and taste sensitivity were used as covariates.

The results of the first MANCOVA showed that using Pillai's trace there was a significant difference between the groups on the dependent variables (V=0.06, F(2,92)=3.15, p=0.048). Further univariate tests showed that the groups differed in variety of vegetables consumed. The results of the second MANCOVA where subdivisions of FV were used as dependent variable, showed that using Pillai's trace there was not a significant effect of OM on the dependent variables (V=0.08, F(4,90)=1.82, p=0.132). Subsequent univariate analysis revealed that there was a significant difference in the variety of non-cruciferous vegetables consumed. Results of the univariate analysis must be however interpreted with caution, given that the multivariate test was not significant. The results are summarised in Table 6.

Table 5.7. Differences between children with history of OM and the controls, in variety of fruit and vegetables consumed.

	OM history		Controls		F-value	p-value
	M	SD	M	SD		
Fruit	2.36	2.27	2.65	1.75	0.05	0.833
Non-astringent	2.00	1.98	2.03	1.48	0.06	0.798
Astringent	0.36	0.56	0.63	0.81	1.18	0.280
Vegetables	3.92	4.05	2.97	2.56	5.73	0.019
Cruciferous	0.68	1.02	0.47	0.77	2.07	0.153
Non-cruciferous	3.28	3.26	2.52	2.21	5.56	0.020

5.3.2.3. Conclusions

The hypotheses were partially supported. Children with history of OM were significantly heavier than the controls without OM history and were more likely to be overweight. Multiple exposure to OM is linked with higher weight, compared to single exposure. Children with multiple history of OM were more likely to be overweight than children with single exposure. There were no differences in the portions of FV consumed between children with OM history and the controls, however there are indications that children with OM history may drink more juice. Further analysis of data showed that children with OM history consumed a greater range of vegetables, with indications that this difference is exclusive to non-cruciferous vegetables. OM related neural damage might affect acceptance of wider range of vegetables, which might suggest comorbidity of CT and GP nerve damage, leading to blunted taste responses from vegetables, resulting in higher intake, although this conclusion is speculative.

5.4 Study II

Results from Study I showed some interesting findings and inspired Study II which was conducted on a younger age group and incorporated a number of improvements, based on the results of Study I. A number of control variables were added in order to ensure more conservative statistical control.
A different, validated measure of FV intake was used, given that the measure used in Study I seemed to aid over-reporting.

5.4.1 Methodology

5.4.1.1 Participants

In total 120 children took part in this study, as a part of a larger project on novel fruit introduction. Only 103 parents provided data on history of OM so 17 parents were excluded from the analyses (details on recruitment and the sample are in Chapter II). There were 42 girls and 61 boys with a mean age of M=29.6 (SD=4.8) months. The mean age of the parents was M=35.3 (SD=5.1) years.

5.4.1.2 Materials and measures

5.4.1.2.1 Demographics

Parents were provided information on breastfeeding duration, pre-term birth and weaning age for control measures (see Appendix A-14; details in Chapter II).

5.4.1.2.2 Parent and Child Neophobia

The Food Neophobia Scale (Pliner & Hobden, 1992; see Appendix A-8) was used to test neophobia in children and parents. Higher scores indicate higher neophobia. For details refer to Chapter II.

5.4.1.2.3 Sensory Profile: SSP

Information about sensory sensitivity in taste/smell, tactile and audio/visual domain was collected using the same measures as described in Study I (see Appendix A-7; details in Chapter II).

5.4.1.2.4 Adiposity

Weight was expressed in the form of BMI centiles and WHtR (for details refer to Chapter II) which were calculated using the same procedure as described in Study I.

5.4.1.2.5 Fruit and Vegetable Intake

FV intake of children and their parents was tested with a Guided One Day Dietary Recall measure (Robinson, et al. 2011; see Appendix A-9). For details refer to Chapter II.

5.4.2 Results

5.4.2.1 Descriptive analyses and evaluation of potential covariates

5.4.2.1.1 Adiposity

One child was removed from the analyses because they did not consent to being weighed. Based on their height and weight, children's BMI z-scores were calculated (M= 0.40, SE=0.12) and were converted to the corresponding BMI centiles (M=61.78, SE=2.65). BMI centiles were not normally distributed (KS; $p<0.05$). Children were divided into healthy weight (n=75), overweight (n=16) and obese (n=10), as recommended by NOO (2011). Children who were classed as overweight or obese were grouped together for the purpose of the analyses and will be referred to as overweight (n=26). Two children were classified as underweight (BMI centile <2%) and were not considered in further analyses, as their weight status might be indicative of feeding issues not accounted for, but which might affect the results.

BMI centiles were not correlated with the control variables: family annual income (Spearman's rho; $r=-0.09$, $p>0.05$), breastfeeding duration ($r=-0.02$, $p>0.05$), weaning age ($r=0.02$, $p>0.05$), neophobia score ($r=0.04$, $p>0.05$) or maternal BMI ($r=-0.003$, $p>0.05$). There were no gender differences in weight ($U=1115.0$, $p>0.05$) and there were no weight differences between children who were born pre-term or full term ($U=631.0$, $p>0.05$). Those variables will therefore not be used as covariates in analyses examining BMI.

The WHtR data were obtained from 95 children, as 8 children showed distress over having their waists measured. The mean WHtR in the sample was M=0.57 (SD=0.04), with higher ratio indicating higher central adiposity. There was a normal distribution of WHtR (KS; $p>0.05$) and no gender differences were found ($t(93)=4.40$, p>0.05). WHtR was not correlated with family annual income (Pearons's r; r=-0.14, p>0.05), breastfeeding duration (r=0.12, p>0.05), weaning age (r=-0.04, p>0.05), neophobia score (r=-0.10, p>0.05), maternal age (r=-0.03, p>0.05) or maternal BMI(r=0.06, p>0.05). As expected, WHtR was negatively correlated with child's age (r=-0.35, p<0.001). For that reason only child's age will be used as covariate in analyses examining WHtR.

5.4.2.1.2 Otitis media

Out of 103 children in the sample, 23 were reported to have had a history of OM (22.3%). In the OM group the range of episodes varied between 1 and 10. A single episode of OM was reported by 12 parents, and multiple episodes were reported by the remaining 11 parents. Children with OM history did not differ from the controls in annual family income ($\aleph^2$ (5, N=103)= 6.73, p>0.05) or education level ($\aleph^2$ 2,N=102)=3.10, p>0.05). There were also no group differences in age, breastfeeding duration, weaning age or maternal BMI. Children with history of OM had significantly older mothers compared to controls and showed higher neophobia compared to controls (for full summary refer to Table 5.8). Children with history of OM and controls did not differ by gender ($\aleph^2$= 0.03, n=103, p>0.05).

Children with history of a single episode of OM did not differ from children with a multiple reported history of OM in any of the following variables: age, breastfeeding duration, weaning age, maternal BMI, maternal age or neophobia score (for full summary refer to table 5.9). There were also no group differences in family income ($\aleph^2$ (4, N=23)=0.77, p>0.05) or education level ($\aleph^2$ (2, N=23)=1.60, p>0.05).

Girls were significantly more likely to have suffered from multiple episodes of OM compared to boys ($\aleph^2$= 5.32, n=23, p=0.021).

Table 5.8 Mean values of various characteristics of children with history of OM and the controls. Differences between the groups were analysed with Mann-Whitney U test.

	OM	Controls	U	p-value
Age (months)	30.0 (4.4)	29.3(4.8)	1016.50	0.443
Maternal age (years)	37.3(4.3)	34.7 (5.1)	1184.00	0.020
Breastfeeding (months)	4.6 (2.0)	4.9 (3.03)	543.00	0.991
Weaning age	5.6 (0.8)	5.7 (2.1)	655.50	0.631
Maternal BMI	24.3 (3.6)	25.8 (6.1)	788.50	0.563
Child's Neophobia	35.3 (11.0)	29.4 (11.3)	969.50	0.045
Maternal Neophobia	28.9 (2.34)	25.2 (1.30)	1088.00	0.09

Table 5.9 Mean values of various characteristics of children with single and multiple history of OM. Differences between the groups were analysed with Mann-Whitney U.

	OM		U	p-value
	Single	Multiple		
Age	28.9 (4.64)	31.2 (4.09)	89.00	0.170
Maternal age	37.0 (3.61)	37.55 (5.16)	69.00	0.880
Breastfeeding (months)	4.9 (1.78)	4.2 (2.24)	31.50	1.000
Weaning age (months)	5.56 (0.90)	5.66 (0.75)	40.50	0.673
Maternal BMI	23.6 (3.22)	24.9 (4.04)	70.00	0.562
Child's Neophobia	33.0 (9.59)	37.6 (12.32)	63.50	0.316
Maternal Neophobia	32.09 (3.55)	25.82 (2.90)	36.50	0.116

5.4.2.1.3 Fruit and Vegetables intake: Portions

The range of reported intake of FV over the 24 hour period was between 0-11 portions. Parents did not report intake of juice unless it was a part of a meal, so intake of juice was excluded from the analyses due to a small mean reported intake (M=0.06 portion a day). Intake of FV or their subcategories all violated the assumption of normality (KS<0.05). Mean values and SE of children's and parental reported intake of FV over the 24 hour period, are presented in Table 5.10. Due to high correlation between child's and maternal intake of FV, parental intake will be controlled for in the analyses examining intake of FV.

Table 5.10. Mean number of portions and SE (in brackets), of fruit and vegetables reported over the 24 hour period for parents and children. Relationship between parental and child's intake reported as r-value (Spearman's rho).

	Child	Parent	r-value
Fruit Total	1.51 (0.12)	0.94 (0.13)	.376***
Astringent	0.34 (0.05)	0.08 (0.03)	.331**
Non-astringent	1.17 (0.09)	0.86 (0.12)	.337***
Vegetables Total	1.45 (0.11)	1.91 (0.18)	.327**
Cruciferous	0.14 (0.03)	0.22 (0.06)	.218[a]
Non-cruciferous	1.28 (0.13)	1.97 (0.33)	.231*
FV (total)	2.96 (0.17)	2.85 (0.21)	.359***

*a p<0.058 *p<0.05, ** p<0.01, *** p<0.001*

FV intake in the sample was not correlated with children's neophobia, age, maternal age, breastfeeding duration, weaning age or maternal BMI. Those variables were therefore not used as covariates in analyses examining intake of FV in children. Intake of fruit was negatively correlated with maternal neophobia and positively with annual family income. Maternal neophobia and annual family income were therefore used as covariates in analyses examining intake of fruit. Intake of cruciferous vegetables was negatively correlated with maternal age and annual family income, which were therefore used as covariates in analyses examining FV intake. For summary of the statistics see Table 5.11. Boys and girls did not differ in the number of any of the consumed portions of FV or their subcategories (p>0.05).

Table 5.11. Relationship between portions of fruit and vegetables consumed, and their subdivisions, with various sample characteristics (Spearman's rho).

Portions	Neo. (ch.)	Age (ch.)	Age (m.)	Breast feeding	Wean ing	BMI (m.)	Neo (m.)	FAI
Fruit	.14	.10	.11	-.13	-.09	-.15	-.28**	.23*
Astringent	-.08	-.01	.17	-.03	-.12	.01	-.26**	.17
Non-astringent	.16	.05	.07	-.10	.03	-.16	-.20*	.11
Vegetables	.01	.06	-.12	-.11	.05	-.05	-.03	-.10
Cruciferous	-.09	-.04	-.25*	.12	-.03	-.08	.05	-.22*
Non-cruciferous	.02	.02	-.09	.10	-.01	-.06	-.01	-.10

*p<.05, ** p<.01

Note Neo= Neophobia; Breastfeeding duration (months); Weaning age; FAI= Family annual income; m.= mother; ch.=child;

5.4.2.1.4 Fruit and vegetable intake: variety

Variety of consumed FV was analysed independent of the number of reported portions consumed. Parents reported the variety of FV consumed by their children in the range of 0-10 different products. The reported variety of FV did not show normal distribution (KS; $p<0.05$). Mean values and SE of children's and parents reported variety of consumed FV, together with the relationship between them, are presented in Table 5.12.

Table 5.12 Mean reported variety of fruit, vegetables and their subdivisions for children and mothers and the relationship between them. SE values given in brackets

	Child	Parent	r-value
Fruit	1.61 (0.11)	0.93 (0.12)	.37***
Astringent	0.35 (0.07)	0.12 (0.04)	.44***
Non-astringent	1.30 (0.09)	0.81 (0.11)	.24*
Vegetables	2.54 (0.16)	3.03 (0.21)	.38***
Cruciferous	0.31 (0.06)	0.44 (0.08)	.35***
Non-cruciferous	2.24 (0.14)	2.41 (0.18)	.30**
FV (total)	4.15 (0.17)	3.97 (0.26)	.42***

*p<0.05; **p<0.01; ***p<0.001

Reported variety of consumed fruit, both astringent and non-astringent was negatively correlated with maternal neophobia. In addition variety of non-astringent fruit consumed was negatively correlated with maternal BMI, and variety of astringent fruit consumed was negatively associated with the age of weaning. Variety of cruciferous vegetables consumed was negatively correlated with maternal age, and intake of vegetables showed trend for negative association with family annual income. Table 5.13 summarises the results. Variables which showed association with fruit or vegetables were used as covariates in analyses examining variety of FV consumed. Boys and girls did not differ in variety of consumed FV or their subdivisions (p>.05).

Table 5.13 Relationship between intake of fruit and vegetables, and their subdivisions, with various sample characteristics (Spearman's rho).

Variety	Neo. (ch.)	Age (ch.)	Age (m.)	Breast feeding	Weaning	BMI (m.)	Neo (m.)	FAI
Fruit	.19	.14	.08	-.05	-.06	-.16	-.35***	.17
Astringent	.01	.07	.15	-.12	-.22*	.15	-.26*	.19
Non-astringent	.19	.11	.06	.02	.03	-.32**	-.27**	.16
Vegetables	-.02	.08	-.11	.11	.05	-.06	-.03	-.19[a]
Cruciferous	-.09	-.06	-.21*	.11	.01	.01	.10	-.19[a]
Non-cruciferous	-.01	.12	-.06	.09	.01	.01	.10	-.19[a]

*p<.05, ** p<.01,***, p<0.001, a p<0.063

Note Neo= Neophobia; Breastfeeding duration (months); Weaning age; FAI= Family annual income; m.= mother; ch.=child;

5.4.2.1.5 SSP

Data from SSP were used to assess sensitivity of children in taste/smell, tactile and audio/visual domain. The results for the total sample and separate results for children with history of OM and controls are presented in Table 5.14. Children with history of OM and the controls did not differ in taste/smell (U=990.00, p>0.05), tactile (U=814.50, p>0.05) or audio/visual sensitivity (U=1025.50, p>0.05). Also, children with multiple history of OM did not differ from children with single reported episode of OM in sensory sensitivity in taste/smell (U=61.00, p>0.05), tactile (U=65.00, p>0.05) and audio/visual domain (U=65.00, p>0.05). Sensory sensitivity in various domains was not correlated with the number of portions of FV consumed. Variety of astringent fruit was positively associated with tactile sensitivity, but other FV groups did not show any association with sensory sensitivity. BMI centiles were not correlated with sensory sensitivity. Only tactile sensitivity was therefore used as a covariate in analyses examining variety of fruit consumed. Data are summarized in Table 5.15.

Table 5.14 Mean and SE of sensory sensitivity in the three domains displayed for the total sample, and separately for children with OM history and the controls without OM history.

	Tactile (0-35)	Taste/Smell (0-20)	Audio/Visual (0-25)
Total sample	29.24 (0.62)	16.19 (0.44)	18.31 (0.44)
Otitis media	29.26 (0.64)	16.48 (0.79)	19.00 (0.77)
Single	29.33 (0.84)	16.67 (1.07)	18.91 (1.08)
Multiple	29.18 (0.95)	16.27 (1.24)	19.09 (1.71)
Controls	29.23 (0.62)	16.11 (0.52)	18.11 (0.52)

Note Minimum and maximum possible score per domain given in brackets.

Table 5.15 Relationship between sensory sensitivity in various domains and the number of portions of FV the child was reported to consume (Spearman's rho).

		Tactile	Taste/Smell	Audio/Visual
	BMI centiles	.06	.03	-.06
	WHtR	.08	.19	.12
Portions	Fruit	.11	.12	.-02
	Astringent	.16	-.02	.12
	Non-astringent	.03	-.02	.08
	Vegetables	-.05	.02	-.03
	Cruciferous	-.01	.06	-.09
	Non-cruciferous	-.03	.05	-.02
Variety	Fruit	.17	-.02	.10
	Astringent	.23*	.01	.06
	Non-astringent	.05	-.06	.11
	Vegetables	-.04	.04	-.10
	Cruciferous	-.01	.13	-.08
	Non-cruciferous	-.06	-.01	-.03

*<0.05

5.4.2.2 Inferential analyses

After examining the results of preliminary analyses of test variables and control variables, a number of statistical procedures were chosen to test the hypotheses. Preliminary analyses showed a number of associations between control variables and test variables. Analyses testing the hypotheses were therefore conducted using a number of covariates to enhance statistical accuracy. Statistical procedures which were used to test the hypotheses alongside appropriate covariates are summarised in Table 5.16.

Table 5.16. Summary of covariates used in analyses testing the hypotheses.

	Analyses examining	Statistical Test	Covariates
	BMI	Mann-Whitney U	n/a
	WHtR	ANCOVA	Child's age
Portions	Fruit Vegetables	MANCOVA	Parental intake (portions) Maternal neophobia Annual income
	Astringent Non-astringent fruit Cruciferous Non-cruciferous veg.	MANCOVA	Parental intake (portions) Maternal neophobia Maternal age Income
Variety	Fruit Vegetables	MANCOVA	Parental intake (variety) Maternal neophobia
	Astringent, Non-astringent fruit Cruciferous Non-cruciferous veg.	MANCOVA	Parental intake (variety) Maternal neophobia Weaning age Maternal BMI Maternal age Tactile sensitivity

5.4.2.2.1 Otitis media and adiposity

BMI

To test the hypothesis that children with history of OM would have higher adiposity than the controls a Mann-Whitney U test was used. The results showed mean BMI centiles of children with history of OM at M=63.9 (SE= 5.78) and the mean of M=61.3 (SE= 3.03) for controls. There were no weight differences between the groups (U=969.00, $p>0.05$). There were also no differences between children with single (M=56.63) or multiple history of OM (M=71.74; U=81.0, $p>0.05$). Children with history of OM were not more likely to be classed as overweight ($\aleph^2$ (1, N=100)= 0.28, $p>0.05$). Also, children with multiple reported episodes of OM were not more likely to be in the overweight group, compared to children with single reported episode of OM ($\aleph^2$ (1, n=23)= 0.38, $p>0.05$).

WHtR

ANCOVA was used in order to analyse WHtR differences in children with history of OM and the controls. WHtR was used as the dependent variable, controlling for age. The results showed a trend for WHtR differences between the groups but missed the level of significance (F (1, 95)=3.49, $p=0.065$). The mean WHtR of children with OM history (M=0.58, SD=0.05) was higher than the controls (M=0.56; SD=0.05). Children with multiple history of OM (M=0.58; SD=0.04) did not have higher WHtR than children with single reported episode (M=0.58; SD=0.06; F (1, 22)= 0.25, $p=0.62$).

Different WHtR cut-off points for overweight have been suggested for boys and girls (Welli et al., 2007). For this reason, another analysis was performed on split-data, based on gender. Subsequent analysis revealed that girls with OM (M=0.60) had significantly higher WHtR than girls without OM history (M=0.56; F (1, 36)= 8.48, p=0.006). In boys, there were no WHtR differences between OM group (M=0.57) and the controls (M=0.57, F (1, 59)= 0.09, p=0.771).[1] There were not enough OM participants to perform split-data analysis based on gender in single and multiple exposure groups.

5.4.2.3 Otitis media and FV intake

Portions

To test the hypothesis that children with OM would eat fewer portions of FV than children without OM, two MANCOVA analyses were carried out. The dependent variables in the first analysis were fruit and vegetables. In the second analysis the subcategories of FV (astringent, non-astringent, cruciferous and non-cruciferous) were used as dependent variables. The control variables used in the first analysis of intake of portions of FV were parental intake of FV, maternal neophobia and annual family

[1] Different effects of OM on WHtR in boys and girls were further analysed in a subsequent ANCOVA where dependent variable was WHtR, and independent variables were gender and OM exposure, controlling for age. The results showed a significant main effect of OM on WHtR (F(1,90)=4.87, p=0.03) and no effect of gender (F(1,90)=1.37, p=0.245). Interaction between OM and gender just missed significance (F(1,90)=3.41, p=0.068). OM group showed higher WHtR than the controls, and girls with OM showed higher WHtR compared to girls without OM history, which difference was not found in boys. Initial data analysis presented earlier (Section 5.4.2.1.2) revealed that girls were significantly more likely than boys to have suffered from multiple episodes of OM. To test whether ANCOVA results presented above showing the effects of OM on WHtR and trend for interaction between OM and gender were due to gender and not the number of OM exposures another ANCOVA was run. Dependent variable was WHtR and independent variable was a newly formed variable in which no exposure, single exposure and multiple exposure groups were compared in one test, controlling for age. The results showed that there were no group differences between the controls, the single and multiple exposure groups (F(2,91)=1.87, p=0.158), indicating that differences found in the above analysis are due to gender differences and not due to frequency of exposure.

income. Control variables used in the second analysis of subdivisions of FV were parental intake, maternal neophobia, maternal age and annual family income.

The assumption of homogeneity of variance-covariance matrices was not violated as indicated by Box's M test ($p>0.05$). Also the assumption of equality of error variance was not violated ($p>0.05$). The first MANCOVA showed that using Pillai's trace there was no effect of OM exposure on intake of portions of FV ($V=0.005$, $F(2, 88)=0.21$, $p=0.813$). Further ANOVA analysis showed no differences between the groups in intake of portions of FV. The second MANCOVA also showed that using Pillai's trace there was no effect of OM exposure on intake of portions of astringent, non-astringent fruit, cruciferous and non-cruciferous vegetables ($V=0.02$, $F(4,78)=0.46$, $p=0.767$). Subsequent ANOVA analysis also did not reveal differences between the groups. For the summary of the results see Table 5.17.

Variety

Differences in variety of FV consumed were analysed in two separate MANCOVAs. Dependent variables in the first MANCOVA were variety of fruit and vegetables consumed and in the second MANCOVA subdivisions of FV: astringent, non-astringent fruit, cruciferous and non-cruciferous vegetables. Control variables used in the first MANCOVA were maternal neophobia and maternal intake of FV. Control variables used in the second MANCOVA were parental intake of FV, weaning age, maternal neophobia, maternal BMI and maternal age. The assumption of homogeneity of variance covariance matrices was not violated as indicated by Box's M test ($p>0.05$). Also homogeneity of error variance was equal between the groups ($p>0.05$).

In the first MANCOVA it was evident that using Pillai's trace there was no effect of OM exposure on variety of fruit or vegetables consumed (V=0.01, F(2, 89)=0.43, p=0.638). Further univariate analysis did not reveal group differences in variety of fruit or vegetables consumed. Also the second MANCOVA, using Pillai's trace did not show effects of exposure to OM on variety of astringent, non-astringent fruit, cruciferous and non-cruciferous vegetables (V=0.40, F(4,68)=0.72, p=0.583). Subsequent univariate analyses of individual components did not reveal group differences. The results are summarised in table 5.18.

Table 5.17 Differences in reported intake of portions of fruit and vegetables of children with and without the history of OM

Portions	**OM history**		**Controls**		**F-value**	**p-value**
	M	*SD*	*M*	*SD*		
Fruit	1.57	1.12	1.51	1.14	0.05	.832
Astringent	0.42	0.46	0.30	0.57	0.39	.535
Non-astringent	1.15	0.91	1.19	0.94	0.12	.728
Vegetables	1.52	1.19	1.42	1.09	0.40	.527
Cruciferous	0.05	0.23	0.14	0.32	0.64	.425
Non-cruciferous	1.46	1.14	1.25	1.10	1.03	.313

Table 5.18. Differences in reported variety of fruit and vegetables of children with and without history of OM.

Variety	**OM history**		**Controls**		**F-value**	**p-value**
	M	*SD*	*M*	*SD*		
Fruit	1.72	1.18	1.61	1.10	0.69	.409
Astringent	0.46	0.66	0.24	0.49	1.91	.172
Non-astringent	1.24	0.93	1.37	0.98	0.58	.448
Vegetables	2.78	1.56	2.51	1.56	0.38	.574
Cruciferous	0.31	0.48	0.31	0.56	0.01	.950
Non-cruciferous	2.62	1.61	2.28	1.44	0.43	.513

5.4.2.4 Conclusions

The hypotheses were not supported, however some interesting findings emerged. The results showed that in children between 2-3 years old, there were no weight differences, based on BMI centiles, between children who suffered with OM and the controls without OM history. However, girls with OM history had significantly higher WHtR compared to girls without OM history, indicating higher central adiposity. This effect was not seen in boys. There were no group differences in the number of portions of FV consumed, or their subcategories. Also the variety of FV consumed did not differ between the groups in this age range.

5.5 Discusssion

The hypotheses were partially supported. In the sample of 5-9 year olds, children with OM had significantly higher BMI than the controls and children with multiple exposure to OM had BMI higher than children with single OM exposure. In the sample of 2-3 year olds, there were no differences in BMI centiles between the OM group and the controls, and no differences were found between the multiple and the single exposure group. However, girls with OM exposure had significantly higher WHtR compared to girls without OM exposure, which effect was not seen in boys.

FV intake was analysed separately for the number of portions and variety of FV consumed. In the sample of 5-9 year olds, there were no differences in intake of portions of FV or their subcategories, other than the difference in consumption of fruit juice, which was higher in the OM group. However, children with OM history consumed higher variety of vegetables, compared to controls, and more specifically the effect was exclusive for non-cruciferous vegetables. There were no observable effects of OM exposure on FV intake in portions or variety in the 2-3 year olds.

5.5.1 OM and adiposity

The results of this study showed that 5-9 year old children with OM history have significantly higher weight compared to their peers without OM history. In the younger sample of children this effect was not evident when adiposity was expressed as BMI centiles. However, when central adiposity was analysed, girls with OM history had significantly higher WHtR compared to girls without OM history, indicating larger central adiposity, which was not seen in boys of the same age group. Furthermore, in the older sample, this group difference in BMI seems to be driven by children with multiple history of OM, who had significantly higher mean BMI centiles compared to children with a single OM exposure, whose mean BMI centiles were similar to the controls without OM history. The same pattern was visible in the younger age group, but the differences were not significant. The results of this study support previous research on OM and adiposity, and indicate that girls with OM history demonstrate a trend for greater central adiposity as early as in 2-3 year olds, and show clear BMI differences in both genders at 5-9 year olds. This study also demonstrates that there might be early-onset gender differences in effects of OM on central adiposity.

Peracchio et al. (2012) also showed that 3-5 year old children with the highest OM exposure averaged higher BMI centiles compared to children without OM history, showing that the number of OM exposures might be a significant contributor to higher weight in this age group. The present studies used children in the age groups not studied by Peracchio et al. (2012) i.e. 2-3 and 5-9 year olds, which together with Peracchio's et al. (2012) report, gives a full picture of the possible relationship between OM exposure and adiposity. In the present report, there were no differences in BMI centiles between children exposed to OM and the controls in 2-3 year olds, but WHtR differences indicate that OM effects on adiposity may begin to already demonstrate in the early childhood. Together with Peracchio's et al. (2012) report, it seems that while in 2-3 year olds the effects of OM on adiposity may be only beginning to show, in 3-5 year olds they become more apparent, and are fully demonstrated in the oldest age group of 5-9 year olds. In the 5-9 year old sample, differences in BMI centiles were quite pronounced as they differed by 17 centiles, with OM group averaging at 67 BMI centiles, in the upper range of the third quartile, while the control group averaged exactly in the middle. Further analysis also showed that children with OM history were more likely to be overweight (≥85 BMI centile) compared to controls, which is an important public health concern. Interestingly, as shown in the single vs. multiple exposure analysis, single exposure to OM may not show significant effects on weight, as the mean BMI centile of children with single exposure was only marginally higher than that of the controls. This is also in line with Peracchio et al. (2012), as in that study there were no weight differences between the controls and single exposure group, but the differences were found for the highest exposure group. The results of the present studies suggest that OM might show gradual effects on weight, which become more apparent in the later stages of development, possibly due to the ability of children to make more autonomous eating decisions as they get older.

Gender differences in the effects of OM on central adiposity have been surprising, and as demonstrated in the results, they were independent from the frequency of exposure. If according to the theory OM damages the CT nerve, then gender differences in central adiposity between OM exposed group and the controls are difficult to interpret. Peracchio et al. (2012) found that boys with OM history had higher relative liking of fat/sugar compared to girls with OM history but the opposite was found in the 2-3 year olds in this study. Snyder et al. (2003a,b) demonstrated that women with OM history did not show the expected pattern of age-dependent decrease in liking of sweet foods. The higher WHtR in girls with OM history found in the present study may be perhaps reflective of different liking of sweet foods, but this is speculative and beyond the scope of this thesis. Unfortunately, waist circumference data were not collected for the older sample of children, but it would be interesting to see if WHtR differ by OM exposure in the older children. Studies by both Peracchio et al. (2012) and Snyder et al. (2003a, b) both indicate that gender differences in effects of OM on adiposity may be mediated by different preferences and/or liking of energy dense foods, but the mechanism remains unknown. However, an alternative explanation for adiposity differences resulting from Otitis media could be due to the treatments used. Otitis media in difficult cases is treated with the use of antibiotics. The use of antibiotics has been previously linked to the risk of overweight in children, via changes in gut microbiota, particularly in prolonged use or in early exposure to antibiotics (Saari, Virta, Sankilampi, Dunkel & Saxen, 2015). Information on treatment methods in this sample would need to be obtained in order to control for the prolonged or early use of antibiotics.

5.5.2 Otitis media and FV intake

The results showed different associations between OM and FV intake in the two samples. In the younger sample, there were no intake differences in the number of portions or variety of FV or their subcategories, between children with OM history and the controls. However, in the older sample, children with OM history consumed more portions of fruit juice compared to the controls, and ate a larger variety of non-cruciferous vegetables. In the older sample, as discussed earlier, there were clear weight differences between OM exposed children and the controls. Higher intake of fruit juice by OM exposed children in the older sample is therefore in line with past research which indicates that fruit juice consumption might be related to higher weight (e.g. Wojcicki & Heyman, 2012). This might suggest that OM exposure predisposes to higher weight possibly by altering palatability of foods related with overweight risk such as fruit juice.

Surprisingly, there were no differences in the number of consumed portions of FV or their subcategories between OM exposed children and the controls in both age groups. It was expected that possible damage to CT nerve due to OM exposure would demonstrate in different eating patterns, especially in astringent fruit and cruciferous vegetables intake, which are characterised by strong taste sensations. However, this was not the case. This shows that FV show equal quantity of intake rates irrespective of OM exposure. However, differences were evident based not on quantity consumed, but variety of FV consumed, which is as important as quantity, to ensure intake of all necessary nutrients. Children in the older sample, who were exposed to OM consumed higher variety of vegetables, more specifically the non-cruciferous vegetables. Bartoshuk et al. (1996) in her release of inhibition model proposed that CT damage due to OM would lead to release of inhibition of CT nerve on the GP nerve, thus increasing taste sensations, which would intensify the unpleasant bitter flavour of cruciferous vegetables and astringent fruit. However, she also proposed that damage to both CT nerve and GP nerve would result in dampened sensory signal transduction from both CT and GP nerves, thus lower perceived intensity of bitter compounds in, for example, cruciferous vegetables and astringent fruit. The results of this study suggest that OM exposed children might be experiencing lower intensity of bitter compounds from vegetables. However, this difference in variety was exclusive to non-cruciferous vegetables only. This suggests that cruciferous vegetables and astringent fruit might be equally aversive to all children and equally commonly rejected, irrespective of exposure to OM. Children who have not been exposed to OM might show higher sensitivity to the marginal concentrations of bitter compounds present in non-cruciferous vegetables, as their taste transducing nerves are intact, and as a result might show higher rejection rates.

Interestingly, in the group of 2-3 year olds, OM exposed children displayed higher neophobia rates compared to the controls. This is an interesting finding as it suggests that neophobia in children may have physiological background via taste signal transduction, which would be affected by OM related CT damage, even though the effects on consumption of FV are not evident yet in this age group. Higher neophobia in OM exposed children seems to contradict the data that in 5-9 year olds OM exposed children consumed a greater variety of vegetables. Unfortunately, neophobia data were not collected for the older sample, so the relationships between OM, neophobia and intake of FV cannot be explored in greater detail in this age group.

Individual differences in experiences of OM deserve further consideration. It should be noted that standard deviation for FV intake data was much higher in the OM group compared to controls, suggesting that there might be more individual differences in intake of FV among the OM sample. These individual differences might be due to different severity of OM episodes or different age of onset of the first exposure, which unfortunately was not measured in this study, but which has been previous shown to affect weight (Nelson et al., 2011). The large standard deviation in FV intake among the OM sample indicates that a division into the frequency of exposure categories may be too simplistic, as it devaluates the importance of severity of OM episodes and it overlooks differences in treatment strategies, which all might contribute to CT damage. It is difficult to separate the effects of frequency and severity, as recurrent OM is likely to result in more severe episodes and would ultimately lead to more aggressive treatment strategies, including surgical treatment. Severity of OM has not been analysed in the present studies, however high standard deviations in the DVs for the OM group suggest that frequency of exposure is not equivalent to the level of possible damage to CT and GP nerve, and suggests large individual differences in possible effects of OM on adiposity and FV intake. Large individual differences might also result from the fact that OM group comprised of children with both single and multiple reported episodes, as the small number of participants in the OM group did not allow for the more intricate analysis of several OM groups based on frequency of occurrence.

5.5.3. Limitations

The limitation in both of the studies was the FV measure used. The FV measure used in the 5-9 year old sample seemed to lead to over-reporting of intake as parents seemed to report higher intake of FV than is feasible. The number of portions reported exceeded the national data (Public Health England, 2014) and did not seem realistic. In order to improve the FV reports, a different measure was used in the subsequent study on the younger sample, however in this case the parents did not seem to report the full intake, and did not report the intake of fruit juice, as they probably did not consider it a part of a meal, so intake of fruit juice could not be measured in the younger population. Reliance on parental reports of FV also poses some methodological problems. Future research should also aim to collect data on the broader diet of children, not only restricted to FV consumption. Furthermore, the measure of neophobia used in Study II was not ideal as it contained some age inappropriate items. The sensory sensitivity measure was also suboptimal as it did not allow for testing the unique contribution of taste sensitivity, as taste and smell sensitivity were measured within one dimension. This is problematic as Otitis media infection is supposed to affect dietary choices via changes in sensory sensitivity, so establishing general sensory sensitivity is crucial. In this sample sensory sensitivity was not linked to Otitis media, perhaps because the measure is not detailed enough. A different measure of sensory sensitivity, perhaps a behavioural one, would be more appropriate.

In both studies the sample was not fully representative of the UK population as the majority of parents were from a white, high socio-economic background, which would also explain lower than expected number of OM exposed children. Another limitation is the lack of waist circumference data for the older sample, as it would be interesting to see whether OM effects on central adiposity still show effects in the older sample of children. Another shortcoming of the studies is a small sample of children with OM and lack of information on the first onset of OM and severity of the illness. Data on any hearing impairments which might be suggestive of severity of OM were also not collected. More balanced distribution would provide a better opportunity to compare the differences between OM group and the controls, and would provide an opportunity to further split the OM sample based on first onset of exposure, severity of illness and build more OM groups based on the number of exposures.

5.5.4 Conclusions

The results of the present studies showed that OM may have detrimental effects on children's adiposity. OM may lead to higher adiposity which begins to demonstrate in the early childhood in girls but not in boys. During later stages of development OM effects on weight are clear in both genders, with children who have been exposed to OM showing significantly higher adiposity than the controls. This effect seems to be more profound in children with multiple OM exposure, while children with single OM exposure seem to show similar weight to those without OM history. Older children with OM history are also more likely to be overweight/obese. There were no FV intake differences between the OM and the control group in the younger sample of children. However, OM exposed children in the older sample were reported to consume more fruit juice, and contrary to the hypothesis, they were reported to consume higher variety of vegetables, and more specifically non-cruciferous vegetables, but these results need to be taken with caution as multivariate tests were not significant. Interestingly, the patterns of differences in intake of FV coincide with the patterns of increased adiposity. Children in the younger age group who had history of OM did not show clear differences in adiposity and no differences in FV intake were seen in this age group. However, in the older age group there were clear differences in adiposity across the two groups, and some differences in eating patterns were noted too. This suggests that OM may lead to changes in eating patterns which may lead to increased adiposity in middle but not early childhood. This supports the theory that OM related changes in dietary patterns and adiposity may be caused by changes in taste perception. Further research is needed on how individual differences in perception of taste qualities may affect intake of FV. This will be the focus of the next chapter.

Chapter VI
Effects of sucrose detection threshold and weight status on intake of fruit and vegetables in children.[2]

6.2 Abstract

Past research on the relationship between taste sensitivity and fruit and vegetable (FV) intake in children has focused on sensitivity to bitter taste. The effects of sensitivity to sweet taste on intake of FV have never been investigated. Furthermore, the effects of children's weight on intake of FV are inconclusive. This study measured the effects of Sucrose Detection Threshold (SDT) and weight status on intake of FV in children. The participants of this study were 99 children between 5-9 years old. Parents reported their own and their children's 24 hour intake of FV and completed a measure of children's sensory sensitivity. Children completed the triangle test with suprathreshold concentrations of sucrose ranging between 0.2%- 1.6%, in 0.2% increments. Two MANCOVAs showed that, controlling for parental intake and children's sensory sensitivity, there was a main effect of SDT on intake of fruit ($p<0.05$), which was exclusive to non-astringent fruit ($p<0.05$), and cruciferous vegetables ($p<0.01$). Weight status had no effect on intake of FV. Mechanisms behind the effects of SDT are discussed in the context of past research on bitter taste sensitivity.

[2] Fogel, A. & Blissett, J. (2014). Effects of sucrose detection threshold and weight status on intake of fruit and vegetables in children. *Appetite,* 83, 309-316.

Chapter VII
General discussion

7.1 Introduction

This chapter will summarise the findings of this thesis. As detailed interpretation and discussion of individual findings was documented separately in every empirical chapter, this chapter will be devoted to summative interpretation of the findings. Strengths, limitations and directions for future projects will be discussed.

7.2 Summary of aims

The aim of this thesis was to explore various internal and external predictors of FV intake in children. While every chapter has been focused on a different factor, a number of covariates were tested alongside the main hypotheses, and these included both external and internal covariates. This thesis took a novel approach to measuring intake of FV, which were tested not only as a unified concept, but were also approached with appreciation of their different sensory properties and as such, the effects of internal and external factors on consumption of individual subgroups of FV were tested. Furthermore, FV intake was assessed not only with regards to the quantity consumed, but also expressed as variety , which is equally important for a balanced diet but which might also be characterised by different drivers to those of quantity. The thesis tested whether intake of FV in children is associated with lifetime exposure to FV, liking of FV, selected parental feeding practices, middle ear infection history and sensitivity to sweet taste expressed as SDT level. A model was created to represent the findings and is presented in Fig 7.1.

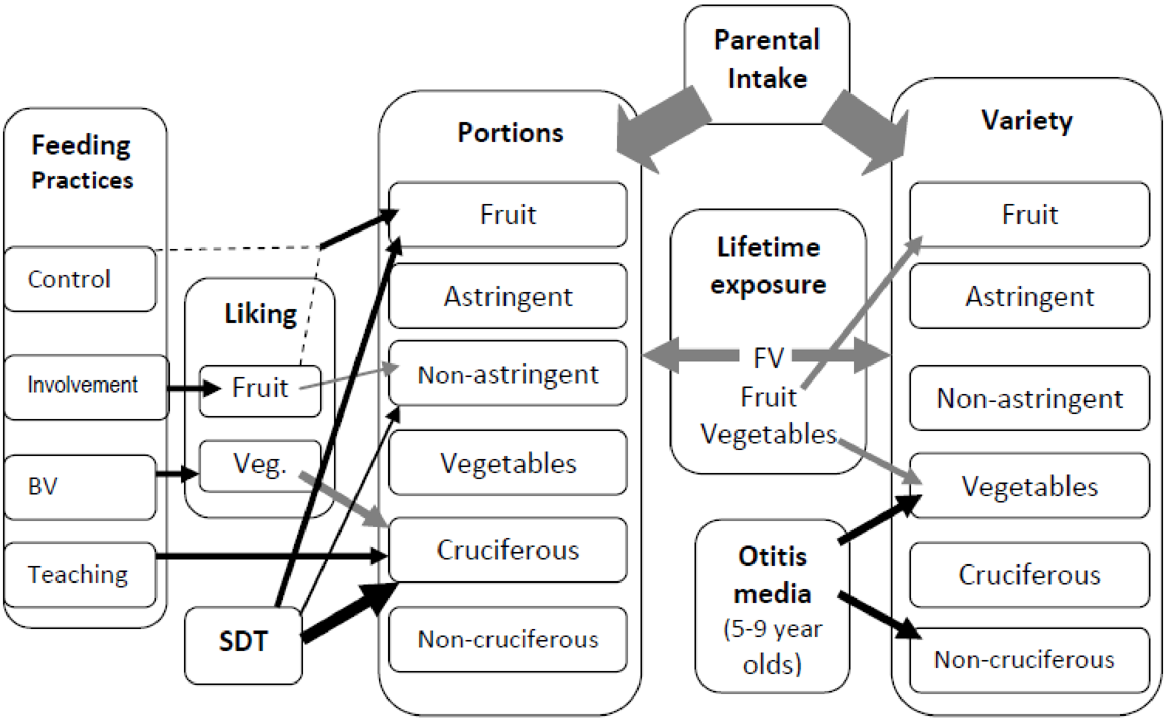

Fig. 7.1. A model representing the findings of this thesis. This model includes only the findings driven by hypotheses and does not include the covariates tested alongside the hypotheses. Black arrows were used for tests of group differences. Grey arrows were used where relationships were tested and so the direction of the arrows represents the direction assumed in the hypotheses, but the actual direction of the links is at present unknown and is not evident from the findings of this thesis. That link could be reversed or the relationship may be bi-directional. Thickness of the arrows represents the strength of the relationship. Dotted arrows represent interaction effects.

7.3 Summary of findings

7.3.1 Fruit

The results presented in this thesis confirmed that intake of fruit has different drivers than intake of vegetables and as such the two groups need to be assessed separately. The preliminary results showed that in the older sample (5-9 year olds), children consumed fewer portions of fruit compared to vegetables (approximately half a portion of average difference), while in the younger sample (2-3 year olds) the number of portions of fruit and vegetables consumed was similar. This is somewhat surprising as past reports have shown that children generally eat more fruit than vegetables (e.g. Forestell & Mennella, 2007) and that younger children eat more fruit than older children (Lorson et al., 2009). When analysing variety of fruit consumed, in the older sample 24 hour variety of fruit consumed was lower than variety of vegetables and this was the case also in the younger age group, who despite consuming equal number of portions of fruit and of vegetables, consumed higher variety of vegetables , indicating that younger children eat more portions of a smaller variety of accepted fruit. How small that variety is deserves further consideration and data collected from a larger selection of days would need to be collected.

While there is a consistent link between children's and parent's intake of FV, that link was weaker for fruit than it was for vegetables, in both age groups. This is also not consistent with past reports, which showed higher similarity between children's and parents' intake of fruit than that of vegetables (e.g. Reinaerts et al., 2007). Perhaps, the relationship between parental and child's intake of fruit was not that strong in these samples because parents in both samples generally ate fewer portions of fruit than of vegetables and so distribution of variance was smaller for parental data. Furthermore, these were self-selected samples with high SES and perhaps with higher interest in healthy eating or nutrition, which may explain those unusual findings.

The results from Chapter III revealed that lifetime exposure to greater diversity of FV predicted 24 hour diversity of fruit consumed but not fruit quantity, and that link was again weaker for fruit than vegetables. While children who have been exposed to more diverse FV do not seem to consume greater amounts of fruit, they seem to accept more different types of fruit and so there are visible benefits of exposing children to diverse flavours of FV. This is consistent with past research which showed that exposing children to various flavours of FV may aid acceptance of new FV (Birch & Fisher, 1998) and so may influence diet diversity. The conclusions that can be drawn from that chapter are that exposing children to various flavours of FV may aid intake of greater amount of FV and greater acceptance of different types of FV. To what extent child's characteristics, such as neophobia, insults to CT or sweet taste sensitivity, are a barrier to successful exposure, needs further consideration and is beyond the scope of this thesis.

While fruits were generally liked in the younger sample (Chapter IV showed that 92% of children were reported to like fruit), parents can further attempt to increase that liking by involving children in meal planning and preparation; a feeding strategy which was associated with higher fruit liking. Whether that strategy would be equally successful in children with higher neophobia or lower levels of liking, requires further research, however the results presented in this thesis show that, potentially, liking of fruit can be increased by exposing children to non-taste sensory properties of fruit during meal preparation or simply by involving the child in grocery shopping. While causation must not be implied from the data presented, past research does show that exposing children to non-taste sensory properties of FV may increase acceptance of novel FV (Dazeley & Huston-Price, 2015).

Liking and intake of fruit evidently have different correlates and so an increase in liking must not be perceived as a behavioural increase in intake of FV. What could be seen in Chapter IV was that correlates of intake of FV were focused on the parent (parental intake, parental age, family income and parental neophobia), while correlates of child's liking were a mixture of child (child's neophobia, child's age, child's

WHtR) and parent-centred factors (parental BMI and family income). In general, whether the child likes fruit is affected by their characteristics and whether the child eats fruit is affected by parental factors. The results of this thesis suggest that the focus of interventions should therefore not be on increasing liking, but on measurable increase in intake of FV. What needs to be noted is that child's liking was based on parental report and to what extent child's characteristics (e.g. adiposity) and behaviours (e.g. fussiness) affect parental perception of child's likes and dislikes is unknown. Past research did however show that parental reports of children's likes are accurate (e.g. Byers et al., 1993) and PALS has been shown to be a reliable indicator of child's FV intake (Scarmo et al., 2012).

It also seems that the link between liking and 24 hour intake of fruit is attenuated by the parental feeding practice of child control. The results presented in this thesis are however somewhat controversial. As was expected, where parents allowed their child more control over their eating, those children who liked fruit ate a lot of it, and those who did not like fruit, did not eat much of it. The controversy in the results lies in parents who imposed a high level of control over their child's eating. While past research suggested that higher parental control may have negative effects on child's eating behaviours, the results presented in this thesis suggest that children of the more controlling parents who showed lower fruit liking consumed more fruit than children who had less controlling parents and lower fruit liking. Perhaps imposing parental control may have both positive and negative effects- positive because it is associated with higher intake of fruit when children's liking of fruit is low, and negative because as based on past research, it may be also associated with eating in the absence of hunger (Birch et al., 2003). Long-term effects of higher control over child's eating are unknown and require further research However, perhaps in the case of children who dislike fruit, higher control of child's feeding would secure a diet richer in FV.

When looking at the internal predictors of fruit intake, there were no differences in intake of fruit between children with history of middle ear infections and those without. Because in the older sample, there were differences in adiposity between OM children and the controls, it was expected that OM history would be associated with differences in dietary patterns, however there was no evidence that OM history might be linked to fruit intake. Peracchio et al. (2012) found that in pre-schoolers children with history of OM were heavier than the controls and also showed lower liking of fruit on the PALS scale, compared to the controls. The results presented in this thesis do not however show measurable differences in intake, and as previously discussed FV liking does not necessarily translate to intake. However, Peracchio et al. also showed that OM effects are dependent on the frequency of OM episodes, and so a larger sample with higher variance of OM episodes is needed to test the potential effects of frequency of OM exposure on intake of fruit in children.

In the subsequent chapter (Chapter VI) it was revealed that intake of fruit varies by SDT. Children with moderate SDT were reported to eat more portions of fruit, compared to children with low SDT (those who show higher sensitivity to sweet taste). Children with the lowest sensitivity to sweet taste also consumed fewer portions of fruit, however that difference missed significance. Those results show that internal predispositions may affect intake of fruit and show that when looking at eating behaviour in children, external influences must be considered alongside the internal predispositions. What needs to be further considered is to what extent individual sweet taste sensitivity affects palatability of different foods and whether sweet taste sensitivity is a phenotype that is parallel or separate from bitter taste sensitivity. This is a novel, but promising approach to understanding our internal predispositions for affinity or aversion to FV. Children with moderate sweet taste sensitivity may require less external facilitation than children who have low or high sensitivity to sweet taste, which seems to be a barrier for fruit intake.

To what extent those internal barriers can be overcome is beyond the scope of this thesis, but requires further research attention. The future of intervention programmes targeting intake of FV lies within customisation of interventions i.e. focusing on promoting certain parental feeding strategies (e.g. child involvement), providing appropriate home environment (e.g. by exposure to various flavours), while showing appreciation of internal predispositions such as child neophobia and sensory sensitivity to different tastes. It is therefore necessary to recognise individual differences in perception of tastes which may have behavioural consequences. This is particularly important in the case of children who show high rejection rates of FV. Parents of such children should be made aware that children may show high rejection rates of FV because they perceive the flavour of those FV in a different way, either more or less intense. In the case of the most fussy children it may be therefore recommended to expose them to the more sweet or calorific fruit, which have low irritant properties.

7.3.2 Astringent fruit

Intake of astringent fruit was analysed as a subgroup of fruit which has strong sensory properties and is considered the healthiest among fruit, and at the same time shows low intake rates (Laaksonen et al, 2011). The results presented in this thesis show that children and parents consume alarmingly few astringent fruit, and younger children eat fewer astringent fruit than older children. Also, interestingly while the correlation between parental and child's intake of fruit in general was moderate, relationship between intake of astringent fruit was much stronger. This indicates the uniqueness of astringent fruit which have different predictors of intake than fruit in general, and depend more on parental intake compared to intake of other fruit.

Intake of astringent fruit was not linked to lifetime exposure to fruit or to FV, which indicates that promotion of astringent fruit intake needs to have a more active form than mere exposure. General liking of fruit was also not linked with intake of astringent fruit, showing that intake of astringent fruit is low independent of fruit liking. What does contribute to intake of astringent fruit is child's age, as older children eat slightly more astringent fruit than the younger ones, which coincides with decrease in neophobia levels in the older children (Dovey et al., 2007). However, in the younger sample, maternal levels of neophobia were associated with child's intake of astringent fruit, showing that those toddlers who had more neophobic mothers ate fewer astringent fruit. More neophobic mothers might expose children to fewer astringent fruit, and are themselves less likely to consume a diverse diet, thus limiting children's exposure to diverse FV (Howard et al., 2012). This shows how maternal influences may indirectly affect child's intake, by decreasing their chances of exposure to various types of astringent fruit.

Looking at the internal correlates of intake of astringent fruit, history of middle ear infections surprisingly was not associated with intake of astringent fruit. It was expected that CT damage possibly as a result of OM history, would show some effects on intake of FV, and those effects would be particularly visible on fruit which have strong astringent properties. This however was not the case. However, intake of astringent fruit was very small across both samples, which likely affected the power to detect any differences.

Further, SDT was also not linked to intake of astringent fruit. Past research showed that people highly responsive to astringency consume less astringent foods and are less familiar with them compared to people with low astringency responsiveness (Dinnella et al., 2011). The lack of differences between children with various SDT status in intake of astringent fruit suggests that sensitivity to astringency and sweetness are not interdependent and are separate phenotypes, so sensitivity to astringency and sensitivity to sweetness are not necessarily convergent. Dinella's et al. study was however conducted on an adult sample, who likely had higher familiarity with astringent foods. An alternative explanation is that perhaps those differences were not evident between children with different SDT because astringent fruit are generally less liked, their intake rates were very small and seemed to be equally aversive to all children, independent of OM history or sweet taste sensitivity. Perhaps a more sensitive measure of intake such as weight of fruit rather than portions consumed would reveal some subtle differences in intake. However, past reports showed that while sourness or astringency is generally disliked in large concentrations, for a third of children liking of sourness increases with concentration and the highest concentration is the most preferred one (Liem & Mennella, 2003). That unusual response corresponded with the highest intake of FV and including fruit with astringent properties. The exact mechanism is not known, however perhaps this liking of extremely sour taste in those children might be reflective of higher sensitivity to sweet taste or higher responsiveness to sweet-to-sour ratio. Universally sweet/sour flavour is liked (Liem and Mennella, 2003) and sweetness suppresses sourness, so perhaps children who like extremely sour tastes have a different perception of sweet-to-sour ratio in foods. Further research should explore the link between sensitivity to sweet and sour taste and its potential effects on astringent fruit liking and intake.

Other factors that might affect intake and liking of astringent fruit are cost and availability. Astringent fruit are usually seasonal (unless bought processed) and are usually more expensive than non-astringent fruit, which might be a barrier to provision and intake. What is not available to children cannot be consumed, which would help to explain the lack of any effects across all the studies conducted in this thesis. Furthermore, astringent fruit are also typically lower in calories than non-astringent fruit, which may be a barrier for flavour-nutrient learning, and as such is in disadvantage compared to the sweeter fruit. Astringent fruit are high in irritant properties, low in energy, expensive and seasonal which makes them particularly difficult to promote. However, while the results presented in this thesis do not show that intake of astringent fruit is driven by intrinsic predispositions or extrinsic factors, this requires further investigation, particularly with regards to testing differences in palatability of astringent fruit in children with history of OM and by SDT status.

The results presented in this thesis do indicate that astringent fruit have different correlates than non-astringent fruit and as such intake of astringent fruit should be further investigated. Results indicate that as none of the feeding practices affected intake of astringent fruit, they might be particularly resistant to promote with the use of conventional strategies. Astringent fruit are very nutritious, but the very same chemicals that determine their healthfulness also contribute to their unpalatable taste. Public knowledge of the benefits of astringent fruit is negligible, as public message with regards to FV is mostly restricted to promotion of quantity not quality of products ('five a day'; 'just 1 more'). Nutrition education is a compulsory part of the curriculum in primary and secondary schools in the UK, so perhaps there should be a greater emphasis to promote the message that while all FV are healthy and need to be consumed in sufficient amounts on a daily basis, there are clear nutritional differences between various types of FV. As such children should be taught not only to eat 5 portions of FV a day, but also should be taught that berries may help prevent cancer and bananas can make the heart stronger (American Institute for Cancer Research, 2011). In terms of implications, perhaps also there should be more public knowledge on how to overcome the irritant properties of astringent fruit, by for example serving them with yoghurt, which would mask the sourness and astringency.

7.3.3 Non-astringent fruit

Intake of non-astringent fruit was not linked to lifetime exposure to FV. It seems that lifetime exposure to FV may affect the overall intake of portions and variety of fruit, without differentiation to astringent or non-astringent fruit. Further, the results from Chapter IV showed that children who were reported to like fruit ate more of non-astringent fruit, which might be due to the fact that the majority (all except one) of the fruit on the PALS scale were non-astringent, and so this scale was perhaps measuring liking of non-astringent fruit only, which translated to intake. Parental feeding practices were not linked with non-astringent fruit intake which might be due to the fact that what is highly liked and consumed does not advantage from further external facilitation.

Looking at the internal drivers of non-astringent fruit intake, children with OM history and those without did not differ in intake of non-astringent fruit. This however is not surprising as any differences due to OM history were expected to be evident in astringent fruit intake. However, there were differences in non-astringent fruit intake between children with different levels of SDT. Mimicking the patterns of intake of fruit in general, children with moderate SDT consumed the highest amount of non-astringent fruit, compared to those with low or high SDT. The results suggest that individual levels of sensitivity to sweet taste affect intake of fruit, but that intake is exclusive to non-astringent fruit. Children with low and high SDT seem to be disadvantaged when it comes to intake of fruit, particularly the non-astringent type, however the exact mechanism is at present unknown. It seems that extreme sensitivity, whether low or high, may be a barrier to intake of fruit.

7.3.4 Vegetables

As discussed before, children in the older sample ate more vegetables than fruit, both in terms of portions and variety. The link between child's and parental intake of vegetables was stronger than that for fruit intake, indicating a greater similarity in intake of vegetables than that of fruit, between children and parents. Children who were exposed to more different FV ate more vegetables and more different types of vegetables. Lifetime exposure to FV seemed to have more influence on 24 hour vegetable intake than on fruit intake, again showing that perhaps what is less liked benefits more from external facilitation. This shows a similar pattern to the one found by Hartvig et al. (2015) who showed that 'initial dislikers' of astringent juices were the only ones who benefitted from repeated exposure and showed an increase in liking. Perhaps lifetime exposure as analysed in this thesis shows similar patterns and only benefits initially disliked products. As vegetables were less liked than fruit, and more children were reported to dislike vegetables, it seems that perhaps external facilitation may increase both liking and intake of vegetables, more so than with the commonly liked fruit.

Looking at the influence of parental feeding practices, it seemed that parents who encouraged balance and variety in the home setting had children who liked vegetables more, and that liking of vegetables showed a strong trend with intake of vegetables, which just missed significance. The fact that encouraging BV may increase liking of vegetables, shows promising results for future intervention programmes. As parental intake was the most substantial contributor to child's intake of vegetables, multi-level intervention programmes should target increase in parental intake and providing home environment which encourages balance and variety of FV, which would translate to greater exposure to vegetables. What needs to be considered is that parents who have children who like vegetables might find it easier to encourage balance and variety in the home setting, so how child's behaviour affects parental feeding practices must be considered.

Looking at the internal contributors to vegetable intake, in the older sample both portions and variety of vegetables were higher among children with more typical taste sensitivity, which supports the findings of Coulthard and Blissett (2012). In the younger sample taste sensitivity was not linked with 24 hour intake of vegetables. It seems that in the younger sample, children's intake of vegetables was more dependent on parental intake and potentially can be modified by the use of appropriate feeding strategies. In the older sample, more personal factors, such as individual taste sensitivity, interact with parental influences to affect intake of vegetables.

What also emerged was that history of OM might affect intake of vegetables in the older children. Children with OM history showed higher intake of vegetables than children without OM history, and further analysis revealed that this increase in intake was exclusive to non-cruciferous vegetables. The effects of OM were evident only in the older sample, as perhaps possible damage to sensory signalling due to OM infections demonstrates at later stages of development rather than leading to immediate effects on vegetable intake. This finding is somewhat surprising as it was expected that children with history of OM would consume fewer vegetables due to intensification of unpalatable tastants. Peracchio et al. (2012) showed that children with the highest exposure to OM showed lower affinity to vegetables compared to children with no exposure. However, when the mean ranks were compared, that difference was very small. Results presented in this thesis may suggest that perhaps children with OM eat more in general or more energy dense foods (as they have higher adiposity), not just more vegetables but still show the same aversion to cruciferous vegetables as children without OM history. This interpretation would be consistent with the previously reported evidence of higher risk of overweight in children with OM history (Nelson et al., 2011). Bartoshuk et al. (2012) proposed that damage to CT nerve as a result of OM may lead to increased palatability of sweet/fat foods such as ice cream or chocolate, by increasing the perception of creaminess of fats and intensification of perception of sweetness, and as a result sweet/fat foods may be perceived as more palatable, hence they may elicit a stronger reinforcing value of those foods compared to people with intact CT nerve. Higher reinforcing value of those high energy foods might then result in overeating. This is consistent with the anaesthesia studies which show that anaesthesia of the CT nerve may affect taste intensities and perception of creaminess/greasiness from fats (Lehman et al., 1995). We might therefore speculate that OM may lead to increased adiposity via changes in food palatability which may result in overeating.

There were no differences in intake of vegetables in children with different SDT. This was expected, as differences in intake were hypothesised to demonstrate on the more bitter vegetables, and not vegetables in general, as children may consume only the liked and accepted vegetables. This again demonstrates the necessity to look at FV intake with appreciation of the differences between different types of products within the FV family.

7.3.5 Cruciferous vegetables

Cruciferous vegetables' intake showed many differences from that of non-cruciferous vegetables. While 24 hour intake of vegetables in general was linked with lifetime exposure to FV, cruciferous vegetable intake was not linked with lifetime exposure to FV, which gives a pessimistic message in terms of public health, as it indicates that intake of cruciferous vegetables does not increase as a function of exposure. It seems that cruciferous vegetables are more problematic when it comes to external facilitation, as in the younger age group even the association between child's and parental consumption of cruciferous vegetables was low. In the older age group, the link between child's and parental intake of cruciferous vegetables was strong, yet intake of cruciferous vegetables was still low, indicating that perhaps increasing parental intake of cruciferous vegetables might result in children eating more of it. Parents who showed higher levels of teaching about healthy eating had children who ate fewer cruciferous vegetables, indicating that either children's aversion to cruciferous vegetables leads parents to employ teaching, or when foods are particularly aversive higher levels of encouragement such as teaching are perceived as coercion and have an inverse effect to that intended.

Cruciferous vegetable intake did not differ among children with OM history and those without, it was equally low among both groups which might explain why no differences were observed between the two groups. When looking at sensitivity to sweet taste however, it was evident that children with lower sensitivity to sweet taste consumed significantly more cruciferous vegetables compared to children with high sweet taste sensitivity, indicating that there might be internal barriers to intake of cruciferous vegetables. It seems that as cruciferous vegetables are particularly resistant to facilitation among children, the best strategy would be to promote consumption among parents from the child's very young age. It seems that young children are more likely to eat what parents eat, rather than respond to other environmental cues like feeding strategies. In terms of public health messages, perhaps it is necessary to increase public knowledge of the benefits of different types of vegetables. While the message of 'five-a-day' seems to be generally known across the UK population, with some data showing that 100% of low FV consumers are aware of five-a-day message, knowledge of the nutritional value of the individual fruit or vegetables is still insufficient (Rooney et al., 2013). While the awareness of FV recommendations is clearly important, perhaps the next step should be to increase awareness that there are important differences between nutritional values of different FV. It is necessary to increase public awareness that cruciferous vegetables such as broccoli or Brussel sprouts are healthier than for example sweetcorn or potatoes. Campaigns such as '5-a-day' or 'just-1-more' are focused on increasing the quantity of FV intake and may not be effective in increasing the quality of consumed FV. As presented in this thesis, cruciferous vegetable intake is very low among the parents and the children, which suggests that there is a need to increase the intake among both children and the parents. One suggestion would be to teach the parents the methods of preparation that would decrease the bitter taste, by for example using small amount of sugar to mask bitterness, in line with associative conditioning mechanisms

7.3.6 Non-cruciferous vegetables

Intake of non-cruciferous vegetables, not surprisingly, was higher than intake of cruciferous vegetables. Children who were exposed to more FV in their lifetime consumed more portions of non-cruciferous vegetables and their non-cruciferous vegetables intake was more diverse. It was not however associated with liking of vegetables, probably because whether children like vegetables or not, the parents would still offer some liked and accepted vegetables even if only a very restricted variety, but that intake would not be reflective of their overall vegetable liking. Parents would be more likely to prepare vegetables that they know their child likes in order assure that the child consumes any vegetables (Fox, Pac, Devaney & Jankowski, 2004). Intake of non-cruciferous vegetables was not associated with parental feeding practices or any other child or parent-centred factors in the younger age group, other than parental intake.

Looking at the internal factors, it was evident that in the older age group children with more typical taste sensitivity consumed more non-cruciferous vegetables compared to more sensitive children, indicating potential internal barriers among the more sensitive children. Furthermore, the previously discussed effects of OM history show that older children with OM history consume greater variety of non-cruciferous vegetables than children without OM, indicating possible damage to the CT nerve which actually facilitates intake rather than decreasing it. This contradicts the findings of

Peracchio et al. (2012). However, that intake should be analysed in the context of general diet, as possibly children with OM history eat more of everything, including high energy foods, which would explain their higher adiposity. This effect was not yet obvious in the younger children. There were no differences in non-cruciferous vegetable intake between children with different SDT status, indicating that sweet taste sensitivity, as was expected, affects only intake of vegetables which contain higher levels of bitter phytochemicals and at the same time are less sweet.

7.4 Strengths

This thesis took a novel approach to looking at FV intake in children. Published research to date rarely looked at FV in children with appreciation of both internal and external drivers of intake. In this thesis both factors were accounted for which allowed to get a comprehensive view of FV intake in children. Furthermore, this thesis promotes the idea that intake of FV must not be approached as a single concept with a stable set of predictors, but instead different types of FV must be separately assessed and different drivers of their intake must be acknowledged, thus promoting more targeted interventions which focus on cruciferous vegetable intake and astringent fruit intake rather than FV intake in general. Further, this thesis looked at sensory sensitivity and used both questionnaire and empirical measures of assessment of taste sensitivity. Finally, this thesis tested two novel contributors to FV intake, which have not been explored in the context of FV to date i.e. influence of individual SDT levels and effects of history of OM on intake of FV.

7.5 Limitations and future directions

There were several limitations to those studies, which need discussion.

Sample I

Firstly, reported intake of FV seemed unusually high, indicating issues with the measure used. It seemed that parents inaccurately reported the number of portions that the child consumed, which resulted in higher intake data. Data on intake from a larger sample of days would provide a more reliable view of the actual diet and consideration of using a food diary rather than recall questionnaire given the possibility of inaccurate reports. Further, perhaps conceptualising intake in terms of weight (e.g. grams) rather than portions would allow the detection of more subtle differences between the tested groups.

Another limitation was lack of further control variables used, such as measurements of home availability or lack of more specific socio-demographic data for the older sample. Also, measuring neophobia levels in the older sample would be particularly helpful, as lifetime exposure data may have been affected by children's neophobia, because the fact the child never tried a given product may have resulted from their rejection or refusal to try the product, which may have been offered to them. This is particularly problematic given that in this sample taste sensitivity was one of the correlates of FV intake. Another limitation is the lack of waist circumference data for the older sample, as it would be interesting to see whether OM effects on central adiposity seen in the younger children still show effects in the older sample of children. Also, in the future, it would be of great benefit to incorporate another measure of exposure and home availability and ask the parents to mark separately the products the child never tried and the products that the child never tried but was offered. It would be beneficial to collect information about which products the child was consuming on a regular basis and which were rarely consumed or which were tasted only once. Also information on the general diet of children would provide a more comprehensive evaluation of dietary patterns which may be related to exposure and intake of FV. Both of the samples were not fully representative of the UK population as the majority of parents were from a white, high socio-economic background, which would also explain lower than expected number of OM exposed children.

Further, the sensory sensitivity measure (SSP) used in both samples does not allow us to distinguish between sensitivity to taste and smell, or between audio and visual stimuli, which is problematic as the scale assumes concordant sensitivity across those domains. Some items from SSP are also more reflective of fussy eating rather than physiological sensory sensitivity and thus we may see artificial overlap between measures of eating and sensory processing in this domain.

Sample II

Many parents did not report an accurate dietary intake with the inclusion of measures or portion sizes and they were removed from the analyses. Perhaps a 3 or 7 day diary with an appropriate training would result in more accurate reporting. Again, collecting dietary data from a larger selection of days would provide more information on the intake of subcategories of FV i.e. cruciferous vegetables and astringent fruit, the intake of which in this sample was extremely limited.

Further, the study utilised a large number of measures and larger sample size would allow for further subdivision of FV into subcategories and looking for moderating effects on the subgroups of FV intake. The PALS liking scale utilised in

Chapter IV contained smiley faces on top of visual scales, which may have swayed the parents to mark the liking consistent with the facial equivalent, thus violating the principle of VAS methodology. Furthermore, PALS is a relatively new instrument for measuring liking and has not been yet validated in the British sample. While there are no indications that PALS should not be used in non-American samples, several items of PALS have been more typical for American than British diet (e.g. melon). The suitability of PALS for this young UK sample needs further validation. The neophobia scale used in this sample is also not ideal as it contains items which are not reflective of the lifestyle of the modern society and some items are focused on acceptance of ‘foreign’ food rather than novel foods.

Another shortcoming in both samples is a small number of children with OM and lack of information on the first onset of OM and severity of the illness. More balanced distribution would provide a better opportunity to compare the differences between OM group and the controls, and would provide an opportunity to further split the OM sample based on first onset of exposure, severity of illness and build more OM groups based on the number of exposures.

7.6 Final conclusions

This thesis demonstrates that both internal and external factors contribute to intake of FV. The most important external driver was parental intake which explained a large variance of FV intake in children. This thesis also shows that history of OM and sensitivity to sweet taste may affect intake of FV in children, which is an important information from public health perspective. It is important to increase public knowledge that there are individual differences in how we perceive different tastes, and there may be behavioural consequences of those individual differences in children's intake of FV. Parents of fussy children should be encouraged to expose children to the sweeter fruit and less bitter vegetables in order to ensure sufficient intake Parents could also use associative conditioning strategies in order to increase intake of astringent fruit and cruciferous vegetables, as a method of promoting range. Furthermore, this thesis provides evidence that different FV groups must be considered separately, as they are guided by different drivers and intervention programmes need to be targeted rather than broad. Intake of cruciferous vegetables and astringent fruit may be particularly problematic due to internal constraints and little impact of external facilitators. Future intervention campaigns should focus on multi-level programmes which target intake both in parents and in children for optimal results. Public interventions should also aim at increasing public knowledge that astringent fruit and cruciferous vegetables are the healthiest types of FV and their intake should be increased. In order to increase liking of astringent fruit and cruciferous vegetables parents should make sure that variety of those is available in the home setting to promote exposure. It is recommended to initially expose children to astringent fruit with the highest acids-to-sugar ratio, as they are the least offensive and to expose them to the most liked of the cruciferous vegetables, which is broccoli. Parents should also have access to the information on the possible link between otitis media infections and adiposity.

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Appendix

Materials Section A

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Supplementary analyses Section C

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C-7 Regression table of teaching on vegetable intake

A-1 Participant information sheet Sample I

Information sheet
Study Title**:** Sweet taste sensitivity **and** eating habits**.**

Experimenters**: Anna Fogel and Dr Jackie Blissett**

You and your child are asked to take part in a study that investigates how sensitive your child is to sweet tastes and how this relates to fruit and vegetables they eat. It is important that you understand what the study is about and what you and your child will be asked to do. Please read the following description and feel free to call or send an e-mail to us at the address below if you have any questions.

What are we testing?

Children are all different. What your child likes to eat may be affected by their in-born liking of sweet tastes, which is what we want to test. One of the things that differs between the children is how many taste buds they have. We are looking at whether the number of taste buds on the tongue has anything to do with how much sweetness children need to like certain foods or to even perceive food as sweet or not. This research will help us understand if at least some preference for fruit and vegetables is in-born. We will also look if the way your child tastes different products is connected to the way their other senses work e.g. reacting to noise, temperature etc.

Who can **take part?**

We want to test children who are between **5-9** years old. We can only test children **without diabetes,** and who are in a healthy condition during the experiment (no **influenza, cold or any condition affecting their nose or throat**). Children with food or food dye allergies cannot participate in the study.

What **will** your **child do?**

Your child will only be asked to do the study if you sign a consent form. If you do, we will collect them from the class about 45 minutes before lunch, to complete the experiment.

The experiment consists of five stages.

First your child will be asked if they want to take part in the study. If they agree, they will be asked how hungry they feel at the moment and rate it on a scale 1-5. If they don't want to take part on the day that is fine. No pressure will be put on them to take part.

During the **first stage** your child will be asked to **sip** three types of drinks and identify the one which tasted different to the other two.

Children will be asked to **spit out** the drinks into a bowl, so they **will not** have to swallow anything, but if they do swallow it, it doesn't matter. One of the drinks will be **sugary water** prepared from standard castor sugar and fresh distilled water. Two other drinks will be clean fresh water. Each drink has a different amount of sweetness ranging from barely detectable to sweet. However, it is important that you know that the amount of sugar in all of the drinks is no more than that in an apple.

Your child will be asked to **rinse their mouth** with water twice and then they will wait for 1 minute. before going to the next round, which is exactly the same procedure. The procedure **will be repeated** a number of times until your child correctly determines the sweet drink 3 times in a row. The minimum number of sips your child will do is 12, and the maximum is 27, depending on their sensitivity.

Then, during the **second part** of the experiment your child will be given 5 drinks of various sweetness and will be asked to **sip** them, and **spit** them out.

After each drink, children will be asked to rate how much they liked the drink. This procedure will be repeated **5 times**. Each child will do the total of 5 sips at this stage.
Then, during the **third part** we will take a picture of your child's tongue. We will dry the tip of the tongue first, with a filter paper. Then we will ask your child to place their palms under their chin comfortably, and stick out their tongue. The child will be shown by the experimenter what exactly they should do.
Then, a filter paper with a safe food dye will be placed at the front part of the tongue for 3seconds. This is just to show up the taste buds. After removing the filter paper, 3 photographs of the tongue will be taken. It is important that you note that we are not taking a picture of your child's face, only their tongue. Therefore, no-one can recognize them in the photographs.
The **fourth part** is weighing and measuring your child. This is done in school clothes but with shoes removed, in a quiet corner of the testing room so no other child can see the weight or height measures. All researchers are trained in sensitive management of weighing and measuring, and are CRB checked.
The **fifth** and last part is the choice of fruit. Your child will be offered 5 fruits, and will be asked to rank them from their most to the least favourite one. Your child will be offered to take their favourite fruit with them to eat as a snack later. It is therefore very important that you let us know if your child or anyone in your family has a food allergy or intolerance, particularly to any kind of fruit. If so, your child will not be able to take part in this part of the study.
Your child is strongly encouraged to brush their teeth after participation since the drinks they will be tasting contain sugar
As a 'thank-you' for taking part in the study your child will then receive a small toy. The total time for the study will not exceed 45 minutes.

What **would I need to do?**
We would ask you to complete a short set of questionnaires at home (they are enclosed in this pack): one brief general questionnaire on your child's health and demographic information, one questionnaire on your fruit and vegetable consumption, and the same one for your child's fruit and vegetable consumption whilst at home. We also ask you to report how generally sensitive your child is to sounds, tastes, smells, light and movement. The minimum time to complete those questionnaires is 15 minutes, but it may take longer.
You will also be given consent forms to participate in the study which we would ask you to sign.
You return the three questionnaires and the consent forms in the envelope provided.
If you want to participate please complete the consent forms and questionnaires, and put the envelope in the **post-box situated in the reception area by xxxx**.
The school will not read the documents.
Please note that without the consent forms your child will not be able to participate in the study.
It is really important that your child **does not know** what the drinks are, and what they taste like. This might affect the way they respond so we would kindly ask you not to give any information about the drinks to your children. What you could tell them, if they have questions, is that they would be tasting different drinks, and rating how tasty they are. It is fine to reassure them that the drinks will not taste bad. You can tell them that a photo of their tongue will be taken, and that they will get some fruit and a toy that they choose at the end of the experiment.
Are **the drinks and the food dye safe?**
Yes, the drinks are perfectly **safe**. Two of the drinks during each round are clean, fresh water and one of the drinks during each round is castor sugar at different concentrations diluted in

water. They are not unpleasant. The child will not swallow them, but will be asked to spit them out to a bowl provided for that. If your child suffers from diabetes and you are not aware of this, then even the accidental swallowing of all provided drinks would not be in any way dangerous. If the child accidently swallowed all the drinks, the total amount of sugar swallowed would not exceed the amount of sugar in half of a banana. The blue food dye is also safe and is used on a regular basis in food industry (e.g. in yoghurts, cakes, ice cream, processed peas, lollipops, packet soups, icings, sweets). The amount of food dye we use for this study is extremely small. However, of course if your child has ever had an allergic reaction to a food dye, we will need to know this so we can exclude them from this part of the study.

What **are the benefits of the research?**

This research will help us to understand why some children eat more fruit and vegetables than others, and like them more. If you want us to, we can send you a summary of our results after the whole experiment is finished and the data are analysed. We will also send a summary to school so that you can find out that way too. We could also tell you what your child's own sensitivity to sweet taste is. To find this out, you would need to email the researcher on the email address below, giving your child's participant identification number (which is in the top right hand corner of all of the documents, including this one). Your child will receive a small toy as a thank you for participation, and a fruit of their choice which they can consume during their lunch break.

Are **there any risks involved?**

There are no risks involved in this study assuming your child has no food allergies. Your child will not be left alone in a room with the researcher at any point. There will always be a second person present. The researchers all hold a CRB check and are cleared to work with children.

What **if I have any questions?**

Feel free to call or e-mail us if you have any questions.

What **if my child wants to stop at any point?**

Your child can stop the experiment at any point, without any consequences. They will still be allowed to keep their toy.

Is **all data confidential?**

Yes, your results are completely confidential and only the experimenters will have access to them. When the results are published, some photographs of taste buds might be published as well. Nobody will be able to identify your child on the basis of the photographs of the tongues. The picture below shows the photograph of the tongue, with the food dye on it and a little piece of paper that shows how big the dyed area is, compared to this paper. We will take the exactly same photograph of your child's tongue. As you can see it is not possible to identify the person whose tongue is photographed. Also nobody will be able to identify the child on the basis of information that you give us. Every questionnaire and consent form has an ID number that we will use to store the data instead of your names. The bottom part of the consent forms which has your child's name on is detachable. As soon as we collect your child from the class and carry out the experiment, we will detach the part of the consent form with your child's name and destroy it. Therefore, we never need to store your child's name and data together, so no-one can identify who took part in the study.

What **if I want to withdraw?**

You have a right to withdraw from the study at any point until the results are published, without giving a reason. All your results will be deleted. Your child will still be able to keep the toy. To withdraw your data after you and/or your child have taken part, e-mail or telephone one of the experimenters (contact details below), quoting your ID number. If you change your mind about taking part before you have returned the consent forms and questionnaires, you need do nothing, we will not test any children who have not had a consent form returned by a parent or guardian.

What **happens to the information?**
We will keep your results confidential. This research meets the regulations of Code of Conduct, Ethical Principles and Guidelines published by the British Psychological Society (www.bps.org.uk) and was approved by the University of Birmingham Ethics Committee. All data will be kept in a secure place accessible only by the research team. No third parties will have access to them. This research is a part of Anna Fogel's Ph.D. thesis and the results will also be published in a scientific journal. However no individuals are identifiable from these results and your records will remain confidential. Data will be stored at the University for 10 years for audit purposes, then all electronic and paper copies of data will be destroyed.

If you have any other questions, please contact:

A-2 Participant consent form Sample I

Study **Title: Sweet taste sensitivity and eating habits.**

Anna Fogel and Dr Jackie Blissett, School of Psychology, University of Birmingham

Please circle either Yes or No in response to each of the questions below.

CHILD'S **DATE OF BIRTH:**

I understand that my participation in this study is voluntary and I can withdraw from the study at any point, without any consequences. YES / NO

I understand that my child's participation in this study is voluntary and he/she can withdraw from the study at any point, without any consequences. YES / NO

I confirm that my child has no known food allergies and there are no food allergies in my child's close relatives. YES/NO

I confirm that my child has no known food dye allergy and there are no food dye allergies in my child's close relatives. YES/NO

I confirm that my child has not been diagnosed with diabetes or glucose intolerance. YES / NO

I give permission for my child to participate in the taste tests. YES / NO

I give permission for my child to be weighed and measured. YES / NO

I give permission for the researchers to take 3 photographs of my child's tongue. YES / NO

I understand that the photograph of the tongue with no facial features might be published in a scientific journal, in which case it will not be possible to identify my child. YES / NO

I confirm that I have been informed of what the study involves. YES / NO

I have had the opportunity to ask questions and all of my questions have been answered. YES / NO

I have read and understood the above, and give consent for myself and my child to participate:

Participant's Signature:________________________________ Date:_________
Signature of Researcher:_______________________________ Date:_________

ID
Your child's name: __________________________________
Your child's class: ---

A-3 Debriefing sheet Sample I

Debriefing sheet

Your child has just taken part in a study that aims at investigating the relationship between sensitivity to sweet taste and fruit and vegetable consumption.

The solutions your child has been sipping consisted of standard sugar dissolved in distilled water. The solutions differed in their concentration of sugar.
We will now analyse your child's ability to detect sweet taste and their liking of different concentrations of sugar in relation to how much fruit and vegetables they eat. We will also look at how the number of their taste buds relates to liking of sweetness and intake of fruit and veg.
If you wish to be informed of the results of the study, please email us:

If you struggle with weight issues, or need some help or guidance regarding your eating habits, contact your GP, or the organization called BEAT (http://www.b-eat.co.uk/Home) which supports people with eating disorders and their carers.

We would be very grateful if you **would not** discuss this study with other people who are going to participate, as it is important that the participants **do not** know what kind of drinks they would be getting.

Thank you for your co-operation and for participating!

A-4 Information sheet Sample II

Participant code:

PARENTS' INFORMATION LEAFLET

Investigating eating in infants and young children

What **is the study about?**
At the Infant and Child Laboratory (ICL) in the School of Psychology, University of Birmingham, we are interested in children's eating behaviour, particularly what makes children more or less likely to try new foods. We also want to see if your own sensitivity is related to your child's sensitivity, and if what you and your child eat on an everyday basis is related to how much you like new food. We can't get all the information we need about this from questionnaires, so we need participants to come into the laboratory so we can video-record your infant or child eating with you.

Who **can take part?**
You can take part if you are the main caregiver of an infant or child between 24 and 36 months, and your child has already been introduced to solid foods. Because our studies take place at the University of Birmingham, participants should live within easy travelling distance of the University of Birmingham (usually no more than 15 miles away). Some families will be unable to take part in these studies. If your child has a serious health condition that affects their eating, if anyone in your immediate family has a food allergy, or if you or your child has an intellectual disability, you will not be able to take part in the study. Finally, if you cannot read or write in English, or if the main language you use to talk to your child is not English, you will not be able to take part in this particular study.

What **will my child and I be asked to do?**
When you arrive at the lab, we will show you round our playroom. In this room, there are small cameras that can record what happens in the room, and lots of interesting toys. Once you and your child are settled and comfortable, we will bring in a lunch for you and your child to eat together. The meal will consist of a range of child-friendly and familiar foods that constitute a balanced meal. We will also ask you to introduce a small amount of a new food to your child, for example, sharon fruit, lychee or date. You will then be given one or two specific feeding practices to try out, to see if they help your child to try the new food. The feeding practices that we ask you to use are all usual practices used by parents in feeding their children, such as encouraging the child to eat through physical prompting (picking the novel food up and holding it up in front of your child or placing the novel food in your child's hand) or modelling the consumption of the novel food by eating some of it yourself. We will discuss with you fully, before the session, what feeding practices you are comfortable using and how we would like you to use them. There will be no pressure to use a practice that you are uncomfortable with.
During the meal, you and your child can eat until you have both had enough. Water is provided to drink. We will video-record this mealtime.
Next, you would be asked to fill in some questionnaires about your own and your child's eating behaviours and likes, food you and your child ate the day before, how you tend to interact with and feed your child, how sensitive you and your child are and a few questions about past illnesses. This will take no more than 20 minutes. During this time you will stay in the playroom with your child but a researcher will come and play with your child so that you can concentrate on filling in the questionnaire. You will be able to see your child at all times. Finally, you and your child will be weighed and measured, and we will measure your waist and your child's waist in light indoor clothing and no shoes.

What **are the benefits of the research**?
There are no major benefits to you for taking part in the study, however, your participation may help us to find out the best ways of helping children to accept a wide range of foods in a healthy mealtime environment. You will receive £10 to cover travel expenses and a small toy or book for your child.

What **are the risks of taking part in this research?**
There are very few risks associated with this research. The main risk is food allergy, which is why we do not include anyone in the study where there is food allergy in the family. We never serve food items containing nuts. We will always show you any food that we ask you to introduce to your child before giving it to your child. Trained first-aiders are present within the School of Psychology. All researchers in the Infant and Child Laboratory are Criminal Records Bureau (CRB) checked. Some of the questionnaires that we ask you complete may raise concerns for you regarding eating. Similarly, when we weigh and measure you and your child you may have some concerns about eating or weight. You can speak to a member of the research team if you are concerned. Sources of support for eating problems and parenting will be listed for you in a sheet to take home after the study.

What **happens to the information I provide to you during the study**?
All the information you provide to us is private and confidential. We give number codes to all participants and never store names or contact details with the study data you provide. We do publish scientific articles using the data you provide but it is never possible to identify any individual. The study cannot be anonymous, because we store video-recordings of you and your child. However, these video-recordings are kept securely on a computer hard disc, which is kept in a locked room in the lab. A CD copy is kept in a locked cabinet in the researcher's office at the University of Birmingham. Only researchers directly involved in this study can access the recordings. Recordings are kept for 10 years, then the discs are destroyed. The recordings on the HD of the computer will be wiped after 10 years. Your questionnaire data is also kept in a locked cabinet in the ICL. This raw data is kept for 10 years then shredded. Databases of the raw data are also made and are kept on PCs. Only the person in charge of the study, and her research team, have access to these databases. Databases will also be deleted after 10 years.

What **if I change my mind?**
You have the right to stop taking part in the study at any time. You can also withdraw data you have provided to us at any time, until the data have been submitted for publication. There are no negative consequences of withdrawing from the study. If you or your child decide to stop taking part in the study once you have arrived in the Infant and Child Laboratory, you will still receive travel expenses. If you withdraw before arrival in the lab, you will not receive travel expenses.

What **do I do if I want to take part**?

Thanks **for considering taking part in our research.**

A-5 Consent form Sample II

Participant code:

Investigating eating in infants and young children

What is the study about**?**
At the Infant and Child Laboratory (ICL) in the School of Psychology, University of Birmingham, we are interested in children's eating behaviour, particularly what makes children more or less likely to try new foods. We are also interested in how their eating is related to other factors such as how sensitive the children are, how much they like different foods, what is their normal diet, how well they can control themselves, how they interact with you when they are eating and in their medical history. We can't get all the information we need about this from questionnaires, so we need participants to come into the laboratory so we can video-record your infant or child eating with you.

Who can take part?
You can take part if you are the main caregiver of an infant or child between 24 and 36 months, and your child has already been introduced to solid foods. Because our studies take place at the University of Birmingham, participants should live within easy travelling distance of the University of Birmingham (usually no more than 15 miles away). Some families will be unable to take part in these studies. If your child has a serious health condition that affects their eating, if anyone in your immediate family has a food allergy, or if you or your child has an intellectual disability, you will not be able to take part in the study. Finally, if you cannot read or write in English, or if the main language you use to talk to your child is not English, you will not be able to take part in this particular study.

What **will my child and I be asked to do?**
When you arrive at the lab, we will show you round our playroom. In this room, there are small cameras that can record what happens in the room, and lots of interesting toys. Once you and your child are settled and comfortable, we will bring in a lunch for you and your child to eat together. The meal will consist of a range of child-friendly and familiar foods that constitute a balanced meal. We will also ask you to introduce a small amount of a new food to your child, for example, sharon fruit, lychee or date. You will then be given one or two specific feeding practices to try out, to see if they help your child to try the new food. The feeding practices that we ask you to use are all usual practices used by parents in feeding their children, such as encouraging the child to eat through physical prompting (picking the novel food up and holding it up in front of your child or placing the novel food in your child's hand) or modelling the consumption of the novel food by eating some of it yourself. We will discuss with you fully, before the session, what feeding practices you are comfortable using and how we would like you to use them. There will be no pressure to use a practice that you are uncomfortable with.
During the meal, you and your child can eat until you have both had enough. Water is provided to drink. We will video-record this mealtime.
Next, you would be asked to fill in some questionnaires about your child's eating behaviours, how you tend to interact with and feed your child, how sensitive your child is, and how well your child can control him/herself. This will take about 10 minutes. During this time you will stay in the playroom with your child but a researcher will come and play with your child so that you can concentrate on filling in the questionnaire. The researcher will play a range of games with your child (building a tower, walking a line and playing for sweets). These games allow us to see how well your child can control him/herself. You will be able to see your child at all times. Finally, you and your child will be weighed and measured in light indoor clothing and no shoes.

What **are the benefits of the research**?

There are no major benefits to you for taking part in the study, however, your participation may help us to find out the best ways of helping children to accept a wide range of foods in a healthy mealtime environment. You will receive £10 to cover travel expenses and a small toy or book for your child.

What **are the risks of taking part in this research?**

There are very few risks associated with this research. The main risk is food allergy, which is why we do not include anyone in the study where there is food allergy in the family. We never serve food items containing nuts. We will always show you any food that we ask you to introduce to your child before giving it to your child. Trained first-aiders are present within the School of Psychology. All researchers in the Infant and Child Laboratory are Criminal Records Bureau (CRB) checked. Some of the questionnaires that we ask you complete may raise concerns for you regarding eating. Similarly, when we weigh and measure you and your child you may have some concerns about eating or weight. You can speak to a member of the research team if you are concerned. Sources of support for eating problems and parenting will be listed for you in a sheet to take home after the study.

What **happens to the information I provide to you during the study**?

All the information you provide to us is private and confidential. We give number codes to all participants and never store names or contact details with the study data you provide. We do publish scientific articles using the data you provide but it is never possible to identify any individual. The study cannot be anonymous, because we store video-recordings of you and your child. However, these video-recordings are kept securely on a computer hard disc, which is kept in a locked room in the lab. A CD copy is kept in a locked cabinet in the researcher's office at the University of Birmingham. Only researchers directly involved in this study can access the recordings. Recordings are kept for 10 years, then the discs are destroyed. The recordings on the HD of the computer will be wiped after 10 years. Your questionnaire data is also kept in a locked cabinet in the ICL. This raw data is kept for 10 years then shredded. Databases of the raw data are also made and are kept on PCs. Only the person in charge of the study, and her research team, have access to these databases. Databases will also be deleted after 10 years. You have the right to stop taking part in the study at any time. You can also withdraw data you have provided to us at any time, until the data have been submitted for publication. There are no negative consequences of withdrawing from the study. If you or your child decide to stop taking part in the study once you have arrived in the Infant and Child Laboratory, you will still receive travel expenses. If you withdraw before arrival in the lab, you will not receive travel expenses.

What **do I do if I want to take part**?

If you would like to take part in this study, please sign and return the consent form to the experimenter. You can provide us with your contact details now and we will contact you, or you can telephone the babylab on [redacted] to arrange a convenient time for you to visit us. Alternatively you can email us at: **b**[redacted]

[redacted]

A-6 Debriefing sheet Sample II

PARENTS' DEBRIEFING LEAFLET
Investigating **eating in infants and young children**

What **was the study about?**
You have just completed a number of questionnaires which will tell us something about your child's eating habits. We want to find out if middle ear infections are related to different liking and intake of fruit and vegetables and if they can explain higher weight of some children. We also want to see if children who like different foods are more likely to eat them, based on the information you gave us about what your child ate yesterday.

All the information you have given us is private and confidential and will be securely stored. You can withdraw data you have provided to us at any time, until the data have been submitted for publication. If you wish to receive a copy of the whole study's findings, you will be able to do this once the study has finished, by following links that will be placed on the Infant and Child Laboratory website.

Thanks **for taking part in our research.**

If taking part in this study has raised some concerns for you, you may like to contact one of the following sources of support:

You can ask your **GP or Health visitor** for advice if your child's weight or eating is causing you concern. You can also view the Infant and Toddler forum web pages for advice on children's eating http://www.infantandtoddlerforum.org/.

If taking part in this study has raised any concerns about your own eating, you may want to contact **BEAT eating disorders**: a charity for anyone affected by an eating problem. http://www.b-eat.co.uk, helpline 0845 634 1414.

For information and support for parenting, you may wish to contact Parentline, a charity providing help and support for anyone caring for children. http://www.parentlineplus.org.uk/. 0808 800 2222

A-7 Short Sensory Profile

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A-8 Food Neophobia Scale

1=disagree strongly, 2=disagree moderately, 3=disagree slightly, 4=neither agree nor disagree, 5=agree slightly, 6=agree moderately, 7=agree strongly

1. My child is constantly sampling new and different foods. 1 2 3 4 5 6 7
2. My child doesn't trust new foods. 1 2 3 4 5 6 7
3. If my child doesn't know what is in a food, s/he won't try it. 1 2 3 4 5 6 7
4. My child likes foods from different countries. 1 2 3 4 5 6 7
5. My child thinks that ethnic food looks too weird to eat. 1 2 3 4 5 6 7
6. At parties, my child will try a new food. 1 2 3 4 5 6 7
7. My child is afraid to eat things s/he has never eaten before. 1 2 3 4 5 6 7
8. My child is very particular about the foods s/he will eat. 1 2 3 4 5 6 7
9. My child will eat almost anything. 1 2 3 4 5 6 7
10. My child likes to try ethnic restaurants. 1 2 3 4 5 6 7

A-9 Guided One Day Dietary Recall

In this section you are asked to remember each eating episode (each time your child ate) yesterday, from waking up to going to sleep (or if your child ate at night). An eating episode includes any food eaten, which includes small snacks and main meals. You are instructed to try and mentally re-visit each eating episode in order, by starting with when your child woke up and working your way through the day and provide as much detail as possible. Please include all food items your child consumed during each episode. Under the heading 'Portion size' please estimate the amount of each food eaten in the episode. Please provide as much information about the portion as possible, so that we can estimate how much of every product was there.
The space below allows for 6 eating episodes, if fewer occurred please leave the additional boxe: empty.

If more than 6 eating episodes occurred, please notify the researcher.

First eating episode –
What time did your child eat?
....
Where did they eat?
....
What did thev eat?

Next eating episode –
What time did your child eat?
....
Where did they eat?
....
What did they eat?

Next eating episode –
What time did your child eat?
....
Where did they eat?
....
What did they eat?_

Next eating episode –
What time did your child eat?
....
Where did they eat?
....
What did they eat?

Next eating episode –
What time did your child eat?
....
Where did they eat?
....
What did they eat?_

Next eating episode –
What time did your child eat?
....
Where did they eat?
....
What did they eat?

A-10 Comprehensive Feeding Practices Questionnaire

Comprehensive Feeding Practices Questionnaire

Parents take many different approaches to feeding their children and may have different concerns about feeding depending on their child. **Please answer the following questions as honestly as possible.**	Never	Rarely	Sometimes	Mostly	Always
1. How much do you keep track of the sweet foods (sweets, ice cream, cake, biscuits, pastries) that your child eats?	1	2	3	4	5
2. How much do you keep track of the snack food (crisps, Doritos, cheese puffs) that your child eats?	1	2	3	4	5
3. How much do you keep track of the high-fat foods that your child eats?	1	2	3	4	5
4. How much do you keep track of the sugary drinks (fizzy pop, sugary squashes) this child drinks?	1	2	3	4	5
5. Do you let your child eat whatever s/he wants?	1	2	3	4	5
6. At dinner, do you let this child choose the foods s/he wants from what is served?	1	2	3	4	5
7. When this child gets irritable, is giving him/her something to eat or drink the *first* thing you do?	1	2	3	4	5
8. Do you give this child something to eat or drink if s/he is bored even if you think s/he is not hungry?	1	2	3	4	5
9. Do you give this child something to eat or drink if s/he is upset even if you think s/he is not hungry?	1	2	3	4	5
10. If this child does not like what is being served, do you make something else?	1	2	3	4	5
11. Do you allow this child to eat snacks whenever s/he wants?	1	2	3	4	5
12. Do you allow this child to leave the table when s/he is full, even if your family has not finished eating?	1	2	3	4	5
13. Do you encourage this child to eat healthy foods before unhealthy ones?	1	2	3	4	5

Please continue to answer the following questions as honestly as possible.	Disagree	Slightly disagree	Neutral	Slightly agree	Agree
14. Most of the food I keep in the house is healthy.	1	2	3	4	5
15. I involve my child in planning family meals.	1	2	3	4	5
16. I keep a lot of snack food (crisps, Doritos, cheese puffs) in my house.	1	2	3	4	5
17. My child should always eat all of the food on his/her plate.	1	2	3	4	5
18. I have to be sure that my child does not eat too many high-fat foods.	1	2	3	4	5
19. I offer my child his/her favourite foods in exchange for good behaviour.	1	2	3	4	5
20. I allow my child to help prepare family meals.	1	2	3	4	5
21. If I did not guide or regulate my child's eating, s/he would eat too much of his/her favourite foods.	1	2	3	4	5
22. A variety of healthy foods are available to my child at each meal served at home.	1	2	3	4	5
23. I offer sweet foods (sweets, ice cream, biscuits, cake, pastries) to my child as a reward for good behaviour.	1	2	3	4	5
24. I encourage my child to try new foods.	1	2	3	4	5
25. I discuss with my child why it's important to eat healthy foods.	1	2	3	4	5
26. I tell my child that healthy food tastes good.	1	2	3	4	5
27. I encourage my child to eat less so he/she won't get fat.	1	2	3	4	5
28. If I did not guide or regulate my child's eating, s/he would eat too many junk foods.	1	2	3	4	5
29. I give my child small helpings at meals to control his/her weight.	1	2	3	4	5
30. If my child says, "I'm not hungry," I try to get him/her to eat anyway.	1	2	3	4	5
31. I discuss with my child the nutritional value of foods.	1	2	3	4	5
32. I encourage my child to participate in grocery shopping.	1	2	3	4	5

33. If my child eats more than usual at one meal, I try to restrict his/her eating at the next meal.	1	2	3	4	5
34. I restrict the food my child eats that might make him/her fat.	1	2	3	4	5
35. There are certain foods my child shouldn't eat because they will make him/her fat.	1	2	3	4	5
36. I withhold sweets/dessert from my child in response to bad behaviour.	1	2	3	4	5
37. I keep a lot of sweet foods (sweets, biscuits, ice cream, cake, pastries) in my house.	1	2	3	4	5
38. I encourage my child to eat a variety of foods.	1	2	3	4	5

39. If my child eats only a small helping, I try to get him/her to eat more.	1	2	3	4	5
40. I have to be sure that my child does not eat too much of his/her favourite foods.	1	2	3	4	5
41. I don't allow my child to eat between meals because I don't want him/her to get fat.	1	2	3	4	5
42. I tell my child what to eat and what not to eat without explanation.	1	2	3	4	5
43. I have to be sure that my child does not eat too many sweet foods (sweets, ice cream, cake, biscuits or pastries).	1	2	3	4	5
44. I model healthy eating for my child by eating healthy foods myself.	1	2	3	4	5
45. I often put my child on a diet to control his/her weight.	1	2	3	4	5
46. I try to eat healthy foods in front of my child, even if they are not my favourite.	1	2	3	4	5
47. I try to show enthusiasm about eating healthy foods.	1	2	3	4	5
48. I show my child how much I enjoy eating healthy foods.	1	2	3	4	5
49. When he/she says he/she is finished eating, I try to get my child to eat one more (two more, etc.) bites of food.	1	2	3	4	5

A-11 Preschooler Adapted Liking Survey

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A-12 24-hour food frequency measure

Now we need to ask you some more information about the fruit and vegetables your child eats. As you fill this in try to report what your child actually ate, rather than what they were offered or served, because we know that parents usually offer a far larger range and amount of fruit and vegetables than the children actually eat! The tables contain a list of various fruit and vegetables. Next to each of the products there is an amount that defines 1 portion of each fruit and vegetable.
Please indicate how many portions of these foods **your child** ate during **the last 7 days** and within the last **24 hours.** Also please indicate which of these products your child has NEVER tried (**mark with an N).** See example below:

Product	Portions last 7 days	Portions in the last 24h	Put N if you have never eaten this food
Apple (fresh): 1 medium apple	6	2	
Fig (fresh): 2 figs			N

This means that the child ate 6 medium apples within the last 7 days, and 2 apples within the last 24 hours. It also means that the child has never tried a fig before.
Please do not include yoghurts. If your child consumed smoothies, **please indicate the brand and type.**
If there are any fruit or vegetables that your child has consumed, but they are not listed in the table, please write them in the spaces provided.

Product	Portions last 7 days	Portions in the last 24h	Put N if you have never eaten this food
Apple (fresh): 1 medium apple			
Apple (puree): 2 heaped tablespoons			
Apricot (canned): 6 halves			
Apricot (fresh): 3 apricots			
Avocado: Half an avocado			
Banana (fresh): 1 medium banana			
Blackberries: 1 handful (9 to 10 blackberries)			
Blackcurrants: 4 heaped			

tablespoons			
Cherries (canned): 11 cherries (3 heaped tablespoons)			
Cherries (fresh): 14 cherries			
Clementines: 2 clementines			
Dates (fresh): 3 dates			
Fig (fresh): 2 figs			
Fruit juice: 100% unsweetened 1 medium (150ml) (indicate flavour)			
Gooseberries: 1 handful			
Grapefruit segments (canned): 3 heaped tablespoons (8 segments)			
Grapefruit (fresh): Half a grapefruit			
Grapes: 1 handful			
Kiwi fruit: 2 kiwi fruit			
Mandarin orange (canned): 3 heaped tablespoons			
Mandarin orange (fresh): 1 medium orange			
Mango (fresh): 2 slices (2-inch slice)			
Melon: 1 slice (2-inch slice)			
Nectarine: 1 nectarine			
Orange: 1 orange			
Passion fruit: 5 to 6 fruit			
Pawpaw (papaya): 1 slice			
Peach (canned): 2 halves or 7 slices			
Peach (fresh): 1 medium peach			
Pear (canned): 2 halves or 7 slices			

Pear (fresh): 1 medium pear			
Pineapple (canned): 2 rings or 12 chunks			
Pineapple (crushed): 3 tablespoons			
Pineapple (fresh): 1 large slice			
Plum: 2 medium plums			
Prune (canned): 6 prunes			
Prune (ready to eat): 3 prunes			
Raspberries (canned): 20 raspberries			
Raspberries (fresh): 2 handfuls			
Rhubarb (canned): 5 chunks			
Rhubarb (cooked): 2 heaped tablespoons			
Satsuma: 2 small satsumas			
Strawberry (canned) 9 strawberries			
Strawberry (fresh): 7 strawberries			
Sultanas: 1 heaped tablespoon			
Tomato (puree): 1 heaped tablespoon			
Tomato (canned): plum 2 whole			
Tomato (fresh): 1 medium, or 7 cherry			
Watermelon: one 1 inch slice			
DRIED			
Apple (dried rings): 4 rings			
Apricot (dried): 3 whole			
Banana chips			

(dried): 1 handful			
Cherries (dried): 1 heaped tablespoon			
Cranberries (dried): 1 heaped tablespoon			
Currants (dried): 1 heaped tablespoon			
Fig (dried): 2 figs			
Mango (dried): 1 heaped tablespoon			
Mixed fruit (dried): 1 heaped tablespoon			
Peach (dried): 2 halves			
Pineapple (dried): 1 heaped tablespoon			
Prune (dried): 3 prunes			
Raisins: 1 tablespoon			
Tomato (sundried): 4 pieces			
Other fruit, or smoothie (indicate the brand and flavour) Use spaces below.			

Product	**Portions last 7 days**	**Portions in the last 24h**	**Put N if you have never eaten this food**
Artichoke: 2 globe hearts			
Asparagus (canned): 7 spears			
Asparagus (fresh): 5 spears			
Aubergine/Eggplant: 1/3rd aubergine			
Beans, (cooked): 3 heaped tablespoons			

Beans, broad (cooked): 3 heaped tablespoons			
Beans, kidney (cooked): 3 heaped tablespoons			
Beans, soya (cooked): 3 heaped tablespoons			
Beansprouts (fresh): 2 handfuls			
Beetroot (bottled): 3 'baby' whole, or 7 slices			
Beetroot (fresh): 3 'baby' whole, or 7 slices			
Broccoli: 2 spears			
Brussels sprouts: 8 Brussels sprouts			
Butternut squash (cooked): 3 heaped tablespoons			
Cabbage: 1/6th small cabbage or 2 handfuls sliced			
Cabbage (shredded) : 3 heaped tablespoons			
Carrots (canned): 3 heaped tablespoons			
Carrots (raw): 1 large			
Carrots (cooked): 1 large			
Cauliflower: 8 florets			
Celery: 3 sticks			
Chickpeas (cooked): 3 heaped tablespoons			
Courgettes: Half a large courgette			
Cucumber: 2-inch piece			
Leeks: 1 leek			
Lentils: 3 tablespoons			
Lettuce (mixed leaves): 1 cereal bowl			
Marrow (cooked): 3 heaped tablespoons			
Mixed vegetables (frozen): 3 tablespoons (please indicate the brand and name)			
Mushrooms (button): 3 handfuls of slices			
Mushrooms (dried): 2			

tablespoons or handful			
Okra: 16 medium			
Onion: 1 medium onion			
Pak choi (Chinese cabbage): 3 heaped tablespoons			
Parsnips: 1 large			
Peas (canned): 3 heaped tablespoons			
Peas (fresh or frozen): 3 heaped tablespoons			
Pepper (canned): Half a pepper (please indicate colour)			
Pepper (fresh): Half a pepper (please indicate colour)			
Potato (boiled/jacket): 1 medium size potato			
Pumpkin (cooked): 3 heaped tablespoons			
Radish: 10 radishes			
Spinach (cooked): 2 heaped tablespoons			
Spinach (fresh): 1 cereal bowl			
Spring greens (cooked): 4 heaped tablespoons			
Spring onion: 8 onions			
Squash (butternut): half a large squash			
Sugarsnap peas: 1 handful			
Swede (cooked): 3 heaped tablespoons			
Sweet potato: 1 large			
Pepper (fresh): Half a pepper			
Pumpkin (cooked): 3 heaped tablespoons			
Sweetcorn (baby): 6 baby corn			
Sweetcorn (canned): 3 heaped tablespoons			
Sweetcorn (on the cob): 1 cob			
Tomato puree:1 heaped tablespoon			
Tomato (canned): plum 2 whole			
Tomato (fresh): 1 medium, or			

7 cherry			
Turnip (cooked): 3 heaped tablespoons			
Vegetable juice: 100% unsweetened 1 medium (150ml) glass (please indicate brand and/or flavour)			
Watercress: 1 cereal/dessert bowl			
Other vegetables or vegetable smoothies, please use the spaces below (please indicate brand and/or flavour)			

A-13 Demographics questionnaire Sample I

Health questionnaire
Please fill in the following details about the child that will be taking part in the taste study, so that we know a little more detail about who is taking part.

Child's Age____
Child's Sex (Please circle) Male Female
Child's Ethnicity (please circle the correct one):
White British Indian Pakistani Bangladeshi Other Asian Black Caribbean Black African Chinese
Other White (please describe) ______________________________
Mixed (please describe)__________________________________
Other Ethnic groups (please describe) __________________________
I'd rather not say
Your age: ____
Your relationship to the child (e.g. mother, father, foster mother etc):
____
Your Ethnicity (Please circle the correct one):
White British Indian Pakistani Bangladeshi Other Asian Black Caribbean Black African Chinese
Other White (please describe)_______________________________
Mixed (please describe)__________________________________
Other Ethnic groups (please describe)__________________________
I'd rather not say
Did your child ever have middle ear infections? (Please circle the correct answer). If you answer Yes, please write how many times
Yes (_____________ times) No I am not sure
Has your child had their tonsils removed? (Please circle the correct answer).
Yes No I am not sure
Did your child have any illness affecting their throat or nose during the last 4 weeks? (Please circle the correct answer). If you answer Yes, please write how many weeks ago.
Yes (____________ weeks ago) No I can't remember

A-14 Demographics questionnaire Sample II

Questions exploring Demographic Characteristics

1. What is your month and year of birth? ____________________

2. How many adults live in your home? ________ 3. How many children live in your home?___

4. Which race/ethnic group best describes you? (please tick)

White British/Caucasian ☐ *Black/Black British* ☐ *Asian/Asian British* ☐
Oriental ☐ *Mixed* ☐ *Other* ☐ ____________________ *(please specify)*

4a. Please describe **your child's ethnic background** using one of the categories listed above………………………………………………………………………..

5. Which of the following categories best describes your **total** annual household income?

Under £15,000 ☐ *£15,000-£30,000* ☐ *£30,000-£45,000* ☐

£45,000-£60,000 ☐ *£60,000-£75,000* ☐ *£75,000+* ☐

6. Which of the following best describes your educational background?
(Please tick only your highest qualification)

☐ *Some secondary school education*
☐ *GCSEs*
☐ *A-levels*
☐ *University graduate (e.g. Bachelor's degree)*
☐ *Post-graduate certificates (e.g. PGCE)*
☐ *Master's degree*
☐ *Professional or Doctorate degree (e.g. Ph.D.)*
*Other:*___________________________

7. Your child's month and year of birth (the child participating in this study) _______________

8. Please indicate the gender of your child (participating in this study):
Male ☐ *Female* ☐

9. What is your relation to this child? (Please tick)

Parent ☐ *Step-parent* ☐*Guardian* ☐ *Other:* _________

10. Does **your child** eat a special diet for any of the following reasons? *Yes* ☐ *No* ☐

If yes, please describe:
Medical: ___________________ *Ethical:* ___________________
Religious: ___________________ *Weight-loss:* ________________*Other:* ____________________

11. Do **you** eat a special diet for any of the following reasons? *Yes* ☐ *No* ☐

If yes, please describe:
Medical: ___________________ *Ethical:* ___________________
Pregnancy: _________________ *Weight-loss:* ________________

Religious: ___________________ *Other:* ______________________

B-1 Gender differences in FV intake in portions

Table B-1. Mean number of portions (SE in brackets) of FV and their subdivisions, consumed by boys and girls and group differences in number of portions consumed (Mann Whitney U).

	Males	Females	U	p-value
Fruit	2.40 (0.29)	2.98 (0.30)	1227.00	.179
Astringent	0.46 (0.10)	0.71 (0.14)	1195.00	.222
Non-astringent	1.93 (0.25)	2.27 (0.25)	1191.00	.287
Juice	1.00 (0.14)	0.96(0.14)	1019.50	.753
Vegetables	2.77 (0.28)	3.5 (0.44)	1205.50	.242
Cruciferous	0.38 (0.09)	0.54 (0.12)	1176.50	.266
Non-cruciferous	2.38 (0.25)	2.96 (0.35)	1168.50	.379
FV (total)	5.17 (0.54)	6.49 (0.58)	1268.50	.098

B-2 Gender differences in variety of FV intake

Table B-2 . Mean variety of FV consumed presented for boys and girls (SE in brackets) and differences in intake between boys and girls using Mann Whitney U test.

	Males	Females	U-value	p-value
Fruit	2.32 (0.27)	2.92 (0.27)	1429.00	.147
Astringent	0.48 (0.09)	0.65 (0.12)	1345.00	.342
Non-astringent	1.84 (0.22)	2.27 (0.25)	1403.50	.200
Vegetables	2.82 (0.36)	3.63 (0.48)	1387.50	.251
Cruciferous	0.46 (0.08)	0.63 (0.08)	1374.00	.222
Non-cruciferous	2.40 (0.30)	3.00 (0.40)	1337.50	.425
FV (total)	5.88 (0.55)	7.10 (0.62)	1429.00	.152

B-3 Correlations between sensory sensitivity and demographics

Table B-3. Relationship between sensory sensitivity in various domains and sample characteristics

	Taste/smell	Tactile	Audio/Visual
Child's age	.03	-.02	.11
Child's BMI centiles	.12	.16	.16
Maternal age	-.06	-.04	.03

C-1 Regression table of involvement on fruit intake

Table C-1. Summary of results of moderated regression analysis: parental involvement as a moderator between liking of fruit and intake of fruit, after controlling for child's neophobia, maternal neophobia, maternal intake of fruit and family annual income.

Model variables	B	SE_b	T	P	R^2	Adjusted r^2
Predictor variables						
(Constant)	1.20	0.59	2.01	.047		
Covariates						
Neophobia (ch)	0.02	0.01	1.58	.117		
Neophobia (m)	-.03	.01	-2.31	.024		
Intake mother	.37	.13	2.80	.007		
Income	.04	0.10	0.41	.686		
Main effects						
Liking	.09	.08	1.16	.250		
Involvement	-.35	.31	-1.13	.259		
Interaction						
Liking x involvement	-.15	.15	-1.02	.314		
Model					.562	.316***

M= mother; ch= child

C-2 Regression table of teaching on fruit intake

Table C-2. Summary of results of moderated regression analysis: teaching as a moderator between liking of fruit and intake of fruit, after controlling for child's neophobia, maternal neophobia, maternal intake of fruit and family annual income.

Model variables	B	SE_b	T	P	R^2	Adjusted r^2
Predictor variables						
(Constant)	1.24	.64	1.96	.054		
Covariates						
Neophobia (ch)	.02	.01	1.41	.164		
Neophobia (m)	-.03	.01	-2.18	.032		
Intake mother	.34	.13	2.70	.009		
Income	.03	.20	.28	.779		
Main effects						
Liking	.08	.07	1.29	.237		
Teaching	.09	.27	.36	.722		
Interaction						
Liking x Teaching	.02	.14	0.54	.878		
Model					.535	.287***

Ch= child; m= mother

C-3 Regression table of Encouraging BV on fruit intake

Table C-3. Summary of results of moderated regression analysis: encouragement of balance and variety as a moderator between liking of fruit and intake of fruit, after controlling for child neophobia, maternal neophobia, maternal intake of fruit and family annual income.

Model variables	B	SE_b	T	P	R^2	Adjusted r^2
Predictor variables						
(Constant)	1.34	.63	2.14	.036		
Covariates						
Neophobia (ch)	.01	.01	1.38	.171		
Neophobia (m)	-.03	.01	-2.28	.026		
Intake mother	.36	.13	2.84	.006		
Income	.02	.01	.24	.810		
Main effects						
Liking	.08	.06	1.35	.182		
BV	-.11	.24	-0.47	.642		
Interaction						
Liking x BV	-.12	.13	-1.034	.305		
Model					.539	.291***

Note BV refers to encouragement of balance and variety; ch= child; m= mother

C-4 Regression table of Encouraging BV on vegetable intake

Table C-4. Summary of results of moderated regression analysis: encouragement of balance and variety as a moderator between liking of vegetables and intake of vegetables, after controlling for child neophobia, child age, WHtR, maternal age, maternal BMI, maternal intake of vegetables and annual family income.

Model variables	B	SE_b	T	P	R^2	Adjusted r^2
Predictor variables						
(Constant)	3.96	2.03	1.95	.057		
Covariates						
Neophobia (ch)	.015	.014	1.10	.279		
Age child	-.008	.03	-.25	.801		
BMI mother	-.03	.024	-1.32	.191		
WHtR	-2.98	2.67	-1.11	.269		
Age mother	-.024	.026	-.905	.369		
Intake mother	.38	.08	4.47	.000		
Income	-.02	.10	-.26	.796		
Main effects						
Liking	.17	.07	2.23	.030		
BV	-.49	.26	-1.91	.060		
Interaction						
Liking x BV	-.03	.12	-.27	.790		
Model					.630	.396***

C-5 Regression table of control on vegetable intake

Table C-5. Summary of results of moderated regression analysis: parental control as a moderator between liking of vegetables and intake of vegetables, after controlling for child neophobia, child age, WHtR, maternal age, maternal BMI, maternal intake of vegetables and annual family income.

Model variables	**B**	**SE_b**	**T**	**P**	R^2	Adjusted r^2
Predictor variables						
(Constant)	4.16	2.24	1.85	.069		
Covariates						
Neophobia	.012	.014	.91	.368		
Age child	-.02	.03	-.67	.504		
BMI (m)	-.01	.03	-.51	.61		
WHtR	-2.99	2.87	-1.06	.294		
Age (m)	-.03	.03	-.99	.325		
Intake (m)	.37	.08	4.45	.000		
Income	-.02	.09	-.21	.833		
Main effects						
Liking	.08	.08	.97	.338		
Control	.29	.27	1.05	.297		
Interaction						
Liking x Control	.17	.13	1.27	.209		
Model					.624	.389***

Ch= child; m= mother

C-6 Regression table of involvement on vegetable intake

Table C-6. Summary of results of moderated regression analysis: parental involvement as a moderator between liking of vegetables and intake of vegetables, after controlling for child neophobia, child age, WHtR, maternal age, maternal BMI, maternal intake of vegetables and annual family income.

Model variables	**B**	**SE_b**	**T**	**P**	R^2	Adjusted r^2
Predictor variables						
(Constant)	3.65	2.22	1.64	.106		
Covariates						
Neophobia (ch)	.02	.01	1.81	.076		
Age child	-.01	.03	-.43	.67		
BMI mother	-.02	.03	-.72	.478		
WHtR	-3.61	2.74	-1.32	.193		
Age mother	-.02	.03	-.64	.527		
Intake mother	.37	.08	4.47	.000		
Income	-.03	.10	-.34	.733		
Main effects						
Liking	.15	.08	1.94	.058		
involvement	-.31	.26	-1.22	.230		
Interaction						
Liking x Involvement	.11	.13	.84	.400		
Model					.619	.383***

Ch= child

C-7 Regression table of teaching on vegetable intake

Table C-7. Summary of results of moderated regression analysis: teaching as a moderator between liking of vegetables and intake of vegetables, after controlling for child neophobia, child age, WHtR, maternal age, maternal BMI, maternal intake of vegetables and annual family income.

Model variables	**B**	**SE_b**	**T**	**P**	R^2	Adjusted r^2
Predictor variables						
(Constant)	3.18	2.28	1.14	.169		
Covariates						
Neophobia (ch)	.017	.013	1.26	.212		
Age child	-.01	.03	-.39	.700		
BMI mother	-.02	.02	-.73	.467		
WHtR	-2.73	2.87	-.95	.346		
Age mother	-.01	.03	-.52	.605		
Intake mother	.37	.08	4.24	.000		
Income	-.02	.11	-.16	.872		
Main effects						
Liking	.11	.08	1.49	.142		
Teaching	-.32	.28	-1.40	.168		
Interaction						
Liking x teaching	-.08	.14	-.56	.578		
Model					.621	.385***

Ch=child