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Howard, Anika J., Mallan, Kimberley M., Byrne, Rebecca, Magarey, Anthea, & Daniels, Lynne A. (2012) Toddlers' food preferences : the impact of novel food exposure, maternal preferences and food neophobia. *Appetite*, *59*(3), pp. 818-825.

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http://dx.doi.org/10.1016/j.appet.2012.08.022

Toddlers' food preferences: the impact of novel food exposure, maternal preferences and food neophobia

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ABSTRACT

Food preferences have been identified as a key determinant of children's food acceptance and consumption. The aim of this study was to identify factors that influence children's liking for fruits, vegetables and non-core foods. Participants were Australian mothers (median age at delivery=31 years, 18-46 years) and their two-year-old children (M=25 months, SD=1 month; 52% female) allocated to the control group (*N*=230) of the NOURISH RCT. The effects of repeated exposure to new foods, maternal food preferences and child food neophobia on toddlers' liking of vegetables, fruits and non-core foods and the proportion never tried were examined via hierarchical regression models; adjusting for key maternal (age, BMI, education) and child covariates (birth weight Z-score, gender), duration of breastfeeding and age of introduction to solids. Maternal preferences corresponded with child preferences. Food neophobia among toddlers was associated with liking fewer vegetables and fruits, and trying fewer vegetables. Number of repeated exposures to new food was not significantly associated with food liking at this age. Results highlight the need to: (i) encourage parents to offer a wide range of foods, regardless of their own food preferences, and (ii) provide parents with guidance on managing food neophobia.

Keywords: food preferences; childhood obesity; food neophobia; repeated exposure.

INTRODUCTION

Many children do not meet recommended daily intake of fruits and vegetables and consumption of energy dense, low nutrient (non-core) foods is common. These dietary quality issues have been associated with the high prevalence of childhood obesity in developed countries (Cooke et al., 2004). In 2008, the US Feeding Infant and Toddler Study (FITS) indicated that at two years of age, 81% of children consumed a dessert, sweet and/or sweetened beverage in the day of the survey whereas 27% had eaten no fruit and 32% no vegetables (Siega-Riz et al., 2010). An Australian study of children aged 12-36 months *(N*=374) showed that 15% of children consumed no vegetables and 11% consumed no fruit in the previous 24 hours. Of 12 specified high fat/sugar foods and drinks, 11% of children consumed none, 20% one, 26% two, and 43% three or more (Chan, Magarey, & Daniels, 2010). These data indicate that dietary quality issues emerge early and hence are a potentially an important target for paediatric obesity prevention and treatment interventions.

Children's dietary patterns are substantially determined by their food preferences, which in turn are strongly influenced by their early feeding experience, particularly the variety of tastes and textures to which they are exposed as infants and toddlers (Domel et al., 1996; Drenwoski, 1997; Gibson, Wardle, & Watts, 1998). To improve child intake of vegetables and fruits we must first understand the factors that shape preferences for these foods. Whilst there is evidence of a genetic component to food preferences (Wardle & Cooke, 2008), environmental factors such as repeated exposure to new foods and parental modelling of healthy eating behaviours have also been shown to influence food preference and acceptance among children (Addessi, Galloway, Visalberghi, & Birch, 2005; Breen, Plomin, & Wardle, 2006). The literature suggests that the number of exposures required for acceptance of a novel flavour or food or increases from very few in infants (Maier, Chabanet, Schaal, Issanchou, & Leathwood, 2007; Sullivan & Birch, 1994), five to ten in 2-year-olds, (Birch &

Marlin, 1982; Birch, McPhee, Shoba, Pirok, & Steinberg, 1987) and up to 15 in 3-4-year-olds (Sullivan & Birch, 1990). However, children are often not offered this number of repeated exposure; with initial rejection commonly interpreted as genuine dislike for the foods being offered (Cooke, 2007; Cooke et al., 2004; Skinner, Carruth, Wendy, & Ziegler, 2002). Campbell and Crawford (2001) emphasise that once foods are no longer offered, the opportunity for flavour learning and enjoyment of foods is undermined, ultimately resulting in reduced dietary variety.

Experimental evidence suggests that novel tastes are more readily accepted when paired with energy density (Johnson, McPhee, & Birch, 1991). As noted by Daniels et al. (2009) and Hill (2002), the ubiquitous availability of, and hence exposure to energy dense, nutritionally poor (non-core) foods in a child's immediate environment may enhance preferences for these foods.

The food behaviours of the family unit also play a pivotal role in the development of child food preferences. Parents, particularly mothers, select foods to be eaten and model food behaviours such as food likes and dislikes to children Cathey & Gaylord, 2004; Savage, Fisher, & Birch, 2007; Scaglioni, Salvioni, & Galimberti, 2008). In Cooke et al.'s study (2004) of children aged two to six years (N=564), children's fruit and vegetable consumption were positively correlated with maternal intake ($r=.39$, $p<.005$ and $r=.49$, $p<.001$), suggesting that mothers and children tend to like similar foods. Studies have also identified that mothers tend to avoid introducing foods to their child which they themselves dislike (Cathey & Gaylord, 2004; Cooke et al., 2004; Falciglia, Pabst, Couch, & Goody, 2004; Skinner et al., 1998). This behaviour has a detrimental impact on children's dietary variety and may enhance food fussiness and neophobia (Dovey, Staples, Gibson, & Halford, 2008).

One to three years of age is a critical period for the acquisition of food preferences (Skinner et al., 2002). During these 'toddler years' children experience developmental gains in body function, language, and motor and social skills (Birch, Savage, & Ventura, 2007; Cathey & Gaylord, 2004), and establish a large proportion of their food preferences (Savage et al., 2007; Scaglioni et al., 2008; Skinner et al., 2002). Food neophobia the unwillingness to try and the rejection of new or novel foods is generally expressed in toddlers as they begin to explore their surroundings. It characteristically peaks between two to six years of age (Addessi et al., 2005; Cooke, Carnell, & Wardle, 2006; Dovey et al., 2008; Falciglia et al., 2004l Falciglia, Couch, Pabst, & Frank, 2000). Although an aversion to novel tastes may have promoted safety from toxins in our prehistoric past when humans foraged for food, food neophobia is no longer adaptive in the modern food environment and can influence children's dietary variety and overall diet quality (Fox, Pac, Devaney, & Jankowski, 2004; Savage et al., 2007; Wardle & Cooke, 2008). Food neophobia among children aged two to five years is associated with reduced preferences for all food groups, in particular vegetables (Cooke, 2007; Cooke, Haworth, & Wardle, 2007; Fox et al., 2004), with liking fewer food types, a higher number of untried food types, a less varied range of food preferences, and less healthful food preferences overall (Carruth & Skinner, 2000; Cooke et al., 2004; Fox et al., 2004; Skinner et al., 2002).

Given that early introduction or exposure to fruits and vegetables is positively associated with increased intake and variety of these foods consumed later in childhood (Cooke et al., 2004; Skinner et al., 2002), investigation into the development of food preferences in very young children is warranted. This paper reports a secondary, cross-sectional analysis of data collected from the control group of the NOURISH randomised controlled trial (RCT) (Daniels et al., 2009). The aim of this study was to examine the influence of maternal food

preferences, child food neophobia, and repeated exposure to novel foods on toddler food preferences in the Australian context.

METHODS

Study Design

The NOURISH RCT was conducted in the capital cities of two Australian states: Brisbane, Queensland and Adelaide, South Australia. NOURISH evaluated an early feeding intervention (commencing at age 4-6 months) designed to promote feeding practices hypothesised to result in healthy child eating behaviour, intake and growth at two years of age. The protocol has been described elsewhere (Daniels et al., 2009). In brief, a two-stage recruitment strategy (referred to as Stage 1 and Stage 2) was used to access a consecutive sample of first-time mothers with the aim of to reducing potential volunteer bias and increasing the representativeness of our study sample. We endeavoured to approach all eligible mothers who had delivered a healthy term infant (>35 weeks, >2500g) whilst they were still in hospital (Stage 1) and to seek consent for later contact. Infants with diagnosed with congenital abnormalities, or a chronic condition likely to affect normal development were not eligible for the trial. Additional eligibility criteria included no documented history of domestic violence or intravenous drug use; no self-reported eating or psychiatric disorder; facility with written and spoken English, and ability to attend group sessions. Mothers who gave consent at Stage 1 were recontacted via mail when their infant was aged 4-6 months (Stage 2).

Of those who consented to recontact and were contactable at Stage 2, 44% (N=698) consented to participate and were allocated to the control or intervention group. Compared to non-consenters and non-contacts, allocated mothers were older (*M*=30.1, *SD*=5.3 vs. *M*=27.4, *SD*=5.6; *p*<.001), more likely to have completed a university degree (58% vs. 33%; OR=2. 9;

CI95%=2.4 to 3.5; $p<0.001$), and more likely to have a spouse (either married or defacto; 95% vs. 88%; OR=2.5, CI95%=1.7 to 3.6; $p<.001$). Mothers who consented were less likely to have smoked at any time during their pregnancy (93% vs. 89%; OR=0.4, CI95%=0.3 to 0.5; $p<.001$), and were more likely to report that they intended to breastfeed their baby exclusively (88% vs. 75%; OR=1.8, CI95%=1.3 to 2.5; $p<.001$). Data were collected at four time points: (i) at birth and first contact (ii) Time 1 (T1): baseline and prior to allocation; infants 4.3±1.0 months; (iii) Time 2 (T2): infants 13.7±1.3 months; and (iv) Time 3 (T3): infants 24.1±0.7 months. Participant characteristics and covariates (except where detailed otherwise) based on data from first contact and Time 1 and outcome data from Time 3 are used in this paper.

Participants

Data from participants allocated to the control group only (N=346 at T1) are presented in this paper. Outcomes of interest in this secondary analysis were the number of vegetables, fruits and non-core foods liked and never tried by children at T3 (N=245). Full data were available for N=230 mother-child dyads for the hierarchical regression analyses reported in this study.

At T3, 81% of participants in the control group and 74% in the intervention group were still active in the study. Mothers who discontinued participation in the study (T3) were younger (M=28.0, SD=5.5 vs. M=30.6, SD=5.2; $p<.001$) and less likely to have a university degree (40% vs. 63%, OR=0.4 CI95%=0.3 to 0.6; $p<.001$) than those who completed. Relationship status, smoking during pregnancy, intention to breastfeed exclusively and being born in Australia did not differ between women who completed or discontinued, p values ≥0.2. However, non-completers did not vary as a function of group allocation on any of these demographic characteristics (data not shown).

Measures

Maternal and Child Characteristics. Maternal and infant characteristics collected at first contact included maternal age at delivery (years), education (University degree), and child gender. Child birth weight was collected from hospital records. At follow up assessments maternal and child weights and heights (child standing) were measured by trained study staff using standard procedures at local child health clinics. Infant birth weight Z-score and current (T3) BMI for age z-score were calculated using the World Health Organization (WHO) Anthro software program version 3.0.1 and macros (2006). Age first given solids (weeks) was reported retrospectively at T2. Breastfeeding duration (wks) was based on corroboration of data from T1, T2, and T3. For the small proportion of mothers (8%) who were breastfeeding their child at T3, child age (wks) at this time point was used as breastfeeding duration.

Food Preferences Questionnaire. Maternal and child food preferences were collected at T3 using an established tool (Wardle, Guthrie, Sanderson, Birch, & Plomin, 2001; Wardle, Sanderson, Gibson, & Rapoport, 2001) that was adapted to reflect commonly consumed Australian foods. Although there is potential for desirability bias (Cooke et al., 2006), maternal reporting of child food preferences has been found to be highly correlated with children's self-reports (Skinner et al., 1998). For younger children, maternal reporting of amount eaten, face grimaces, or food refusal (Skinner et al., 2002) have been previously used to assess infant food likes and dislikes as relevant to the present study.

Mothers rated their own and the their child's food preferences for listed food and beverage items (n=56 and n=61 respectively) from six groups (grain foods, vegetables, fruits, dairy, meat and meat alternatives, 'other' foods and beverages) on a five-point scale ranging from 'likes a lot' to 'dislikes a lot'. A sixth option 'never tried' was added as given the age of the children the likelihood that all food items listed would have been tried was low; this assumption was confirmed by the data (see Table 1).

The food categories vegetables, fruits and non-core foods were selected as outcome variables due to their association (negative/positive) with adiposity and weight gain (Hill, Wardle, & Cooke, 2009). Response options 'likes a lot' and 'likes a little' were combined to represent food 'likes'. Total number and proportion (%) of vegetables (*n*=23), fruits (*n*=17) and non-core foods (*n*=18) 'liked' and 'never tried' from the selected list of items were calculated for children. Total number and proportion (%) of these food types 'liked' by mothers were also calculated (see Appendix).

Child Food Neophobia Scale. The Child Food Neophobia (CFN) scale (Pliner & Hobden, 1992) is a validated tool which uses parental reporting of child neophobia. Four items were excluded from the CFN scale for not being considered age-appropriate (e.g. *My child likes to eat in ethnic restaurants*). The six remaining items were: *My child does not trust new foods*; *If my child doesn't know what's in a food, s/he won't try it*; *My child is afraid to eat things s/he has never tried before*; *My child will eat almost anything* (reversed score); *My child is very particular about the foods s/he will eat*, and *My child is constantly sampling new and different foods* (reversed score). Responses ranged from 'strongly disagree' to 'strongly agree' on a four-point scale. Mean CFN score was computed, with higher scores indicative of a stronger behavioural display of neophobia (Falciglia et al., 2000; Fox et al., 2004l Pliner & Hobden, 1992).

Novel Food Exposure. Number of repeated food exposures was assessed in the item *How many times do you offer a food to your child before deciding whether (s)he likes the food?*. Five categorical response options were available: 'once', 'twice', '3-5', '6-10', and '11+'. Responses were dichotomised into 'less than six exposures' and 'six or more exposures' to reflect minimum recommendations (Cathey & Gaylord, 2004; Cooke, 2007; Skinner et al., 2002).

Data management and statistical analysis

Six hierarchical regression models were used to determine the unique contribution of predictors on toddler food preferences, after the variance explained by maternal and child covariates were taken into account. Each regression model contained four steps. Hierarchical regression was used such that ΔR2 could be obtained for each of the predictor variables of interest (i.e., the unique variance accounted for by a predictor after controlling for the variance accounted for by variables already in the model). The order of entry of the predictor variables was based on the presumed importance of each for explaining variance in the outcome variable. Thus, step 1 included maternal (age at delivery [years], BMI at T1, and education [University degree] as a proxy for socioeconomic status) and child covariates (gender [male], and birth weight Z-score) as well as age first given solids [weeks] and breastfeeding duration [weeks]). Maternal liking for the particular food group was added in step 2, CFN score was added in step 3, and novel food exposure (exposure frequency [≥6 times]) was added in step 4. In all instances collinearity diagnostics revealed no multi-collinearity between variables in the regression models. Influential data points (multivariate outliers) were checked using Cook's distance, with all values well below the recommended maximum of 1.

The outcomes: percentage of vegetables never tried; percentage of fruits never tried; and percentage of non-core foods never tried, were each positively skewed. Square root transformation of these outcome variables reduced skewness (although the variables skill remained positively skewed) but did not substantively alter interpretation of the results. Thus, to further verify the robustness of the effects observed in the hierarchical linear regression models, each of the outcomes was dichotomised at the 75th percentile to isolate those children who had tried few of the listed foods in the relevant category from the majority of children who had tried most of the listed foods in the category. Binary logistic regression

analyses (data not shown) were thus performed in the same manner (i.e., same predictor variables) as per the linear regression analyses (Table 3). In no instance did the interpretation of the results differ: the same variables remained as significant predictors of the outcomes. Thus, effects from the hierarchical linear regression using raw (untransformed) data are reported for all outcome variables (i.e., children's 'likes' and 'never tried').

Data analyses were performed using SPSS/PASW Version 18.0. A conservative method of listwise deletion of missing data was used. A significance level of $p \leq .05$ was applied throughout.

Approval was obtained from 11 Human Research Ethics Committees covering Queensland University of Technology, Flinders University and all the recruitment hospitals (QUT HREC 00171 Protocol 0700000752). The trial was registered with the Australian and New Zealand Clinical Trials Registry Number (ACTRN) 12608000056392.

RESULTS

Characteristics of mother-infant dyads, number of listed vegetables, fruits and non-core foods liked by mothers and children, and the number never tried by children, are presented in Table 1. The top three (i) vegetable, (ii) fruit and (iii) non-core items 'liked' by children were: (i) potato (85%), cooked vegetables (85%) and corn (85%); (ii) apples (96%), bananas (95%) and grapes (90%), (iii) crackers (93%), hot chips (90%) and sweet biscuits (88%), and the three top 'never tried' items were: (i) brussels sprouts (60%), eggplant (47%) and cabbage (32%) (ii) paw paw (52%), canned fruit in syrup (50%) and plums (24%), and (iii) chocolate spreads (73%), fruit sticks/straps (48%) and fast foods (47%).

Liking for vegetables, fruits and non-core foods

Table 2 shows the unstandardised regression coefficients (B) with 95% Confidence Intervals and standardised regression coefficients (β) for the final regression models predicting children's liking for vegetables, fruits and non-core foods; ΔR^2 after each step is also shown.

Proportion of vegetables liked was significantly predicted by the model (R^2=.34, R^2_{Adj}= .31; F(10, 219)=11.25, p<.001), which accounted for 31% of the variance in liking for vegetables. Children whose mother's liked vegetables were more likely to like vegetables (β=.268, p<.001) and children who scored higher on the measure of food neophobia liked fewer vegetables (β=-.453, p<.001).

Liking for fruits was also significantly predicted by the model (R^2=.33, R^2_{Adj}= .30; F(10, 219)=10.81, p<.001), with 30% of variance in proportion of fruits liked being accounted for. Similar to findings on liking for vegetables, mothers' and children's liking for fruits were positively correlated (β=.451, p<.001) and high child food neophobia was associated with children liking fewer fruits (β=-.282, p<.001).

The full model predicted 25% of variance in proportion of non-core foods liked (R^2=.28, R^2_{Adj}= .25; F(10, 219)=8.54, p<.001). Mothers' and children's liking for non-core foods was positively correlated (β=.304, p<.001). As shown in Table 2, children's liking of a larger proportion of non-core foods was significantly associated with younger mothers (β=-.228, p=.001), earlier cessation of breastfeeding (β=-.141, p=.023) and earlier introduction to solids (β=-.130, p=.32).

Vegetables, fruits and non-core foods never tried

Table 3 shows the unstandardised regression coefficients (B) with 95% Confidence Intervals, standardised regression coefficients (β) and ΔR^2 after each step of the regression models predicting proportion of vegetables, fruits, and non-core foods never tried.

The full model for proportion of vegetables never tried by the child accounted for 18% of the variance (R^2=.22, R^2_{Adj}= .18; F(10, 219)=6.016, p<.001). Lower maternal liking for vegetables (β=-.337, p<.001) and higher child food neophobia (β=.184, p=.003) were associated with a greater proportion of vegetables never tried by the child.

Overall, 6% of the variance in proportion of fruits never tried was accounted for (R^2=.10, R^2_{Adj}= .056; F(10, 219)=2.36, p=.011). Mothers' liking for fruits was inversely related to proportion of fruits never tried by children (β=-.256, p<.001).

The full model predicted 21% of variance in proportion of non-core foods never tried by children (R^2=.24, R^2_{Adj}= .21; F(10, 219)=7.06, p<.001). Children of older mothers and mothers with a lower BMI had tried a smaller proportion of non-core foods (β=.228, p<.001, and β=-.128, p=.044, respectively). Conversely, higher birth weight Z-score and earlier cessation of breastfeeding were associated with having tried a greater proportion of non-core foods (β=-.123, p=.047, and β=.209, p<.001, respectively).

DISCUSSION

This study examined the effects of maternal food preferences, repeated exposure to new foods, and child food neophobia on toddler 'liking' of vegetables, fruits and non-core foods and the proportion of these food types never tried. On average toddlers liked 70% of the listed fruits and 69% of the listed non-core foods, but only 57% of the specified vegetables. Somewhat encouragingly, on average only 12% each of vegetables and of fruits and 21% of non-core foods listed had not been tried by toddlers.

Maternal liking for vegetables, fruits and non-core foods was positively associated with children's liking of these foods and inversely related to the proportion of listed fruits and vegetables never tried by the child. This is consistent with evidence that there is concordance between mothers' and children's food preferences (Cathey & Gaylord, 2004; Cooke et al.,

2004; Falciglia et al., 2004; Skinner et al., 1998), and suggests that mothers' food likes influences whether or not they offer particular foods to their child. Constraining young children's experience of new foods, such as different vegetable types, may reduce acceptance of these foods in the long-term (Skinner et al., 1998). To promote variety in children's diets, parents should be encouraged to positively model healthy dietary behaviours by actively introducing new and previously disliked foods to their own and their child's diet, even if they themselves do not like these foods.

Child food neophobia (CFN) emerged as a significant predictor for toddler liking for vegetables and fruits, after adjusting for potential covariates and maternal food preferences. Specifically, CFN was negatively related to the proportion of both vegetables and fruits liked by children, but was not associated with children's liking of non-core foods. Moreover, children who were rated as more food neophobic had tried fewer vegetables than their less neophobic peers. The results align with previous findings whereby children (aged 4-5 years) with higher CFN scores typically consumed fewer vegetables and fruits (Cooke et al., 2006) . The absence of a relationship between CFN scores and liking of non-core foods most likely reflects children's innate taste preferences for the predominant tastes (sweet and salty) of these foods (Wardle & Cooke, 2008).

In the present sample, reported number of repeated exposures was quite high (36% offer new foods six or more times) in comparison to the prevalence reported in previous research. For instance, in FITS (2002) most mothers (53%) with children between 19-24 months of age reported that they offered a novel food 3-5 times whereas only 19% offered more than six times (Carruth, Ziegler, Gordon, & Barr, 2004). However, the present analyses did not provide support for the notion that number of repeated exposures to new foods (at least six times) was associated with the proportion of vegetables, fruits or non-core foods liked.

Failure to find evidence for a relationship between repeated exposures to novel foods and liking for fruits and vegetables in the present study may be accounted for by a number of factors. First, the number of repeated exposures required to enhance food acceptance tends to increase with age. Thus, it may be that the window for overcoming food neophobia and enhancing acceptance with six repeated exposure (cut-off used in present study) is much earlier than two years of age (Dovey et al., 2008). If this is the case, then longitudinal, rather than the present cross-sectional study design, may be necessary to detect an effect of earlier feeding practices (i.e., repeated exposure to novel foods) on preference – and acceptance – of fruits and vegetables.

Second, it may also be that the *way* in which novel foods are offered (i.e., feeding practices), may moderate the efficacy of this strategy. For instance, the use of 'pressure to eat' feeding practices are associated with greater child food neophobia and lower child intake of fruits and vegetables (Fisher, Mitchell, Smiciklas-Wright, & Birch, 2002; Galloway, Fiorito, Lee, & Birch, 2005; Wardle, Carnell, & Cooke, 2005). The present analysis did not take into consideration parental feeding practices, thus the potentially moderating influence of this construct on the hypothesised relationship between repeated exposures and children's liking for foods cannot be assessed.

Third, the sensitivity and specificity of the present self-report measure of exposure to novel foods may be limited. The item used for the present study to assess the number of times a mother repeatedly exposed her child to a new food used a limited number of categorical response options and did not include a dislike option. As such, the responses provided may not elicit the total number of times a mother will trial a new food item with a toddler before determining like or dislike, or before giving up. To improve the sensitivity and specificity of this variable, future studies may benefit by including both a 'like' and 'dislike' statement in the question design, and record responses on a continuous scale. Furthermore, to provide

insight into the number of repeated exposures required for toddlers to accept and enjoy vegetables and fruits independently, separate questions that assess exposure to each food category may be beneficial.

Fourth, evidence for the effect of repeated exposure to novel food on increased preference/liking for the food, the child needs to actually taste the food; thus, offering alone may not be sufficient (Maier et al., 2007). The phrasing of the item in the current study (*How many times do you offer a food to your child before deciding whether (s)he likes the food?*) does not distinguish between these two concepts/behaviours. Whether this may have compromised the construct validity of the question is a difficult question to answer, but methodological issues such as these are clearly worth noting for future research in the field.

A range of maternal and child covariates were included in all analyses. Children of older mothers had generally tried fewer non-core foods, and liked a smaller proportion of non-core foods, however maternal age was not significantly related to the proportion of vegetables and fruits liked or tried. Higher maternal BMI and higher child birth weight Z-score were both associated with the child having tried a greater variety of non-core foods. Earlier introduction of solids was related to children liking a greater proportion of non-core foods at age two. In the Perth Infant Feeding Study II, a longitudinal study of 587 infants residing in a major metropolitan Australian city, early introduction of solid foods (prior to 17 weeks of age) was positively associated with introduction of non-core foods by 52 weeks of age (Koh, Scott, Oddy, Graham, & Binns, 2010). It may be that mothers who introduce solids early also introduce non-core foods early. If this occurs at an age when new food acceptance is comparatively high (6-12 months), then it may perpetuate the innate preference for sweet and salty foods and result in greater liking of non-core foods. Duration of breastfeeding was also related to the proportion of non-core foods liked and tried. Earlier cessation of breastfeeding was associated with children liking a greater proportion of non-core foods and having tried

more non-core foods. Previous research has indicated benefits of breastfeeding on children's vegetable intake (Cooke et al., 2004), but associations between breastfeeding and intake and/or preferences for non-core foods have been largely overlooked in the literature. Duration of breastfeeding, age at introduction of solids and higher maternal BMI tend to be associated with lower socioeconomic status and lower maternal educational achievement (Lanigan, Bishop, Kimber, & Morgan, 2001). Children of parents with lower education levels have been shown to have poorer quality dietary intake (Burnier, Dubois, & Girard, 2011). However, maternal education was not a significant predictor in the present analysis, thus a more complex assessment of socioeconomic status may be needed to explain these relationships. It is important to note that although the literature suggests many of the variables may be associated there was no evidence of multi-collinearity or singularity from the regression analyses (all $r<.2$).

This study provides information on the unique contribution of a range of variables on toddlers' liking for vegetables, fruits and non-core foods, and the proportion of foods from these groups never tried. In contrast to previous studies that have assessed the effect of one independent variable, such as child age, on child food preferences (Cooke & Wardle, 2005; Fox et al., 2004l Skinner et al., 2002), this study sought to investigate the multivariable effect of three key predictor variables on toddler food preferences after also adjusting for key maternal and child covariates. The number of food types (categories) assessed is comparable to previous studies investigating child food preferences (Fox et al., 2004; Skinner et al., 1998; Wardle, Guthrie, et al., 2001; Wardle, Sanderson, et al., 2001) as is the number of individual food items specified for each (Hill et al., 2009). However, an important limitation of this study is that there was no assessment of fathers' food preferences. Both parents contribute to the genetic component of child food preferences. It is plausible that fathers' preferences may have an additive effect through influencing what the family eats and hence what the child is

offered and has an opportunity to learn to like. Another notable limitation of the present study is that the long term consequences of the predictors on food liking and variety of foods tried could not be ascertained. Longitudinal analyses of the relationship between food exposure, maternal (or familial) food preferences and food neophobia and child food preferences would no doubt add value to the current findings. Similarly, corroboration of the present findings with data on toddlers' dietary intake will further enhance our understanding of the relationship between food preferences, intake and overall dietary quality. Assessing the longer-term impact of toddler food preferences on intake during childhood will also be possible as the mother-infant dyads participating in the NOURISH RCT (Daniels et al., 2009) are followed-up at 3.5 to 4 and 5 years of age.

Finally, it is uncertain if the findings can be generalised beyond first time English-speaking mothers who delivered a healthy, full-term infant and live within the Australian metropolitan context. Furthermore, mothers included in the study reported no history of domestic violence, intravenous drug use or psychiatric illness (including eating disorders). The consecutive sampling framework used allowed participation bias to be assessed. This revealed that mothers who agreed to participate in NOURISH were 2-3 years older, of higher education level, more likely to have a spouse and less likely to have smoked during pregnancy than mothers who provided some information at the first stage of recruitment but who did not participate. Such selection bias is common and probably unavoidable in intervention trials but must be considered in extrapolating the results beyond the research context.

Conclusion

Child health initiatives to promote fruit and vegetable and reduce non-core intake among children need to address the factors that shape food preferences. As indicated by the present findings, this should involve the consideration of child food neophobia and maternal food preferences. Toddlers with high child food neophobia scores typically disliked a greater

proportion of vegetables and fruit; and were more likely to have tried fewer vegetables than their non-neophobic peers. Maternal liking was related to both their child's liking for, and experience with vegetables, fruit and non-core foods. The lack of association between repeated exposure and preferences in our cross sectional analysis in two year olds does not preclude this as a useful strategy in younger infants. Overall, these results speak to the need for parents to offer a wide range of foods to their child even if they themselves do not like/eat these foods and particularly if their child has higher innate levels of neophobia. In the short term, public health initiatives must consider: (1) encouraging caregivers to promote healthy eating to their children by modelling healthy food behaviours; and (2) the need to provide guidance on effective strategies to handle food refusal and child food neophobia. These strategies are likely to contribute to development of life-long healthy eating habits, thereby enabling the next generation to enjoy good health.

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Table 1. Characteristics of mother-infant dyads in the NOURISH control group (*N*=277) who provided data at Time 3 (18 month follow up from baseline) (Daniels LA, 2009).

Variable	Mean ± SD; %(n)
Maternal characteristics	
Age at delivery (years)	30 ± 5
University Education (yes)	63 (173)
BMI (kg/m^2) [a]	26 ± 6
Child characteristics	
Age (months) (*n*=277)	24 ± 1
Gender (female)	51 (141)
Birth weight Z-score	0.4 ± 0.9
Current BMI for age Z-score (*n*=271)	0.7 ± 0.9
Breastfeeding duration [b] (weeks) (*n*=275)	41 ± 29
Age first given solids [c] (weeks) (*n*=275)	23 ± 5
'Average' number of repeated exposures to new food (*n*=244)	
1-6 times	64 (157)
≥6 times	36 (87)
Child Food Neophobia score [d] (*n*=245)	2.2 ± 0.6
Food preferences and exposure [e]	**Median (IQ range)**
Number of listed foods 'liked' by mothers (*n*=245)	
Vegetables (*n*=23)	19 (17 : 20)
Fruits (*n*=17)	13 (11 : 14)
Non-core foods (*n*=17)	13 (10 : 14)
Number of listed foods 'liked' by child (*n*=245)	
Vegetables (*n*=23)	13 (9 : 16)
Fruits (*n*=17)	12 (10 : 15)
Non-core foods (*n*=18)	13 (10 : 15)
Number of listed foods 'never tried' by child (*n*=245)	
Vegetables (*n*=23)	2 (1 : 4)
Fruits (*n*=17)	2 (1 : 3)
Non-core foods (*n*=18)	3 (1 : 5)

[a] BMI calculated from height and weight data collected at T1 (infants 4.3±1.0 months);

[b] breastfeeding duration reported retrospectively at T1/T2/T3;

[c] infant age when solids first introduced reported retrospectively at T2 (infants 13.7±1.3 months);

[d] mean score on 4-point Child Food Neophobia (CFN) scale (Pliner & Hobden, 1992), with higher scores indicative of a stronger behavioural display of neophobia;

[e] Based on listed items in each food category (see Appendix),'liked'= number of items rated as 'likes a lot/likes a little' vs. 'neither likes nor dislikes/dislikes a little/dislikes a lot/never tried', 'never tried'= number of items rated as 'never tried' vs. 'likes a lot/likes a little/neither likes nor dislikes/dislikes a little/dislikes a lot'.

Table 2. Proportion of vegetables, fruits and non-core foods 'liked' by 230 (52% female, aged 24±1 month) toddlers.

Variable		**Foods 'liked' by child** [a]					
		% Vegetables [b] M=57 ± SD=25		**% Fruits** [c] M=70 ± SD=20		**% Non-core foods** [d] M=69 ± SD=19	
		B (CI95%)	β	B (CI95%)	β	B (CI95%)	β
Step 1		ΔR^2=.018 (p=.764)		ΔR^2=.033 (p=.385)		**ΔR^2=.184 (p<.001)**	
Maternal age at delivery (yr)		.001 (-.004 to .007)	.031	.001 (.110 to .595)	.017	-.008 (-.013 to -.004)	-.228**
Maternal BMI [e]		.002 (-.003 to .007	.047	.003 (-.004 to .005)	.084	.000 (-.004 to .004)	.005
Maternal university education (yes)		.014 (-.044 to .071)	.028	.007 (-.001 to .007)	.016	.018 (-.028 to .065)	.048
Child gender (male)		.005 (-.046 to .057)	.012	.019 (-.043 to .056)	.047	.041 (-.001 to .083)	.113
Birth weight Z-score		-.009 (-.039 to .022)	-.033	.017 (-.026 to .063)	.075	.025 (.000 to .050)	.118
Breastfeeding duration [f] (wk)		.000 (.000 to .001)	.057	.000 (-.009 to .043)	.025	-.001 (-.002 to .000)	-.141*
Age first given solids [g] (wk)		-.001 (-.007 to .004)	-.026	-.001 (-.001 to .004)	-.027	-.005 (-.009 to .000)	-.130*
Step 2		**ΔR^2=.127 (p<.001)**		**ΔR^2=.219 (p<.001)**		**ΔR^2=.080 (p<.001)**	
Foods 'liked' by mother [a]	% vegetables [b]	.425 (.245 to .605)	.268**	--	--	--	--
	% fruits [c]	--	--	.532 (.399 to .666)	.451**	--	--
	% non-core [d]	--	--	--	--	.290 (.178 to .402)	.304**
Step 3		**ΔR^2=.190 (p<.001)**		**ΔR^2=.075 (p<.001)**		ΔR^2=.009 (p=.097)	
Child food neophobia [h]		-.164 (-.204 to -.123)	-.453**	-.087 (-.122 to -.053)	-.282**	-.028 (-.061 to .004)	-.101
Step 4		ΔR^2=.004 (p=.274)		ΔR^2=.004 (p=.256)		ΔR^2=.008 (p=.122)	
Novel food exposure frequency [i] (≥6 times)		.030 (-.024 to .083)	.061	-.027 (-.073 to .019)	-.064	-.034 (-.078 to .009)	-.090

**p≤.001; *p≤.05; all values given as per final regression model;

[a] Mean % (± SD) of listed items in each food category (see Appendix) on food preferences questionnaire (Wardle, Guthrie, Sanderson, Birch, & Plomin, 2001; Wardle, Sanderson, Leigh Gibson, & Rapoport, 2001),'liked'= proportion of items rated as 'likes a lot/likes a little' vs. 'neither likes nor dislikes/dislikes a little/dislikes a lot/never tried';

[b] Vegetable items (n=23);

[c] Fruit items (n=17);

[d] Non-core foods (n=18 [children], n=17 [mothers]);

[e] BMI calculated from height and weight data collected at T1 (infants 4.3±1.0 months);

[f] breastfeeding duration reported retrospectively at T1/T2/T3;

[g] infant age when solids first introduced reported retrospectively at T2 (infants 13.7±1.3 months);

[h] mean score on 4-point Child Food Neophobia (CFN) scale (Pliner & Hobden, 1992), with higher scores indicative of a stronger behavioural display of neophobia;

[i] responses to item *How many times do you offer a food to your child before deciding whether (s)he likes the food?* dichotomised as 1-6 times vs. ≥6 times.

Table 3. Proportion of vegetables, fruits and non-core foods 'never tried' by 230 (52% female, aged 24±1 month) toddlers.

		Foods 'never tried' by child [a]					
Variable		**% Vegetables [b]** M=12 ± SD=9		**% Fruits [c]** M=12 ± SD=10		**% Non-core foods [d]** M=21 ± SD=16	
		B (CI95%)	β	B (CI95%)	β	B (CI95%)	β
Step 1		ΔR^2=.047 (p=.151)		ΔR^2=.030 (p=.437)		**ΔR^2=.227 (p<.001)**	
Maternal age at delivery (yr)		.002 (.000 to .004)	.119	.002 (-.001 to .004)	.102	.007 (.003 to .011)	.228**
Maternal BMI [e]		-.001 (-.003 to .001)	-.065	-.001 (-.004 to .001)	-.080	-.004 (-.008 to .000)	-.128*
Maternal university education (yes)		-.009 (-.033 to .014)	-.050	.019 (-.007 to .044)	.099	.025 (-.018 to .068)	.073
Child gender (male)		-.013 (-.034 to .008)	-.073	.004 (-.019 to .027)	.022	-.029 (-.067 to .010)	-.088
Birth weight Z-score		-.007 (-.019 to .006)	-.066	-.001 (-.014 to .013)	-.005	-.023 (-.046 to .000)	-.123*
Breastfeeding duration [f] (wk)		.000 (-.001 to .000)	-.098	.000 (-.001 to .000)	-.079	.001 (.000 to .002)	.209**
Age first given solids [g] (wk)		.000 (-.002 to .002)	.012	-.001 (-.003 to .002)	-.035	.002 (-.002 to .006)	.068
Step 2		**ΔR^2=.135 (p<.001)**		**ΔR^2=.059 (p<.001)**		**ΔR^2=.008 (p=.120)**	
Foods 'liked' by mother [a]	% vegetables [b]	-.202 (-.277 to -.128)	-.337**	--	--	--	--
	% fruits [c]	--	--	-.136 (-.206 to -.066)	-.256**	--	--
	% non-core [d]	--	--	--	--	-.082 (-.185 to .021)	-.096
Step 3		**ΔR^2=.032 (p=.003)**		ΔR^2=.001 (p=.732)		ΔR^2=.001 (p=.943)	
Child food neophobia [h]		.025 (.008 to .042)	.184*	.003 (-.015 to .021)	.024	.000 (-.030 to .030)	-.002
Step 4		ΔR^2=.002 (p=.453)		ΔR^2=.007 (p=.180)		ΔR^2=.009 (p=.116)	
Novel food exposure frequency [i] (≥6 times)		-.008 (-.031 to .014)	-.046	.017 (-.008 to .041)	.088	.032 (-.008 to .072)	.094

**p≤.001; *p≤.05; all values given as per full regression model;

[a] Mean % (± SD) of listed items in each food category (see Appendix) on food preferences questionnaire (Wardle, Guthrie, et al., 2001; Wardle, Sanderson, et al., 2001), 'never tried'= proportion of items rated as 'never tried' vs. 'likes a lot/likes a little/neither likes nor dislikes/dislikes a little/dislikes a lot' and 'liked'= proportion of items rated as 'likes a lot/likes a little' vs. 'neither likes nor dislikes/dislikes a little/dislikes a lot/never tried';

[b] Vegetable items (n=23);

[c] Fruit items (n=17);

[d] Non-core foods (n=18 [children], n=17 [mothers]);

[e] BMI calculated from height and weight data collected at T1 (infants 4.3±1.0 months);

[f] breastfeeding duration reported retrospectively at T1/T2/T3;

[g] infant age when solids first introduced reported retrospectively at T2 (infants 13.7±1.3 months);

[h] mean score on 4-point Child Food Neophobia (CFN) scale (Pliner & Hobden, 1992), with higher scores indicative of a stronger behavioural display of neophobia;

[i] responses to item *How many times do you offer a food to your child before deciding whether (s)he likes the food?* dichotomised as 1-6 times vs. ≥6 times.

Appendix. Items by food category listed in food preferences questionnaire (Wardle, Guthrie, et al., 2001; Wardle, Sanderson, et al., 2001).

Vegetables (n=23)
Cooked vegetables
Raw vegetables
Green beans
Broccoli
Spinach
Carrots
Pumpkin
Sweet potato
Corn
Green peas
Potato – boiled, mashed, roasted
Zucchini
Cabbage
Cauliflower
Brussels sprouts
Lettuce and other salad leaves
Celery
Tomato
Cucumber
Avocado
Mushrooms
Capsicum
Eggplant

Fruits (n=17)
Canned fruit in syrup
Canned fruit in juice or water
Apples
Pears
Peaches, nectarines
Bananas
Strawberries and other berries
Oranges and other citrus fruit
Watermelon
Rockmelon
Plums
Grapes
Mango
Paw paw
Pineapple
Kiwi fruit
Sultanas

Non-core foods (n=18)
Ice cream
Potato crisps/corn chips
Fried potato/hot chips
Fast foods (e.g. KFC, McDonalds)
Sweet biscuits
Savoury biscuits
Crackers
Chocolate
Lollies
Cake, doughnuts, buns, pastries
Muesli bars
Fruit sticks/straps
Chocolate spreads (e.g. Nutella)
Honey and/or jam
Vegemite, Promite, Marmite
Cheese spread or dip
Peanut butter
Fruit gel or jelly[a]

[a] Food item not present in maternal food preferences survey