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Chawner, LR orcid.org/0000-0002-4905-0397, Blundell-Birtill, P and Hetherington, MM orcid.org/0000-0001-8677-5234 (2022) An online study examining children's selection of vegetables at mealtimes: The role of meal contexts, variety and liking. Appetite, 169. 105803. ISSN 0195-6663

https://doi.org/10.1016/j.appet.2021.105803

An online study examining children's selection of vegetables at mealtimes: The role of meal contexts, variety and liking.

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Abstract

Associative learning predicts that children expect to eat vegetables together with foods high in carbohydrate and protein at mealtimes. However, choosing to eat and consume vegetables may be less likely if they are presented alongside more palatable, competing foods. This study examined food choices of children (N = 180, 8-11 years, 84 female) in a mealtime context. During an online task, children chose one food for a meal, from a choice of vegetables and either a food high in carbohydrate or protein. Preference was assessed with and without a partial meal stimulus, to test the effect of other foods on the plate. Vegetables were selected more often with a meal stimulus, especially when it consisted of carbohydrate and protein foods, meaning that the vegetable option added nutritional variety to the meal. This effect was moderated by the difference in liking between the food options available. Vegetables were selected more if they were better liked than the competing food option, although it was not necessary that vegetables were better liked if they added nutritional variety to the meal. Food fussy children were less likely to select vegetables, but no other effects of child appetitive traits or parental practices were found on children's food choices. Children may be more likely to select vegetables if they add nutritional variety to a meal and are similarly or better liked than competing food options. Future research could test specific meal configurations which promote children's selection and intake of vegetables at mealtimes.

Keywords: Food choice, Competing foods, Vegetables, Mealtime, Children.

[1]

[1] Abbreviations: CEBQ – Child Eating Behaviour Questionnaire; CFQ – Child Feeding Questionnaire; PMAS-R – Parent Mealtime Action Scale.

1 Introduction

The home and school environments, including practices at mealtimes and social norms, can help to shape school age children's food preferences and their ability to self-regulate food intake (De Wit et al., 2015; Pedersen, Grønhøj, & Thøgersen, 2015; Sharps & Robinson, 2015). This means that although parents and schools are the main providers of food to children, determining the types of food available and their quantities (Ventura & Birch, 2008), children are also able to control which of the available foods they will eat and how much (Warren, Parry, Lynch, & Murphy, 2008). At mealtimes, it is recommended that a balanced meal consists of foods high in protein and carbohydrates, with half a plate of vegetables (Public Health England, 2018). However, children often refuse to consume vegetables in recommended portion sizes due to their appearance or lack of familiarity (Appleton, Hemingway, Rajska, & Hartwell, 2018; Houston-Price, Butler, & Shiba, 2009), bitter (e.g. dark-green vegetables)(Bell & Tepper, 2006) or bland (e.g. cauliflower)(Zeinstra, Vrijhof, & Kremer, 2018) tastes, varying textures (Farrow & Coulthard, 2018), low energy density (LED) or the availability of more palatable foods (Gibson & Wardle, 2003). This often results in large amounts of plate waste (Marlette, Templeton, & Panemangalore, 2005; Martins, Rodrigues, Cunha, & Rocha, 2020). Therefore, to reduce plate waste, improve children's dietary variety and vegetable intake, there is a need to understand how and why children make choices regarding what to eat at mealtimes.

Previous research examining how to promote healthy eating choices in children has often presented food options differing in energy density, with 'less healthy' food items (high energy dense: HED, often high in fats, sugar and salt) being offered alongside 'healthier' items (LED, often fruits and vegetables), usually as snack or single food (Pearce et al., 2020). The use of simple heuristics facilitates decision making in this context, with the child using

53 only information that is most valuable to them (Rangel, 2013; Schulte-Mecklenbeck, Sohn,
54 de Bellis, Martin, & Hertwig, 2013). Consequently, taste is a strong predictor of food
55 selection in children, overriding cognitive aspects of choice such as the healthiness of foods
56 (Nguyen, Girgis, & Robinson, 2015). When children are hungry, neural food cue reactivity is
57 heightened, especially to HED foods (Charbonnier et al., 2018). Therefore, choosing a HED
58 food may be driven by the desire to eat a specific food (Pearce et al., 2020) and attempting
59 to change this behaviour to selecting healthier food options may be challenging, as this
60 requires inhibitory control by the child (Ha et al., 2016; Pearce et al., 2020).
61 Individual differences between children further predict habitual food consumption.
62 Children with traits of fussy eating or food neophobia are less likely to consume vegetables
63 or seek a variety of foods (Dovey, Staples, Gibson, & Halford, 2008; Lafraire, Rioux,
64 Giboreau, & Picard, 2016). Conversely, children with high enjoyment of food are found to
65 have larger consumption of fruits and vegetables (Cooke et al., 2004), as are those that are
66 variety seekers (purposefully choosing foods that are different, or from a different food
67 group) (Nicklaus, Boggio, Chabanet, & Issanchou, 2005). However, these traits have seldom
68 been researched in relation to children's food choice (Chawner & Hetherington, 2021).
69 Although, variety seeking traits may promote diversification when choosing snacks for an
70 entire week all at once, compared with choosing one snack each day of the week
71 (Echelbarger, Maimaran, & Gelman, 2020).
72 Among many influences on children's food choices for snack items, associative
73 learning theory predicts that children may expect to eat some vegetables within the context
74 of a meal, due to previous mealtime learning and experiences of vegetables being paired
75 with other foods (Birch & Anzman, 2010; Bouton, 2010). Children in the UK consume the
76 majority of their daily vegetable intake at family evening mealtimes, most commonly

77 alongside foods high in protein and carbohydrates (Chawner, Blundell-Birtill, &
78 Hetherington, 2020). Therefore, when promoting the selection of vegetables from available
79 choices, the context of mealtimes and presenting familiar foods together (with varying
80 levels of palatability) may be important. Parents and schools often provide children with
81 choices between foods to eat at mealtimes (Hendy, Williams, Camise, Eckman, &
82 Hedemann, 2009), but little is known about children's selection of foods when offered
83 alongside competing meal items. Allowing children to make some food choices may be
84 beneficial for their intake of certain foods, however offering too many choices and
85 consequently providing meals for children that are different from the rest of the family is
86 often problematic in encouraging healthy eating (Harris, Ria-Searle, Jansen, & Thorpe, 2018;
87 Powell, Farrow, Meyer, & Haycraft, 2017).
88 There is mixed evidence for whether offering a choice of vegetables affects intake of
89 those vegetables at mealtimes. In a study by Zeinstra, Renes, Koelen, Kok, and de Graaf
90 (2010), children were given a choice of two vegetables before meals and this did not
91 increase consumption or liking of vegetables compared with not having a choice. Yet in a
92 later study, de Wild, de Graaf, Boshuizen, and Jager (2015) showed that offering a choice of
93 vegetables increased intake, but this was mediated by liking for the vegetable. Domínguez
94 et al. (2013) suggested that offering a choice increases vegetable intake compared with not
95 having a choice. To date, it is not known how choice affects children's selection of
96 vegetables alongside competing foods in the context of meals. In addition to flavour, hunger
97 and healthiness of food items, the meal context itself and different configurations of several
98 foods within meals is worthy of investigation for their potential effects on food intake and
99 food choice. When entrées (the main course of a meal) are paired with vegetables, it is
100 reported that food waste may be linked to the palatability of the different foods on the

plate (Ishdorj, Capps Jr, Storey, & Murano, 2015). When a highly palatable food (chicken nuggets) was paired with a less liked vegetable (green beans), there was more waste of the vegetable compared with when the same vegetable was paired with a less palatable/liked entrée (steak fingers) (Ishdorj et al., 2015). This is especially relevant to consider at times that children are required to choose their own foods, such as at school lunchtimes, as many children avoid vegetables when competing or more palatable foods are available (Miller et al., 2015).

In the current study, using an online experiment, children's selection of vegetables was examined when food choices were presented within a Meal Context (a partial meal stimulus was presented and children chose a food option to add to it) compared with No Meal Context (food choices were imagined to be eaten with a meal, but no meal stimulus was presented). When the meal context frames the food choices available, it is hypothesised that children will select a food from a food group that is not present in the stimulus, so that a balance of food groups (nutritional variety) is achieved within the meal. Therefore, vegetables will be chosen more often when vegetables are not part of the meal stimulus. However, when the food groups available to choose from are the same as those presented in the meal stimulus (i.e. there is no nutritional variety available to choose), it is hypothesised that the most liked food will be chosen. Furthermore, we predict that children scoring higher on traits of fussy eating will select vegetables less frequently, compared with children that score higher on measures of enjoyment of food.

2 Methods

2.1 Participants

Parent and child dyads (N = 180) were recruited online via Prolific (www.prolific.co). Parents were invited to take part if their child was aged between 8-11 years old and the child did not identify as a vegetarian or vegan. To ensure that individuals met these criteria, screening questions in Prolific were used. The sample was restricted to individuals from the UK (due to familiarity with food stimuli used), parents living with their child full-time and with children born between 2009 and 2012. All parents (mothers, n = 119) completed the study along with their child (female, n = 84) and monetary payment of £1.75 (rate: £7.50/hour) was received by parents for completing the study. A further 22 parent-child dyads started the study but did not complete the child part and were therefore not included in any analyses. Ethical approval was received from the University of Leeds Psychology Research Ethics Committee (reference number: PSYC-75). Full sample demographic information is described in **Table 1.**

Table 1. Participant Characteristics.

Participant Characteristics.	
Total Parents, Male (%)	180, 61 (33.89)
Total Children, Male (%)	180, 96 (53.34)
Parent Age, Mean (SD) [Range]	39.4 (6.77) [25-64]
Child Age, N (%)	
8	62 (34.45)
9	46 (25.56)
10	44 (24.45)
11	28 (15.56)
Ethnicity of child, N (%)	
White/White British	162 (90.0)
Black/Black British	4 (2.22)
Asian/Asian British	1 (0.56)
Mixed ethnic Group	11 (6.11)
Prefer not to say	2 (1.11)
Household Income, N (%)	
Less than £25,000	35 (19.44)
£25,000 to £49,999	81 (45.00)
£50,000 to £74,999	49 (27.22)
above £75,000	9 (5.0)
prefer not to answer	6 (3.33)
Parental Education, N (%)	
Some High School or Less	14 (7.78)
Some college education	54 (30.0)
Associate Degree (AA) or vocational license	8 (4.44)
Bachelor's degree	64 (35.56)
Graduate or professional degree	40 (22.22)

2.2 Study design

The study protocol can be viewed at Open Science Framework (OSF: https://osf.io/5jtbr/?view_only=34705e2f47ea479485eb4a16c67238f6). Questionnaires were completed by parents followed by food choice tasks which children completed. All procedures were conducted online using Gorilla Experiment Builder (www.gorilla.sc) to create and host the study. A mixed, within-between individuals design was used in which children made food choices across conditions and comparisons were made between children. The experiment had two main conditions, food choice with a meal context and food choice with no meal context. In both conditions, children made a choice between two

146 foods. In the meal context condition a partial meal stimulus made up of two different foods
147 was presented to children before they made a choice between two other foods. Children
148 were instructed that they should imagine eating the food choices with the foods in the
149 partial meal stimulus. The no meal context condition did not include a partial meal stimulus,
150 only a choice between two food options (*see section 2.4 stimuli for further detail).* In both
151 conditions, the dependent variable was selection of the vegetable item from the choices
152 presented (binary response, selected or not selected).

153 Within the meal context condition, a further 2x3 factorial design was implemented to
154 examine predictors for why children made their food choices. Changes were made to the
155 food groups presented in the partial meal stimulus and to nutritional variety (a different
156 food group offered) from the response options (i.e. were the response options from the
157 same food group as the foods in the partial meal stimulus, or was there a different food
158 group in the response options). This had three levels (1. stimulus meal included a vegetable
159 and either protein or carbohydrate – choice options were the same as those food groups in
160 the stimulus; 2. stimulus meal included a vegetable and either protein or carbohydrate -
161 nutritional variety available from the competing food option; and 3. stimulus meal included
162 protein and carbohydrate - nutritional variety available from the vegetable option). The
163 second independent variable was the competing foods that were available. This had two
164 levels (vegetable versus protein; and vegetable versus carbohydrate). See **Table 2.** for
165 combinations of the partial meal stimuli and response options

166 For each trial, two different foods from different food groups were included in the
167 meal stimulus (from vegetable, carbohydrate and protein) and two different foods from
168 different food groups (one option was always a vegetable) were presented in the response
169 options (although these foods could be from the same food groups as a food in the meal

stimulus; see **Table 2.**). Lastly, for the no meal context condition, only the competing foods presented changed as there was no meal stimulus in this condition.

Table 2. Combinations of the partial meal stimuli (meal context condition only) and response options (both no meal context and meal context conditions), referred to as trial type in the results section. Trial type refers to the three levels of combinations of partial meal stimulus and whether a nutritional variety is available from the response options (detailed in *2.2 Study design*).

Trial type levels	Stimulus same as choice	Stimulus same as choice	Competing food adds variety	Competing food adds variety	Vegetable adds variety	Vegetable adds variety
Combinations of food groups in the partial meal stimulus	Vegetable & Carbohydrate	Vegetable & Protein	Vegetable & Protein	Vegetable & Carbohydrate	Carbohydrate & Protein	Carbohydrate & Protein
	↓	↓	↓	↓	↓	↓
Combinations of food groups in the response options	Vegetable vs Carbohydrate	Vegetable vs Protein	Vegetable vs Carbohydrate	Vegetable vs Protein	Vegetable vs Carbohydrate	Vegetable vs Protein

& = Presented together in meal stimulus; VS = Competing to be chosen as the response.

2.3 Study procedure

Parents were invited to participate in the study using a tablet or a desktop computer (mobile phones were not permitted due to small screen sizes which failed to show food pictures sufficiently clearly). After parental consent and child assent were confirmed, parents were asked a range of demographic questions about themselves and their child (**Table 1.**), how much they perceive their child to like each food stimulus used in the experiment (Visual Analogue Scale: VAS, 0-100) and how often each food is eaten at home (familiarity: 5-point Likert scale ranging from Never to Everyday). Parents were then required to complete the enjoyment of food and food fussiness subscales of the Child Eating Behaviour Questionnaire (CEBQ: Wardle et al., 2001), the restriction and pressure to eat

189 subscales of the Child Feeding Questionnaire (CFQ: Birch et al., 2001) and the food choice
190 subscale of the Parent Mealtime Action Scale (PMAS-R: Hendy, Harclerode, & Williams,
191 2016). The food fussiness and enjoyment of food subscales of the CEBQ were comprised of
192 six and four questions, respectively. These scales were included to control for the effects of
193 children's appetitive traits on their food choices. The restriction and pressure to eat
194 subscales of the CFQ were comprised of eight and four questions, respectively. These scales
195 were included to control for the effects of parental feeding practices on children's food
196 choices. Lastly, the food choice subscale from the PMAS-R comprised of four items that
197 measure child involvement in choosing meal items (e.g. the child eats whatever he/she
198 wanted, the child can choose which foods to eat but only from those offered). This scale was
199 included to control for children that have restricted or more open choice of foods to eat at
200 mealtimes.

201 Parents were then instructed to pass the device to their child. Children were firstly
202 required to confirm their age and how hungry they were feeling on a four-point Likert scale
203 (not at all, somewhat, moderately, extremely). Next, children were requested to complete
204 the food choice task (both no meal context and meal context conditions in a randomised
205 order). After children completed the food choice task, they were asked to rate their liking
206 for each food individually (VAS, 0-100; each food was presented in a randomised order) and
207 comparatively for all foods (ranked liking; each food's initial ranked position was
208 randomised), before being debriefed of the study aims.

209 *2.4 Stimuli*

210 Nine foods were used throughout the experiment, with three foods each belonging
211 to the food groups carbohydrates (roasted potatoes, mashed potatoes, and boiled
212 potatoes), proteins (sausages, beef slices and chicken slices) and vegetables (peas, broccoli,

and green beans) (see **Table 3.** for estimated nutrient compositions of each food used). These foods were chosen because each food is familiar to UK children and commonly eaten at mealtimes (Chawner et al., 2020; Gregory et al., 2000). Additionally, most combinations of these individual foods are also plausible to be eaten together within a meal (with the possible exception of different types of potato being eaten together). Within food groups, the foods were matched to be as similar as possible in taste, texture, colour and general liking, so that each individual food would have a similar chance of being chosen to be added to the meal. Therefore, no one food was prominent in the meal stimulus or as a choice (e.g. carrots are often liked by children and may have been chosen more often than other vegetables. Carrots are also brighter in colour which may be a further reason to choose this food, as carrots would add visual variety to a meal).

Images of each food used were adapted from the Child Food Atlas-Primary (Foster, Hawkins, & Adamson, 2010) where the median portion size was used. For meal stimuli, composite meal pictures were created from two individual foods belonging to two different food groups (e.g. broccoli and roasted potatoes). Each food and meal stimulus image also included text writing of which individual food or meal stimulus was presented (see **Figure 1 and 2.** for example stimuli).

230 **Table 3.** Estimated nutrient composition and energy content of each food used per 100g

231 (McCance & Widdowson, 2021).

Item	Energy (kcal/100g)	Fat (g/100g)	CHO (g/100g)	Sugars (g/100g)	Protein (g/100g)
Sausages	224	22.1	9.8	1.5	14.5
Chicken	114	1.5	2.0	0.2	23.2
Beef	193	6.3	0.0	0.0	34.0
Mashed Potatoes	102	3.9	15.9	1.0	1.9
Boiled Potatoes	74	0.1	17.5	0.8	1.8
Roasted Potatoes	161	5.7	26.4	1.2	2.6
Broccoli	28	0.5	2.8	1.6	3.3
Peas	79	1.6	10.0	1.2	6.7
Green Beans	26	0.3	4.0	3.0	2.1

232

Figure 1. Illustration of a meal context trial. The example is when carbohydrates and protein are in the partial meal stimulus, and the choices available to add to the meal are a carbohydrate or a vegetable. Fixation points were shown for 250ms and all other stimuli were presented on screen until the participant clicked on the "Next" button or an available response option.

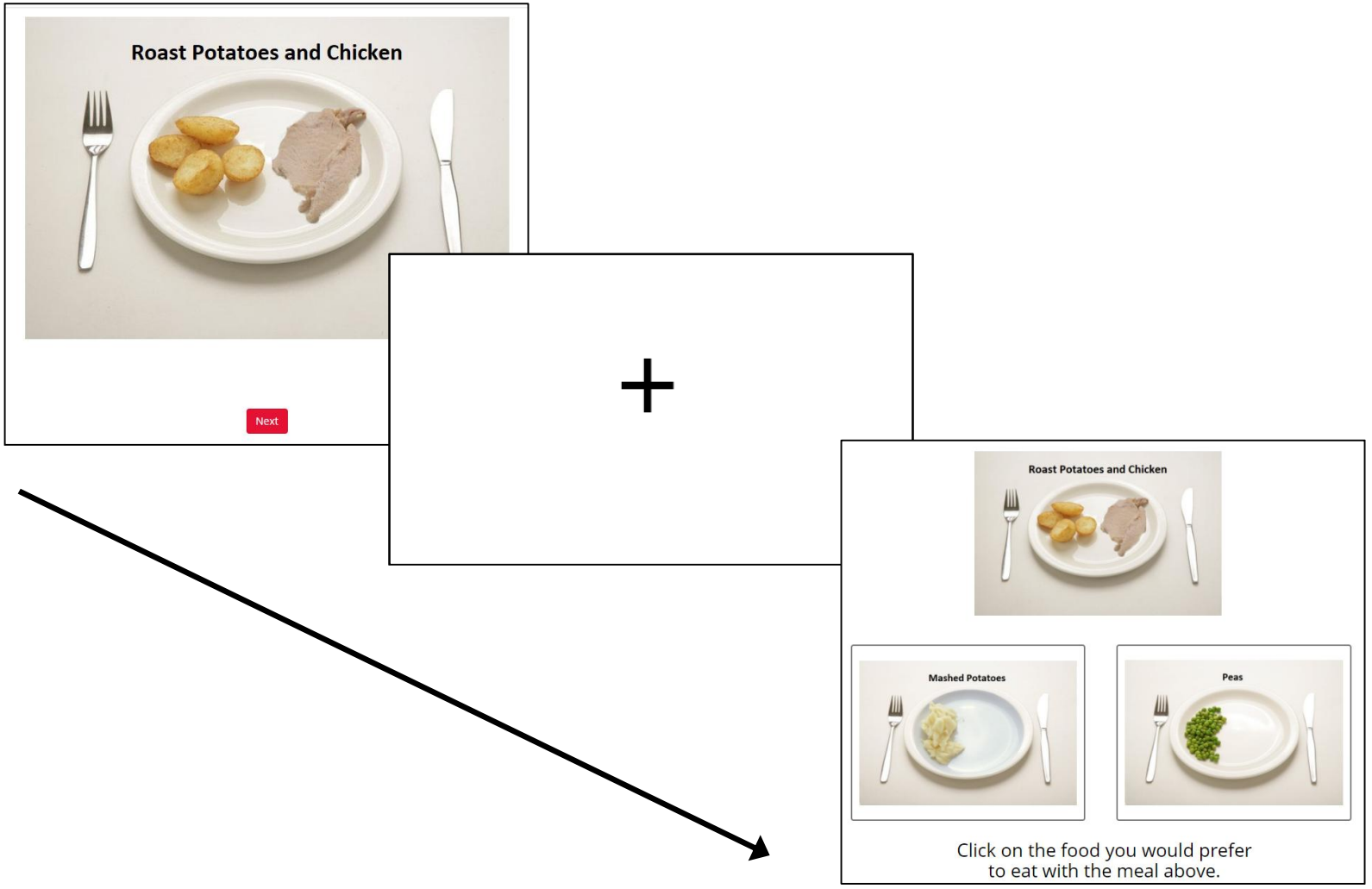
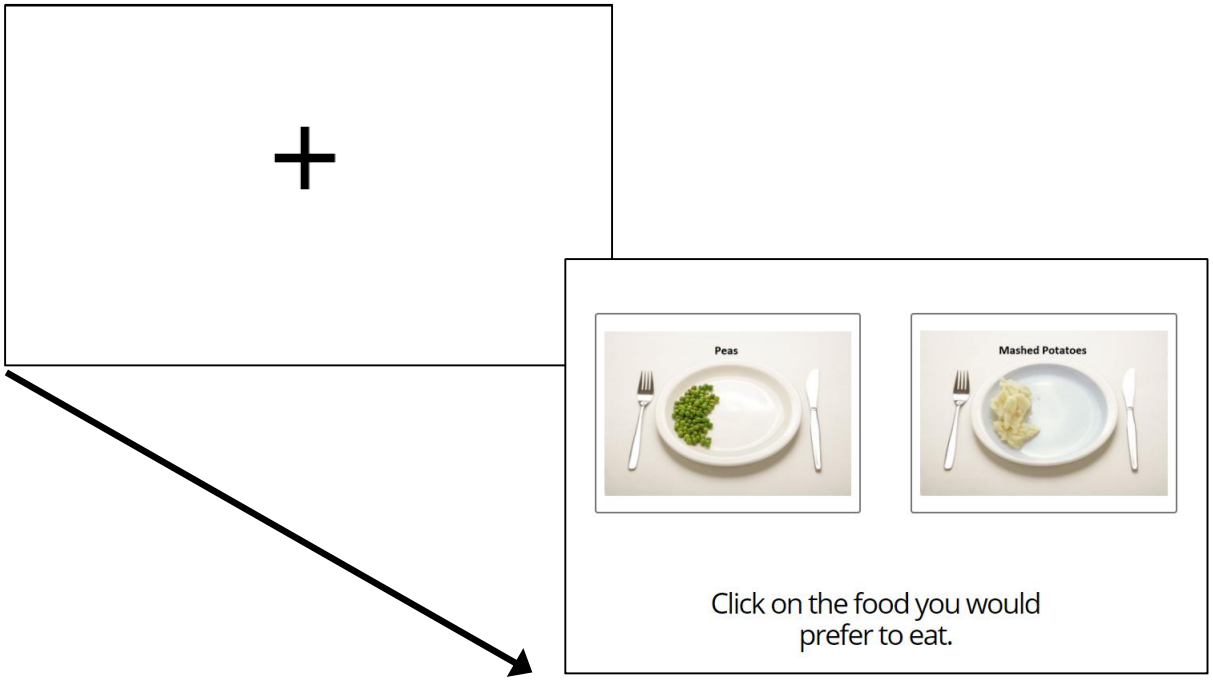


Figure 2. Illustration of a no meal context trial. The example is when the choices available to eat at a mealtime are a carbohydrate or a vegetable. No meal stimulus was used in this condition. Fixation points were shown for 250ms and all other stimuli were presented on screen until the participant clicked on the "Next" button or an available response option.



2.5 Food choice task

Two parts were included in the food choice task, the no meal context condition and the meal context condition. In the no meal context condition, children were instructed to: "Please imagine that your parent is preparing a meal in the evening. They give you a choice of two foods. You will see two foods side by side. Please click on the food that you would prefer to eat." The child would then see a fixation cross in the middle of the screen (250ms), followed by two food options that appeared on the left- and right-hand side of the screen. The child was asked to click on the food that they would prefer to eat. For the meal context condition, the wording was changed slightly, adding that the child, "will see a picture of a meal, followed by two foods side by side. Please click on the food that you would most like to eat with the meal shown." The child was then shown a picture of a partial meal stimulus with two foods. The child was required to click a continue button, before seeing a fixation cross, followed by the meal stimulus and two food choices on the left- and right-hand side of the screen. Children were asked to click on the food that they would choose to eat with the meal presented above.

The same food choices were presented in both conditions, allowing for direct comparisons to be made. The conditions were block randomised (two blocks: no meal context and meal context) as well as randomising individual trials within each condition (six trials per condition). Children were asked to make six food choices per condition (12 choices overall) to reduce the likelihood of demand characteristics, reduced attention of the child and to allow children time to think about their food choices. Children did not complete food choices for every trial or combination of stimuli and responses. Instead, to ensure random presentation of stimuli and response options, all stimuli and responses had an equal opportunity to appear throughout the experiment and children were randomised (and

294 counterbalanced across consecutive dyads using the randomised – balanced node in Gorilla)
295 to receive one of six sets of stimuli. Within these six groups, all stimuli and responses
296 occurred the same number of times. Each individual food was presented as a response a
297 maximum of two times over six trials (vegetables were each presented twice as an option
298 due to being the dependent variable, all other foods were only presented once per
299 condition). This also ensured that any strong preferences for a particular food would not
300 overly affect the outcome.

301 *2.6 Food ratings*

302 Children were asked to rate their relative and absolute liking (rank order and VAS) for
303 all nine foods presented. Children were asked to rank each food from their "most favourite"
304 (top) to their "least favourite" (bottom). Each food was also rated for liking on a 100 point-
305 VAS labelled with "I dislike this food" and "I like this food a lot" at opposing ends of the
306 scale. Parents were likewise asked to rate how much they perceived their child to like each
307 food using the same 100 point-VAS.

308 *2.7 Statistical analyses*

309 A comparison of the number of times vegetables were chosen (count) between the
310 two main conditions (no meal context and meal context) and between the six groups of
311 children receiving different stimuli, was conducted using Generalised Estimating Equations
312 (GEEs). GEEs were used due to violation of independence for chi-square or regression
313 analyses. GEEs are population averaged (e.g. marginal) models and therefore provide the
314 average effect, rather than the effect for the average person (as multi-level models
315 provide). This method of analysis was chosen as the research question was concerned with
316 comparing groups, rather than level-two individual effects in a multi-level model.

To illustrate differences in liking and familiarity of food options across trials, categories were made for whether the vegetable option was better liked (3 categories: VAS difference > 5 = vegetable is more liked, < -5 = vegetable is less liked, else = both foods are liked the same) and whether the vegetable option was more familiar (3 categories: the vegetable option was offered/eaten most frequently at home = vegetable most familiar, the frequency eaten for both foods was the same = same familiarity, the vegetable option was less frequently eaten = vegetables less familiar).

Parents rated how much they perceived their child to like each food so that comparisons could be made between parental perceptions and children's own liking ratings. Therefore, Pearson's correlations were conducted for ratings of liking for each food (**Supplementary material Figure 1**).

We further explored children's specific food choices using two multi-level models – one for each condition (no meal context and meal context). In both models we predicted children's selection of the vegetable option (outcome), with participant as a random factor. The child's age and sex, trial type (see **Table 2.**), difference in liking (between the vegetable option and competing option: VAS rating for vegetable option – VAS rating for competing option), vegetable familiarity category, hunger level and subscale scores from the CEBQ (enjoyment of food and food fussiness), CFQ (restriction and pressure to eat) and PMAS (many food choices) were entered as predictors. As the outcome was binary, we used the logit model. All questionnaire scores and difference in liking scores (between vegetable and competing foods) were centred and scaled to ensure model convergence and to allow for simpler parameter estimate interpretation. Interaction terms between trial type and difference in liking, vegetable familiarity category and questionnaire subscales were also included in the models. For no meal context and meal context, trial type was analysed

differently. This is because there were three trial types in the meal context condition depending on both the meal stimulus, the available responses and which food group added nutritional variety to the meal stimulus (see **Table 2.:** Stimulus same as choice, Competing food adds variety and Vegetable adds variety). However, there were only two categories for the no meal context condition because each trial was essentially a choice between either a vegetable versus a protein or carbohydrate food.

Data analyses were conducted using RStudio 1.1.383, with R (version 3.5.2, Eggshell Igloo), tidyverse 1.3.0, lme4 1.1-21, lmerTest 3.1-0, GLMMapadptive 0.8-0, geepack 1.3-2 and sjPlot 2.8.8.

3 Results

3.1 Descriptive statistics

Sample characteristics presented in **Table 1.** illustrate that most participants were White/White British (N = 162), with a household income of between £25,000 and £49,999 (N = 81) and parents educated to degree level (N = 64). A third of all participating parents were fathers (N = 61) with a close to equal split by child sex (female = 84) and child ages. Parents were asked to complete questionnaire subscales for children's eating traits, parental feeding practices and children's opportunities to choose foods at mealtimes. On average, children in the sample were scored as being moderately fussy on the CEBQ food fussiness subscale ($M = 2.88 \pm 0.87$, *Range* = 1-5), but scored higher for enjoyment of food ($M = 4.09 \pm 0.76$, *Range* = 1.5-5). From the CFQ, parents, on average, often reported the use of feeding practices that are restrictive ($M = 3.38 \pm 0.85$, *Range* = 1-5) and pressure children to eat ($M = 2.83 \pm 0.91$, *Range* = 1-5). Lastly, using the PMAS food choice subscale, parents

reported that on average their children are often given some choices of the foods that they eat at mealtimes (*M* = 3.03 ± 0.57, *Range* = 1.5-4.75).

3.2 Hunger

Before completing the food choice tasks, most children reported that they were "A little" hungry (N = 80, 44%), with many other children reporting that they were "Not at all" hungry (N = 44, 24%) or "Moderately" hungry (N = 46, 26%). Only ten children reported that they were "Extremely" hungry (N = 10, 6%) prior to the food choice tasks.

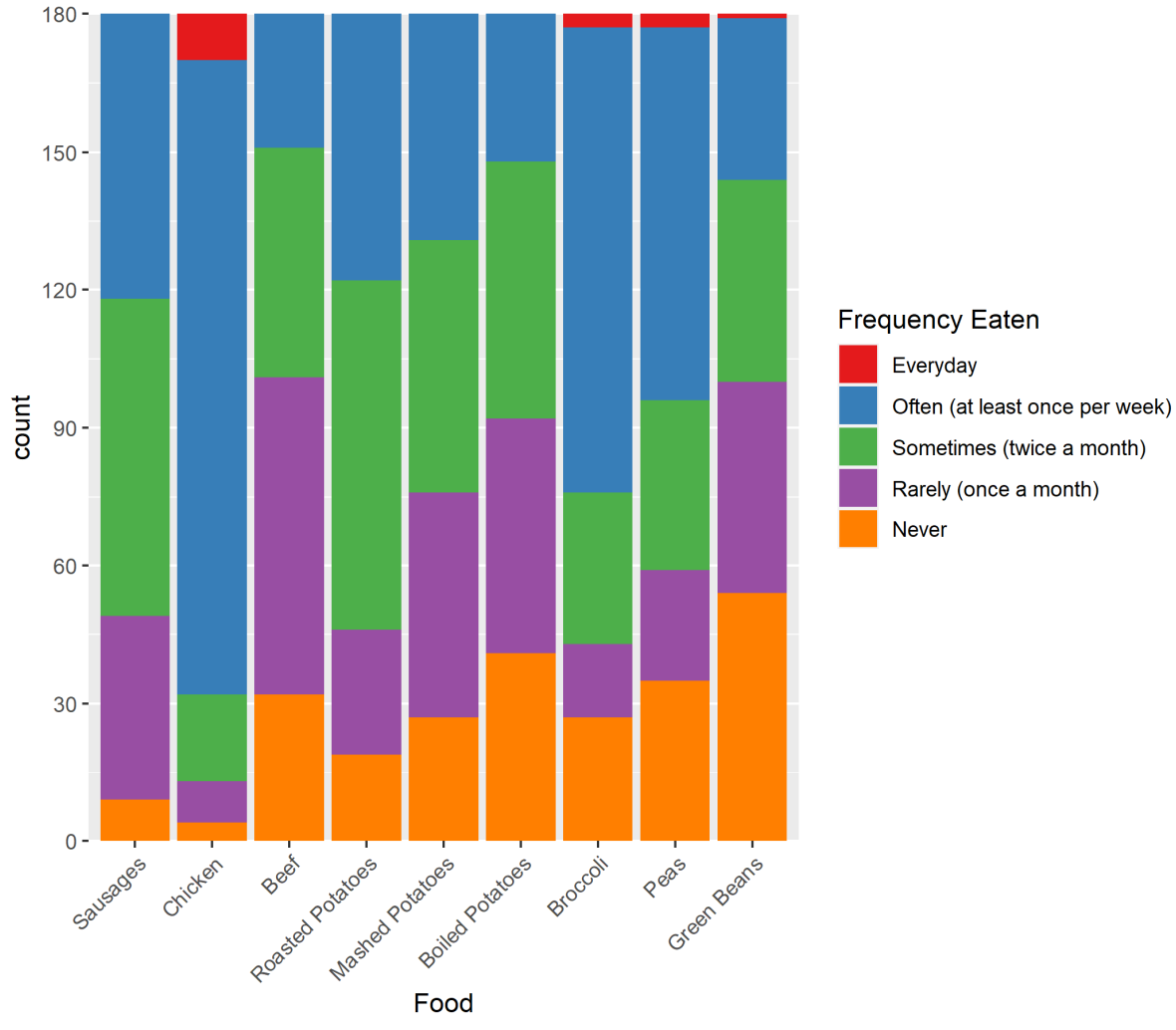
3.3 Food familiarity and liking ratings

Using both ranking and VAS methods to rate relative and absolute liking for foods, children ranked foods high in protein as most liked (Median, [Mode]: sausages = 2, [1]; chicken = 3 [2]; beef = 5 [3]), followed by foods high in carbohydrates (potatoes mashed = 5 [4]; boiled = 7 [6]; roasted = 3 [3]), with vegetables rated as the least liked food group (broccoli = 6 [9]; peas = 6 [7]; green beans = 7 [9]). However, individual differences in liking for each food were present as shown by the range of rank and VAS scores using the entire scale for rating each food. Overall, sausages were consistently rated as the most liked food from the foods used, with green beans consistently ranked as the least liked food from the options. Correlation analyses show that parent perceived child liking and child self-rated liking for each food used were highly correlated (**Supplementary material Figure 1.**).

Each food was reported as either eaten often (once per week) or at least once or twice per-month (**Figure 3.**). Few individuals reported that they never eat the foods used in the study, with the exception of parents reporting that their child never eats boiled potatoes (N = 41) or green beans (N = 54). Despite some parents reporting that their child never eats these foods at home, these children remained in the analyses as their preferred choices may have differed to what they are offered at home and the child may still be offered these

foods at school or elsewhere. Chicken was found to be the most commonly eaten food item, with 148 participants eating this food at least once per week or more, followed by broccoli (Once per-week or more, N = 104).

Figure 3. Frequency of foods eaten at home as reported by caregiver.



For each individual trial, **Figure 4.** illustrates the percentage of trials (for the meal context condition only, as the same foods were also presented in the no meal context condition) in which the vegetable option was more familiar. It is shown that the different conditions had similar proportions of vegetables being more, the same and less familiar

than the competing food option. **Figure 5.** similarly illustrates the percentage of trials in which the vegetable option was better liked, similarly liked, or less liked than the competing food option. Vegetables were found to be the less liked food option in up to two thirds of trials across the different trial types.

Figure 4. The percentage of trials across trial types that vegetables were more, similarly, and less familiar than the competing food option.

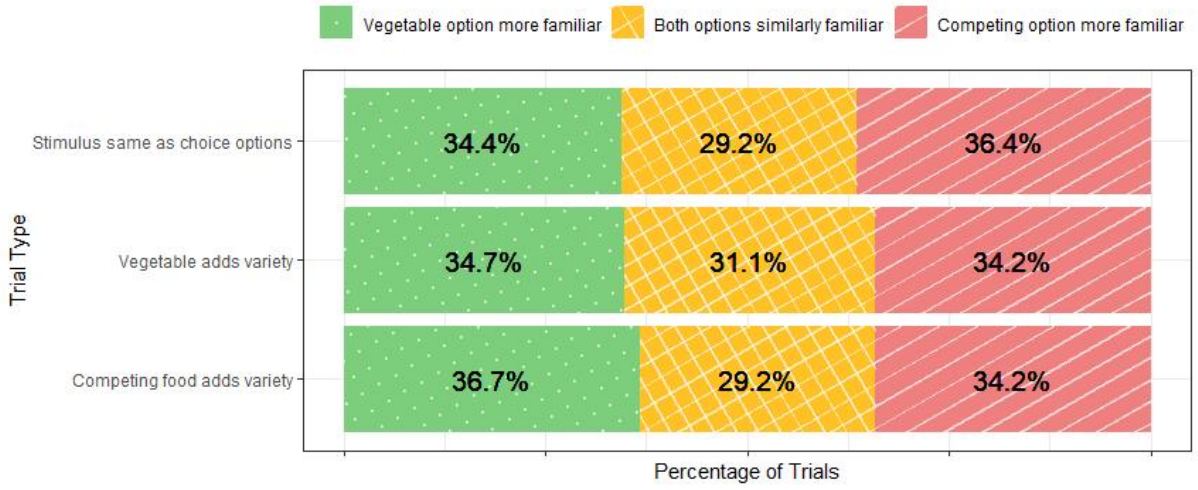
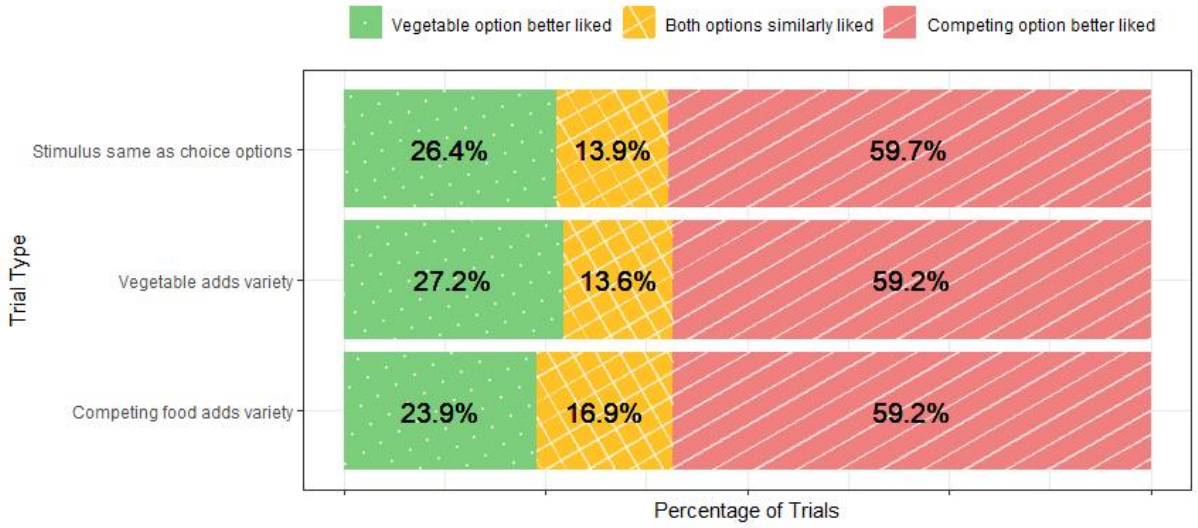


Figure 5. The percentage of trials across trial types that vegetables were better liked, similarly liked, or less liked than the competing food option.



3.4 Food choices

There were no differences in overall selection of vegetables (count) between the six groups that received different stimuli (different individual foods within trials but still the same trial types) in either the meal context, $\chi^2(5, N = 180$ clusters with cluster size of 6) = 2.2, $p = .82$, or the no meal context, $\chi^2(5, N = 180$ clusters with cluster size of 6) = 3.48, $p = .63$, conditions.

Overall, children were more likely to select vegetables during the meal context condition compared with the no meal context condition, $\chi^2(1, N = 180$ clusters with cluster size of 12 [12 food choices were made]) = 63.3, $p < .001$, *OR* = 1.57. **Figure 6.** illustrates the percentage of trials in which children chose the vegetable option in the no meal context condition, with **Figure 7.** displaying the percentage of trials in which children chose the vegetable option across different trial types in the meal context condition.

Figure 6. Percentage of trials in which children selected the vegetable option versus the competing food option (***no meal context*** condition).

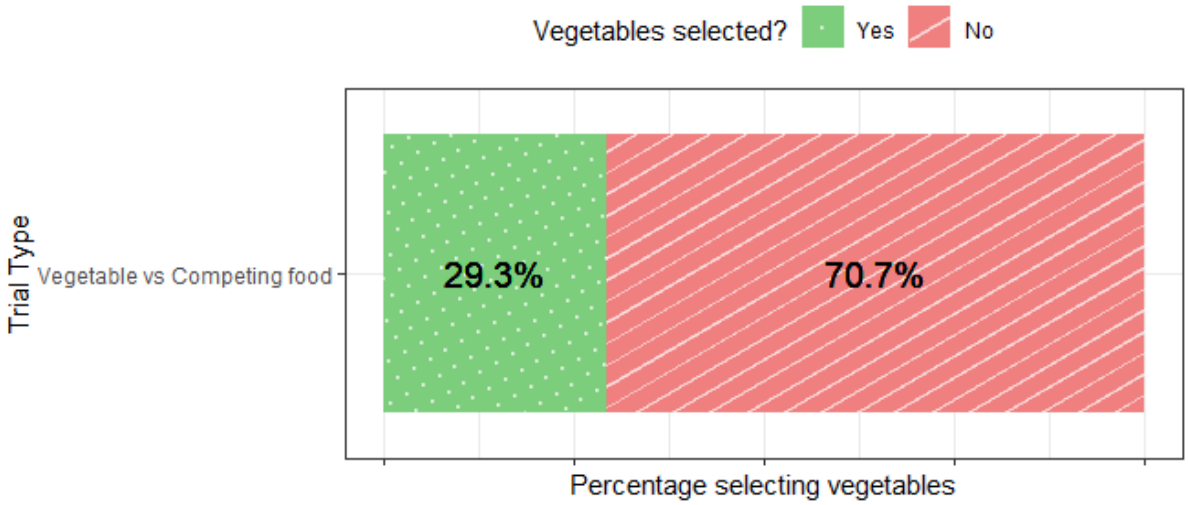
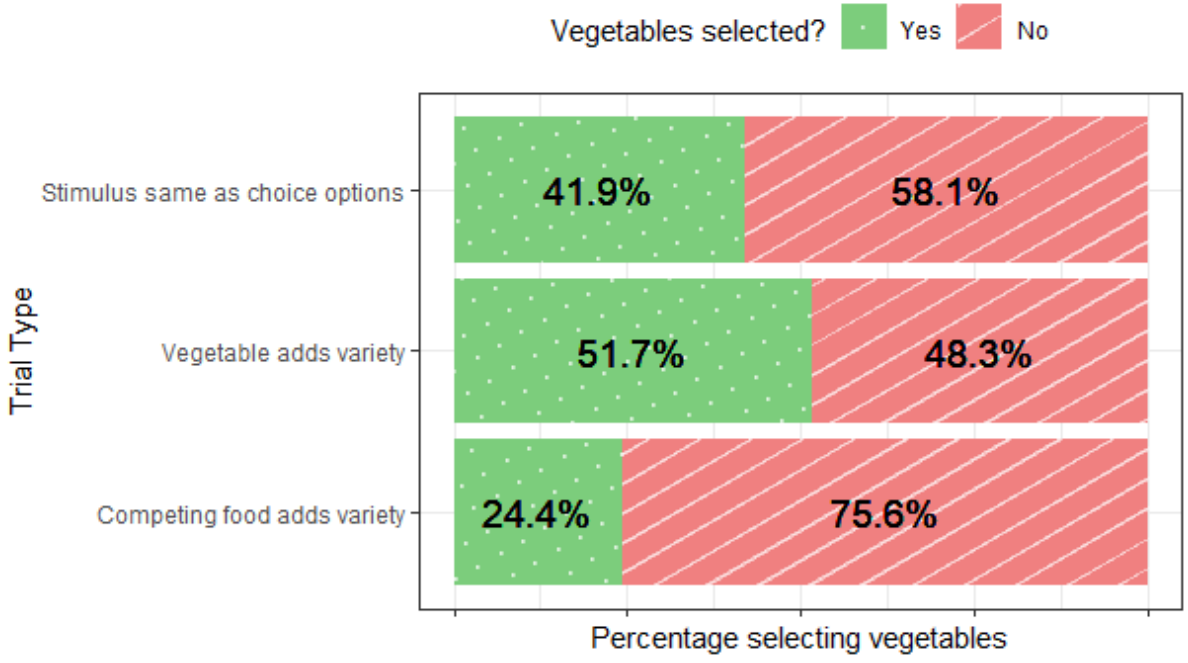


Figure 7. Percentage of trials across trial types in which children selected the vegetable option versus the competing food option (***meal context*** condition).



3.5 Predictors of children's food choice

Within the no meal context and meal context conditions, we further examined predictors of children's food choice. For the no meal context condition, the initial multi-level

429 model was singular, possibly due to the differences in liking variable explaining all (or most)
430 of the variance. Therefore, we used the GLMM adaptive package in R, which fits the model
431 using an adaptive Gaussian quadrature rule. We found main effects for the trial type,
432 difference in liking (between the vegetable and competing option) and vegetable familiarity
433 category. Children were 25x more likely to select the vegetable option (than the competing
434 option) for every unit increase of being better liked than the competing option and 2x more
435 likely to choose the vegetable option if it was more familiar (**Table 4.**).

436 Child age, child sex, hunger, all questionnaire subscale scores (CEBQ Food fussiness
437 and enjoyment of food; CFQ restriction and pressure to eat; PMAS many food choices) and
438 interaction effects did not add to the model and were therefore not included in the final
439 model. The final model explains 78% of the variance in children's food choices, with almost
440 none of the variance explained by the random effects of participant. This suggests that
441 whether a vegetable was chosen or not was likely to change more within an individual (than
442 between individuals), depending on the food options that were presented on each trial and
443 the child's own liking and familiarity of the options presented.

Table 4. Results of multilevel logit modelling using an adaptive Gaussian quadrature rule to predict the selection rate of vegetables during the no meal context condition.

	Likelihood of choosing the vegetable option (no meal context)				
Predictors	*Odds Ratios*	*std. Error*	*CI*	*Statistic*	*p*
(Intercept)	0.12	0.03	0.08 – 0.19	-9.35	**<0.001**
Trial Type: Veg vs Carb	*Reference*				
Veg vs Prot	0.76	0.16	0.51 – 1.14	-1.34	0.181
Difference in liking (between vegetable and competing option)	25.72	6.32	15.88 – 41.64	13.21	**<0.001**
Vegetable familiarity category: Both options same familiarity	*Reference*				
Vegetable option more familiar	2.01	0.46	1.28 – 3.15	3.03	**0.002**
Competing option more familiar	1.12	0.34	0.62 – 2.04	0.39	0.699
	Random Effects				
σ^2	3.29				
$\tau_{00\ Participant.Private.ID}$	0.01				
ICC	0.00				
$N_{\ Participant.Private.ID}$	180				
Observations	1080				
Marginal R^2 / Conditional R^2	0.780 / 0.781				

Veg = Vegetable, Prot = Protein, Carb = Carbohydrate.

For the meal context condition (**Table 5.**), we found main effects for the trial type, difference in liking, vegetable familiarity category and CEBQ Food fussiness score. Children were 8x less likely to select the vegetable option when the competing food option provided nutritional variety to the partial meal stimulus, compared with when no nutritional variety was available (stimulus same as choices). Whereas, children were 2x more likely to select

453 the vegetable when vegetables were not included in the partial meal stimulus and therefore
454 offered the nutritional variety. Further, children were more likely to select the vegetable
455 (than the competing food) when it was the better liked and more familiar option. Children
456 that scored higher on traits of food fussiness were 1.3x less likely to choose the vegetable
457 option than the competing option across all trial types.

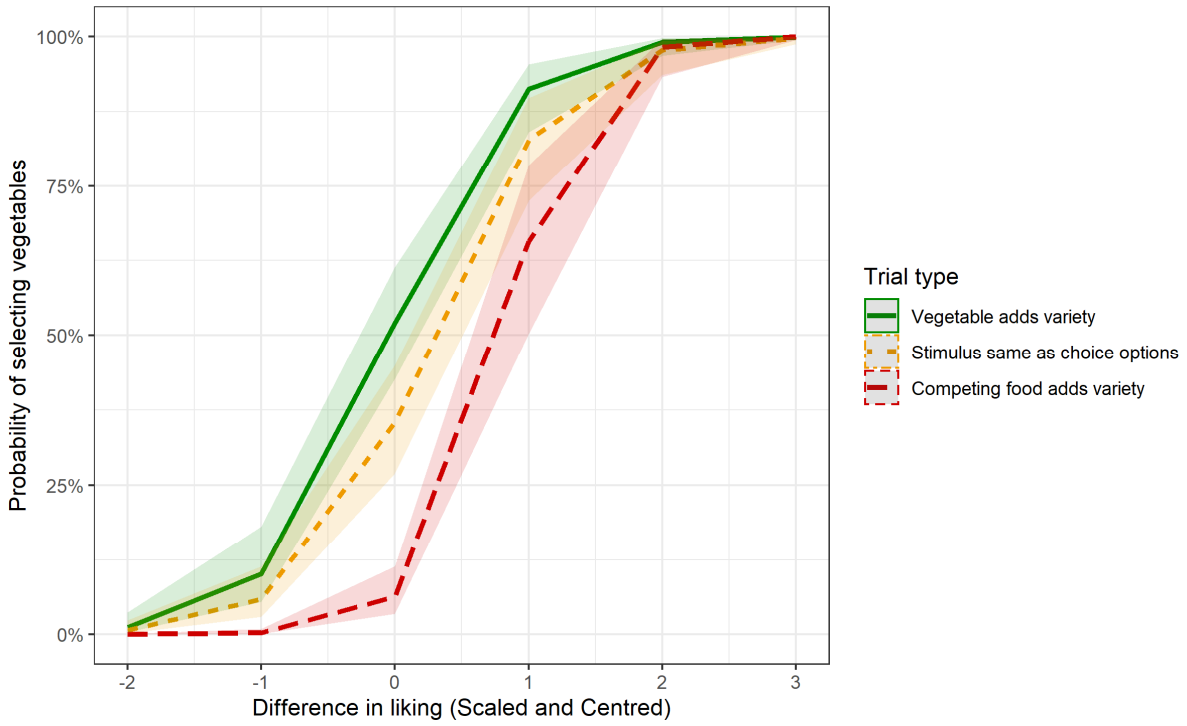
458 A two-way interaction between trial type and difference in liking was also observed
459 (**Figure 8.**). This illustrates that children were more likely to select vegetables if they were
460 better liked. However, the extent of the difference in liking between the vegetable and
461 competing food option that is required to select a vegetable depended on the trial type. For
462 a higher likelihood of being selected, vegetables were not required to be more liked than
463 the competing option if they added nutritional variety to the meal. However, if vegetables
464 were much less liked than the competing option, they would not be selected even if they
465 added a nutritional variety to the meal.

466 Child age, sex, hunger and all questionnaire subscale scores, except for food fussiness,
467 (CEBQ enjoyment of food; CFQ restriction and pressure to eat; PMAS many food choices) did
468 not add to the model. The final model explains 75.6% of the variance in children's food
469 choices. Only 9% of the variance explained is between subjects, meaning that whether a
470 vegetable was chosen or not was likely to change more within an individual (than between
471 individuals), depending on both the meal stimulus and the two food choices available during
472 each individual trial.

Table 5. Results of Analysis of deviance with type II Wald chi-square tests method and parameters from multilevel logit modelling for the selection rate of vegetables during the meal context condition.

		Likelihood of choosing the vegetable option (meal context)				
Predictors	χ^2 – Tests, p-value	*Odds Ratios*	*std. Error*	*CI*	*Statistic*	*p*
(Intercept)		0.55	0.11	0.37 – 0.81	-2.97	**0.003**
Trial Type: *Stimulus same as Choices*	χ^2 (2) = 68.3, ***p<0.001***	*Reference*				
Competing food adds variety		0.12	0.04	0.06 – 0.24	-6.21	**<0.001**
Vegetable adds variety		1.98	0.43	1.30 – 3.02	3.17	**0.002**
Difference in liking (between vegetable and competing option)	χ^2 (1) = 148.06, ***p<0.001***	8.74	2.36	5.15 – 14.82	8.04	**<0.001**
Was vegetable option more Familiar? Both options same familiarity	χ^2 (2) = 10.49, ***p=0.005***	*Reference*				
Vegetable option more familiar		1.60	0.36	1.03 – 2.47	2.09	**0.036**
Competing option more familiar		0.68	0.17	0.41 – 1.12	-1.53	0.127
CEBQ Food Fussiness Mean	χ^2 (1) = 7.46, ***p=0.006***	0.75	0.08	0.61 – 0.92	-2.73	**0.006**
Interaction effects						
Trial type - Competing food adds variety* Difference in liking	χ^2 (2) = 6.03, ***p=0.49***	3.24	1.61	1.23 – 8.56	2.37	**0.018**
Trial type - Vegetable adds variety * Difference in liking		1.10	0.40	0.54 – 2.25	0.26	0.799
Random Effects						
σ^2		3.29				
$\tau_{00\ Participant.Private.ID}$		0.34				
ICC		0.09				
$N_{\ Participant.Private.ID}$		180				
Observations		1080				
Marginal R^2 / Conditional R^2		0.731 / 0.756				

Figure 8. Relationship between predicted probability of selecting the vegetable option for different trial types and difference in liking between food options (vegetable versus competing food). Difference in liking was calculated by subtracting the VAS liking score for the competing option from the liking score of the vegetable option. Difference in liking was then centred and scaled.



4 Discussion

This study showed that in an online food choice setting, children chose vegetables more frequently in the context of a meal than with no meal. Selecting vegetables was more likely when they increased nutritional variety in the meal; whereas vegetables were less likely to be selected if the competing food increased nutritional variety. This effect was moderated by the difference in the child's liking for the food options provided, such that vegetables were more likely to be selected when they were better liked than the competing food option. These effects interacted, illustrating that when vegetables added nutritional variety to the meal, then this promoted choice, even if they were less liked (**Figure 8.**). Finally, children that scored high on trait food fussiness were less likely to select the vegetable option in all circumstances.

When presented with a vegetable free meal stimulus, children may select vegetables to increase the variety of their foods, as predicted by associative learning. Whilst children's preference for variety at mealtimes has not been studied extensively, providing a variety of vegetables as a snack increased the likelihood of selecting a vegetable to eat, as well as increasing overall vegetable intake (Roe, Meengs, Birch, & Rolls, 2013). Similarly, increasing the variety of vegetables available at a buffet (using fake foods, no consumption) increased the amount of vegetables children chose and served themselves (Bucher, Siegrist, & Van der Horst, 2014). Therefore, increasing the variety of foods and/or the variety of vegetables available may be a useful tool to promote not only vegetable consumption, but also vegetable selection when a choice of foods is offered (e.g. at a school canteen where being served vegetables can be a choice). The current findings add the observation that

506 vegetables may be chosen in place of more palatable foods to accompany a meal if the
507 vegetable adds nutritional variety to the meal.

508 The main effect of trial type (whether the vegetable or competing food added
509 nutritional variety or not) on the likelihood of vegetable selection was moderated by the
510 difference in liking of the available food options. The more liked the vegetable was in
511 comparison to the competing food, the more likely the vegetable would be chosen. Liking
512 for, and palatability of, individual food items has previously been shown to be an important
513 factor for children's (Nguyen et al., 2015) and adult's (Hayes, 2020) food choices and intake.
514 Hayes (2020) illustrates that although liking is correlated with intake, it is disliking of foods
515 that consistently predicts non-consumption. This may be because a food can be better-liked
516 (e.g. chocolate) but individuals tend to moderate their intake, yet if a food is disliked it is
517 often not eaten. Therefore, it is fitting that absolute liking for vegetables moderates the
518 effect of trial type and variety. To be selected, liking for the vegetable does not have to be
519 greater than liking for the competing food if the vegetable also adds nutritional variety.
520 However, if the vegetable is especially disliked, it is unlikely to be selected, regardless of the
521 context.

522 This moderation effect between food liking and context (trial type) suggests that
523 children were not choosing a variety of food groups based solely on schemas and meal
524 scripts to meet expectations of what a meal should comprise of (Pliner, 2008), nor what
525 children may think the experimenter 'wanted' as a typical response. Although associative
526 learning theory predicts that children may expect to eat some vegetables at mealtimes as
527 part of the meal as a whole (Birch & Anzman, 2010; Bouton, 2010), the palatability of the
528 individual food options is also considered by the child. Due to past experiences with

529 vegetables being paired with other foods in different recipes, previous learning may
530 influence children's selection of food options based on achieving a variety of food groups in
531 the meal; especially as each food choice in this study individually affected the configuration
532 of the entire meal (how well the foods 'go together'). However, each individual food item
533 presented to the child as an option also has an incentive value to the child (Berridge, 2004).
534 Although the individual food may add palatability to the meal, adding variety also considers
535 the different foods already in the meal stimulus. One interpretation is that children may
536 choose to select a variety (potentially informed by meal schemas and previous learning), but
537 only if the vegetable option is acceptable in terms of its palatability.

538 The interaction between foods that are presented within a meal is also of particular
539 interest. Whilst previous research has not examined choice of vegetables when presented
540 alongside other mealtime food items, it has been illustrated that pairing vegetables with
541 liked foods (e.g. flavour-flavour and flavour-nutrient learning, evaluative conditioning) does
542 not consistently increase vegetable consumption and often leads to less vegetable intake at
543 mealtimes (Correia, O'Connell, Irwin, & Henderson, 2014; Leak et al., 2017). Similarly, when
544 neutrally liked vegetables were served alongside better liked or disliked vegetables,
545 vegetable liking and intake were either stable or decreased across time (Olsen, Ritz, Kraaij, &
546 Møller, 2012). Together with our findings, this may suggest that both vegetable selection
547 and (potentially) intake may be greatest when liked vegetables are provided at mealtimes
548 alongside competing foods that are of similar palatability. This supports findings from
549 Ishdorj et al. (2015), suggesting that there is often larger plate waste of vegetables when
550 presented alongside much more palatable foods.

551 Selection of vegetables was further found to be more likely if the child chose the
552 food option that was more familiar. Whilst less liked in comparison to other foods, broccoli
553 and peas were reported as being provided more often at home than other foods. This
554 higher frequency of provision may have influenced some children's selection of vegetables,
555 as greater availability of vegetables in the home is linked with increased consumption
556 (Pearson, Biddle, & Gorely, 2009). However, it is important to note that effects of liking and
557 familiarity are difficult to disentangle and it is likely that these two factors combine to guide
558 the child's decision, as familiarity drives liking (Zeinstra, Koelen, Kok, & De Graaf, 2010). It is
559 important to consider whether vegetables offered at home are more liked, or whether liked
560 vegetables are offered more frequently. Caregivers are reported to offer only vegetables
561 that they perceive as liked by the child and may not buy vegetables that are perceived as
562 disliked (Holley, Farrow, & Haycraft, 2017). In contrast, there were many instances where
563 children chose a food that was never eaten at home (e.g. beef), but it was highly liked by the
564 child. Overall, beef was reported as the food least often provided by parents, yet most
565 children ranked this food as their third liked food (median placement as 5th out of all 9
566 foods). This could suggest a disparity between the foods that are being offered at home and
567 what children would like to eat. Disparities have previously been described when children
568 and parents rate food liking. Stage et al. (2019) reported that children rated liking for
569 vegetables higher than what parents estimated their child's liking to be. A possible
570 explanation for this is that children's responses to survey items may be unreliable, or lack
571 stability, especially as in the current study children were asked questions of opinion (food
572 liking) rather than questions of fact (Holaday, Turner-Henson, & Swan, 1991; Vaillancourt,
573 1973). However, in the current study, the data did not support this for the foods used.
574 Instead, strong correlations between child liking and parental perceived child liking were

observed (**Supplemental material Figure 1.**). This suggests that parents are mostly aware of their child's food likes and dislikes, however we cannot infer whether this influences the foods that are offered at home. Alternatively, it is possible that children are exposed to these foods outside of the home (e.g. at school), or that parents do not offer certain liked foods for reasons not measured (e.g. high cost, reducing beef intake for environmental reasons) and this may impact on children's food choice decisions.

Lastly, we found that children scoring higher on measures of fussy eating were slightly less likely to select vegetables. This is may be linked with general avoidance/neophobia towards vegetables throughout childhood (Maratos & Staples, 2015). However, contrary to our hypotheses we did not find that those who scored higher on enjoyment of food measures were more likely to select vegetables. Though, other studies have found that children with higher enjoyment of food ate vegetables more often (Cooke et al., 2004). We also did not observe any differences in selection of foods based on reported parental practices. It is possible that enjoyment of food measures may not be sensitive to direct competition within food choices. In this study, children were required to choose only one food option to the exclusion of the other. Whereas, if both options were presented on a plate, children that score highly for enjoyment of food may consume both options. Additionally, parental practices such as child control, monitoring, restriction and pressure to eat foods have been better linked to consumption of fruits and high fat/sugar foods than preferences for vegetables (Vollmer & Baietto, 2017). To our knowledge, no studies have yet examined the effects of these practices on children's own food choices. Indeed, the questionnaire subscales of child eating traits and parental feeding practices capture wider behaviours that may impact liking and familiarity of foods. It is possible that enjoyment of food and parental feeding practices may not predict vegetable selection

beyond the effects of liking and familiarity. However, when liking and familiarity were removed from the models and these questionnaire scales were the only variables used to predict vegetable selection, only food fussiness continued to significantly predict vegetable selection. This may suggest that either the questionnaires used are more sensitive to consumption behaviours, rather than food choice behaviours, not related to food choice behaviours, or that there was not enough variation in our sample to detect any differences between individuals on these traits and parenting practices.

4.1 Strengths

Previous studies of children's food choices at mealtimes have been conducted in school cafeterias (Miller et al., 2015) or a buffet setting (Bucher et al., 2014), where children can choose which foods to eat, which to avoid and sometimes how much to take. However, if children are given a choice of foods at home, the choice is usually fixed or with few available options (Hendy et al., 2009). Although conducted online, in this study we restricted the choices available to the child, so that only one food could be chosen, providing direct competition between food options. During buffets or in school cafeterias, there may be less direct competition between foods because all foods can potentially be selected or avoided, which is less like a home mealtime setting. Furthermore, we measured eating related traits and parental practices and their potential influence on children's food choice. Previously, studies have only examined parental practices on children's consumption of foods rather than their choices.

4.2 Limitations

We did not measure actual food choice or intake due to data being collected during the COVID-19 pandemic (August 2020, UK) and therefore only a virtual selection of food

choice was assessed. Additionally, children were choosing pictures of foods and therefore were not receiving a full sensory experience to aid their choices (e.g. seeing, smelling the food before choosing). Due to the hypothetical nature of the food choices, demand characteristics of children may mean that children were choosing vegetables more often than they would at an actual meal. However, even though children were not required to eat the foods they chose, most children were consistently not choosing vegetables. Even when the context prompted a choice of vegetables (vegetables were not in the meal stimulus) around half of the children did not choose the vegetable option. This would suggest that if we were to measure intake, consumption of vegetables would be low among certain subgroups of children (e.g. fussy eaters), as many children would not choose to have them on their plate, especially when other food groups (and potentially more palatable foods) were already present.

Secondly, as the study was conducted online, it is possible that some parents did not allow their child to complete the study, or may have influenced their child's choices. Precautions were taken to enhance the probability that children would complete the experimental part of the study, such as limiting the scope of participants in Prolific (see 2.1 *Participants* section) and asking the child confirmatory questions before they started the experiment.

4.3 Future research

Future research could examine how differences in palatability and liking between competing foods may impact on food choice and how these choices affect consumption of vegetables at mealtimes. Furthermore, it was not within the scope of this study to allow the manipulation of portion sizes. Although children tend to consume larger amounts of

vegetables when portion sizes are increased (Roe, Sanchez, Smethers, Keller, & Rolls, 2021; Spill, Birch, Roe, & Rolls, 2010), it is not known how manipulating portion size of vegetables in the context of highly liked competing foods influence a child's decision to select vegetables to accompany their meal.

Conclusion

This study examined children's food choices within a meal context, where vegetables competed with foods high in protein and carbohydrate to accompany a partial meal stimulus or an imagined meal. It was observed that children were more likely to choose a vegetable depending on the food groups presented in the meal context, specifically when vegetables were not presented in the meal stimulus. However, this effect was moderated by children's absolute liking for the food choices presented, with children being less likely to select vegetables if the competing food was much better liked than the vegetable option. Fussy eaters were further less likely to select vegetables compared with non-fussy children. These findings may indicate that when offering children food choices with the intention to promote vegetable selection, the vegetable food options should be similarly or better liked than competing food options and different from those foods already presented within the meal.

Acknowledgements

The authors would like to thank Professor Ashley Adamson and Maisie Rowland (BSc, RNutr), University of Newcastle for providing us with pictures from the Child Food Atlas. We also thank Mike Birtill for assistance in preparing the pictures for the study.

Author contributions

Conceptualization and study design, L.R.C., P.B-B. and M.M.H.; Data curation and analyses, L.R.C.; Writing-Original draft, L.R.C.; Writing-Review and editing, L.R.C., P.B-B. and M.M.H.

Funding

The first author is in receipt of an Economic and Social Research Council (ESRC) and White Rose Doctoral Training Partnership (WRDTP) collaborative studentship.

Conflict of interest

None.

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