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Repeated exposure to models' positive facial expressions whilst eating a raw vegetable increases children's consumption of the modelled vegetable

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A R T I C L E I N F O

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A B S T R A C T

Exposing children to adults eating a raw vegetable with positive facial expressions ('positive modelling') increases children's consumption of the modelled vegetable. However, whether repeated versus a single exposure to positive modelling enhances this effect, and whether it generalises to a non-modelled vegetable, remains to be examined. Hence, this study examined the effect of a single exposure, versus repeated, exposure to positive modelling on children's acceptance and intake of a modelled and non-modelled vegetable. Children aged 5–6 years ($N = 153$; 81 males, 72 females) were randomised to one of three conditions in which they had i) a single or ii) repeated exposure to a video of adults eating raw broccoli with positive facial expressions or iii) were exposed to a no-food control video. Children's acceptance (measured as willingness to try and number of tastes), intake and liking of a modelled (raw broccoli) and non-modelled vegetable (raw mangetout) were measured. Children had greater raw broccoli consumption and liking if they had received repeated exposure to positive modelling, compared to children who had received a single exposure, but not compared to children in the control condition. Children's mangetout intake was greater in the single (versus repeated) positive condition, but this effect was not dependent on time. There was no effect on children's vegetable acceptance. Repeatedly exposing children to adults enjoying a vegetable encourages children's intake of the modelled vegetable in comparison to a single exposure. Thus, repeated exposure to others' food enjoyment may be a practical and useful strategy to encourage children's vegetable consumption.

1. Introduction

Consuming sufficient vegetables has important health benefits, such as providing key vitamins (Slavin & Lloyd, 2012) and reducing risk of chronic diseases (Boeing et al., 2012). However, vegetable consumption by children is often lower than recommended (Health Survey for England, 2018; Keats et al., 2018; Kupka et al., 2020). Dietary behaviours in childhood can persist into adulthood (Craigie et al., 2011), thus, determining strategies to encourage children's vegetable acceptance is essential.

Encouraging vegetable consumption by children can be challenging because vegetables are often bitter in taste and innately less preferred (Wardle & Cooke, 2008). One way in which children learn to accept food is by observing and modelling the behaviour of others, particularly if positive consequences are observed (Bandura, 1977). Indeed, children are more likely to consume fruit and vegetables after observing a model verbally state that they enjoy eating that food (Appleton et al., 2019; Hendy & Raudenbush, 2000). Another way in which food enjoyment is conveyed is through facial reactions whilst eating. Exposure to adults' smile signals encourages children's approach behaviour towards an unfamiliar item (Klinnert et al., 1986). Thus, it is plausible that exposing children to adults consuming food whilst smiling could encourage children's acceptance of that food. Indeed, research has found that exposing children to positive facial expressions (FEs) increases children's desire to eat disliked foods (Barthomeuf et al., 2012). Specifically, exposing children to videos of adults eating vegetables with positive FEs increases children's consumption of the modelled vegetable (Edwards et al., 2022). Therefore, watching adults enjoying less preferred foods such as vegetables can have the immediate effect of increasing children's vegetable consumption.

Abbreviations: FE, facial expression; FEs, facial expressions; CEBQ, Children's Eating Behaviour Questionnaire; CFNS, Child Food Neophobia Scale; SEQ, Sensory Experiences Questionnaire.

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Whilst it has been established that a single exposure to adults enjoying a vegetable encouraged children's vegetable intake at that occasion (Edwards et al., 2022), we do not know whether a single exposure is sufficient to enhance intake in the longer term, or whether repeated exposure to food enjoyment enhances the effect. Determining whether parents must smile each time they eat a vegetable, or whether demonstrating their enjoyment on one occasion is sufficient to facilitate consumption, has important implications for the development of interventions aimed at increasing children's vegetable consumption. Familiarisation with vegetables through repeated exposure is an important facilitator of children's vegetable acceptance. Indeed, research has shown that children's preference for, and consumption of, vegetables can be increased using repeated visual exposure (Farrow et al., 2019; Heath et al., 2014; Rioux et al., 2018) and repeated taste exposure to vegetables (Appleton et al., 2018). This highlights the important role of repeated exposure for encouraging vegetable acceptance by young children. Since eating often occurs in social contexts, and this can influence the development of children's eating behaviour (Higgs & Thomas, 2016), it is important to examine how repeated exposure to vegetables in a social context (i.e., through social modelling) influences children's vegetable acceptance and consumption. Indeed, interventions using repeated exposures to a positive modelling video, combined with reward (Food Dudes), have been found to increase children's vegetable intake and liking (Horne et al., 2004; Horne et al., 2009; Lowe et al., 2004; Marcano-Olivier et al., 2021). Additionally, Zeinstra et al. (2017) exposed 4–6-year-olds to a video of television idols who consumed carrots enthusiastically and suggested that they make you strong and fast (positive modelling), or a no modelling video (control condition). After receiving exposure to positive modelling, children had greater carrot intake at 9-months after the intervention, than children in the control condition. Research by Farrow et al. (2019) has also demonstrated the effect of repeated visual exposure, rewards, and positive modelling for increasing preschool children's vegetable consumption. However, since modelling alone was not examined, and the effect of repeated exposure was not compared to a single exposure of modelling, the frequency of positive facial expression (FE) exposures that are required to influence children's vegetable consumption remains to be investigated.

Additionally, most research examines the effect of modelling on consumption of the modelled food. It is also important to consider whether the effect of modelling generalises to the acceptance of similar, non-modelled vegetables. Research has demonstrated mixed findings, with some studies showing that modelling vegetable intake increases the intake and liking of non-modelled vegetables (Farrow et al., 2016; Horne et al., 2011), and others showing that positive modelling does not influence liking and can lead to lower intake of a non-modelled vegetable (Appleton et al., 2019). Based on classical conditioning principles, it is plausible that learning one food is safe or enjoyable to eat, will generalise to a similar food, in the same food category (e.g., another vegetable). Indeed, research has shown that pairing bitter tasting vegetables with a more palatable flavour (associative conditioning) increases children's vegetable consumption (Wadhera et al., 2015). Thus, it is possible that children may be more likely to consume another vegetable (e.g., mangetout – also known as snow peas) if they have watched someone enjoying a different, but similar, vegetable (e.g., broccoli – another green vegetable). However, research showing a generalised effect has paired modelling with reward (Farrow et al., 2019; Horne et al., 2011), suggesting that modelling alone does not increase children's non-modelled vegetable consumption (Appleton et al., 2019). Therefore, research is needed to establish whether positive FEs are useful for encouraging vegetable consumption more broadly, or whether their effects are limited to the modelled vegetable.

Here, we examine the effect of a single exposure of positive modelling versus repeated exposure to positive modelling, on acceptance and intake of a modelled and non-modelled vegetable. Children aged 5–6 years were examined. Identifying strategies to encourage vegetable consumption by children is important due to the developmental peak in food neophobia between 2 and 6 years old which can interfere with children's acceptance and intake of vegetables (Cooke et al., 2003; Dovey et al., 2008; Perry et al., 2015). Whilst it is important that children consume sufficient vegetables from a young age, children aged 5–6 years were selected for this study because emotion recognition develops significantly between 3 and 4 years (Pons et al., 2004) and we wanted to ensure that the children would have the capacity to understand and cooperate with online procedures. For example, children were required to complete multiple online video sessions, requiring the child to focus and engage with several tasks. Since 5–6-year-olds in the UK attend primary school, they are more likely to be familiar with completing computer tasks. Based on previous research (Edwards et al., 2022), it was hypothesised that children's acceptance (measured as willingness to try and frequency of tastes), intake and liking of a modelled vegetable (raw broccoli) will be greater following exposure to videos of models' consuming raw broccoli with positive FEs, compared to when exposed to a non-food control video. Therefore, this effect was expected at both the first and the second session which occurred one week later. Repeated exposure to models consuming raw broccoli with positive FEs was hypothesised to strengthen this effect, such that children who were exposed to positive FEs repeatedly would show greater acceptance, intake and liking of the modelled vegetable, compared to children who had a single exposure, and children who were exposed to a non-food control video. Given the previously reported mixed findings in relation to the effect of modelling on responses to a non-modelled vegetable, we did not make a directional prediction in relation to generalisation of any effects.

2. Method

2.1. Design

A mixed design with 2 factors was used: condition (between-subjects factor; single positive exposure, repeated positive exposure, and control) and time (within-subjects factor; session one versus session two). See Fig. 1 for details of the experimental procedure.

2.2. Participants

A G*Power calculation (Faul et al., 2007) for planned Bonferroni *t*-tests to detect differences between conditions (80 % power, $\alpha = 0.02$, $d = 0.6$; Edwards et al., 2022), recommended 150 children. Moreover, a

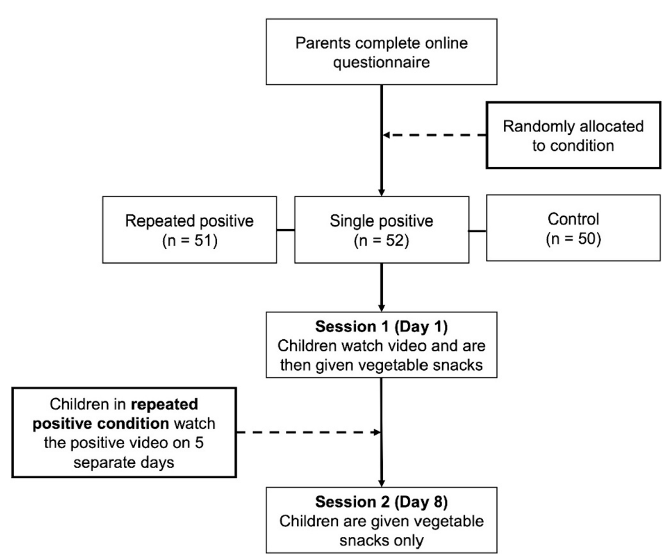

Fig. 1. Outline of experimental procedure.

G*Power calculation (Faul et al., 2007) for planned ANOVA to detect a two-way interaction (80 % power, $\alpha = 0.05$, $\eta_p^2 = 0.07$; Edwards et al., 2022), recommended 132 children. Between July 2021 and March 2022, 161 5–6-year-olds and their parents were recruited in the UK via online advertisements and schools. Unpaid, online poster advertisements were placed on social media sites, such as Twitter, Facebook, LinkedIn, and Mumsnet. Parents were recruited through primary schools by poster advertisements circulated by teachers. Posters included information about the study procedure, eligibility criteria, participant incentives, and contact information. Eligibility criteria included children not having tried raw broccoli or raw mangetout (also known as snow peas) before, which was determined by parents reporting either 'yes' or 'no', for each food, separately. Children were still eligible to participate if they had tried cooked broccoli or cooked mangetout before. Children with food allergies or medical conditions affecting eating behaviour, or a household member with an allergy to fruit or vegetables were not eligible to participate. Aston University Research Ethics Committee provided ethical approval (#1790). Parents provided informed consent for their own and their child's participation, and children provided verbal assent.

2.3. Measures

2.3.1. Experimental videos

Experimental videos comprised 6 clips of unfamiliar adult models consuming raw broccoli with a positive FE (single and repeated positive conditions) or putting pens away with a neutral FE (control condition), presented in a randomised order. Videos had no sound and were intentionally short to avoid boredom effects (positive video = 62 s; control video = 60 s). Each video featured the same 6 models: 3 men and 3 women (20–26 years) of different ethnicities (White British = 4; Asian British = 2). Children in the repeated positive condition alternated watching this video with an additional positive video during the repeated exposure intervention period (between days 1–8) to avoid habituation effects. This alternative video lasted 74 s and featured 6 different models: 3 men and 3 women (22–34 years) of different ethnicities (White British = 4; Indian = 1; Mixed Black Caribbean and White Irish = 1). A pilot study with 20 adults, and FaceReader 7.0 software (Noldus., 2016) confirmed that each video conveyed the intended valence. See supplementary files 1 and 2 for examples of positive and control clips.

2.3.2. Dependent variables: children's vegetable acceptance, intake, and liking

Children's acceptance, intake and liking of a modelled vegetable (raw broccoli) and a non-modelled vegetable (raw mangetout) was measured at both sessions. To determine whether there was a generalised effect on vegetable intake, the non-modelled vegetable was raw mangetout because of its similarity to broccoli in colour and energy density (mangetout = 38 kcal and broccoli = 35 kcal, per 100 g). Raw broccoli and mangetout were selected because of their bitter taste (Bell & Tepper, 2006) and because they are novel to most children in the UK in their raw form. Furthermore, broccoli and mangetout are familiar and widely available to purchase for parents, which was important for the remote study design. Acceptance was measured as willingness to try, and frequency of tastes for each vegetable. Willingness to try was measured as children's greatest observed engagement with each vegetable (Table 1; Blissett et al., 2012; Blissett et al., 2016). For example, if a child placed a vegetable in their mouth but did not swallow it, 'placed in mouth' (score = 5) was recorded as the greatest observed engagement for that vegetable. If a child did not interact with a vegetable (i.e., no active refusal or engagement), it was recorded as missing data. Higher engagement scores indicated greater willingness to try the vegetable. The frequency of children's tastes of each vegetable (defined as any occurrence of oral exposure to the vegetable) was determined by counting the number of times each vegetable was 'placed in mouth', 'swallowed but refused', and 'swallowed and accepted'. Intake of each vegetable was measured as the amount (grams) consumed; parents weighed each vegetable pre- and post- intake and reported the weights to the researcher. A 3-point thumbs up and down scale representing 'I like it', 'okay', and 'I don't like it' assessed children's liking of each vegetable (van der Heijden et al., 2020).

Table 1
7-point scale measuring children's willingness to try vegetables.

Behaviour Category	Description of Behaviour	Example
(1) Physical refusal	Any occurrence of the child physically refusing the vegetable	Turning head away from offered vegetable
(2) Verbal refusal	Any occurrence of the child verbally refusing the vegetable	Child said "I don't want it"
(3) Touched	Any occurrence of the child physically touching the vegetable, but no further interaction with it	Picks up the vegetable but puts it back in the bowl
(4) Smelled	Any occurrence of the child smelling the vegetable, such as by picking it up and bringing it to the nose, but no further interaction with it	Smelling the vegetable after picking it up
(5) Placed in mouth	Any occurrence of the child placing the vegetable to or inside the mouth, but no further interaction or its consumption	Putting the vegetable into the mouth without biting it, holding it inside the mouth, but refusing to swallow
(6) Swallowed but refused	Any occurrence of the child chewing and swallowing some of the vegetable but refused further or expressed dislike	Biting off a piece of the vegetable, chewing and swallowing it, but refusing another bite
(7) Swallowed and accepted	Any occurrence of the child chewing and swallowing some of the vegetable without a negative reaction	Biting off a piece of the vegetable, chewing and swallowing it, and eating another piece

2.3.3. Demographics and lifestyle questionnaire

Parents provided demographic information: child sex and age, and parent gender, age, ethnicity, education level and number of children (Blissett et al., 2019). Child height and weight was parent-reported to calculate BMI z-scores (BMIz) using the Child Growth Foundation Reference Curves which adjust for sex and age (Cole, 1995; Freeman et al., 1995). Demographic information was gathered to check for baseline differences between conditions, since these characteristics have been found to influence children's eating behaviour (Jarman et al., 2022). Information about food allergies, food intolerances, or medical conditions affecting eating behaviour was used to exclude participants. Parent and child habitual fruit and vegetable intake was assessed to ensure there were no differences between conditions, measured as the number of usual daily servings and the number of servings consumed yesterday (adapted from Thomas et al., 2016). Children's typical liking and intake of cooked broccoli and mangetout was parent-reported, to determine whether children's familiarity with these vegetables differed between conditions (Owen et al., 2018).

2.3.4. Questionnaires measuring child characteristics

Parents completed questionnaires about their child's characteristics due to their influence on eating behaviour: children's appetitive traits, food neophobia, and sensory processing. These characteristics were measured as potential covariates to ensure that there were no differences between conditions that could explain any effects of the experimental manipulation. Four subscales of the Children's Eating Behaviour Questionnaire (CEBQ; Wardle et al., 2001) assessed children's appetitive traits due to their association with food acceptance (Blissett et al., 2019; Cooke et al., 2004; Fildes et al., 2015): food fussiness (e.g., 'my child refuses new foods at first'), food responsiveness (e.g., 'my child is always asking for food'), satiety responsiveness (e.g., 'my child gets full up easily'), and enjoyment of food (e.g., 'my child loves food'). The CEBQ is a reliable and valid measure, with research showing that the CEBQ subscales predict children's observable food intake (Carnell & Wardle, 2007; Wardle et al., 2001; Rendall et al., 2020). The CEBQ subscales showed good reliability and validity in the current sample with the following Cronbach's alphas for each subscale: satiety responsiveness $\alpha = 0.79$; food responsiveness $\alpha = 0.84$; enjoyment of food $\alpha = 0.89$, food fussiness $\alpha = 0.91$. Food neophobia is associated with lower intake and variety of fruit and vegetables (Cooke et al., 2003; Perry et al., 2015). Thus, parents completed the reduced 6-item Child Food Neophobia Scale (CFNS; Pliner, 1994) which examined children's food neophobia (e.g., 'my child will eat almost anything'). The CFNS has been related to children's observable willingness to try new foods (Pliner, 1994), and is a reliable and valid measure (Cooke et al., 2006; Perry et al., 2015; Pliner, 1994). The CFNS showed excellent reliability and validity among the current sample, with Cronbach's alpha = 0.94 in this study. The 21-item Sensory Experiences Questionnaire (SEQ; Baranek et al., 2006) examined children's sensory hyper- and hypo- responsiveness (e.g., 'avoids textures') because sensory sensitivity is associated with lower fruit and vegetable intake (Coulthard & Blissett, 2009) and selective eating (Farrow & Coulthard, 2012). The SEQ has good internal consistency and test-retest reliability (Baranek et al., 2006; Little et al., 2011). The SEQ showed good reliability and validity among the current sample, with Cronbach's alpha = 0.86 in this study.

2.4. Procedure

Parents completed an online questionnaire about their own and their child's characteristics. Next, parents arranged 2 online video-based sessions with their child and the researcher, using the online platform Zoom. For each session, parents prepared separate bowls of raw broccoli and raw mangetout (8 pieces of each vegetable, roughly 30 g each) and recorded the weight of each bowl. Details of instructions given to parents are in the supplementary material. Study materials were shown using Zoom's screen share feature. At session one, parents reported the time since their child had last eaten. Children provided verbal assent and rated their hunger from 1 'very hungry' to 5 'not hungry at all/ very full' (Bennett & Blissett, 2014). Children then watched the randomly assigned video (positive or control) and reported how they thought the models felt about eating broccoli or putting pens away (3-point smiley face scale: positive, neutral, or negative), to check task engagement. Next, children were told they would be given a snack to try if they wanted to and that the researcher would turn off their camera and microphone during this time. Parents gave their child both vegetable snacks to consume ad libitum and were asked not to encourage or pressure their child to eat. Children's interactions with the vegetables were video recorded using Zoom. When ready to move on from the snack, children put their thumb up to the camera and the researcher returned. Parents reweighed each bowl of vegetables using kitchen scales and reported the pre- and post- weights of each vegetable to the researcher. Parents were asked to covertly weigh the vegetables to avoid influencing their child's eating behaviour.

In the single positive and control conditions, families did not complete any further activity until session two. Families in the repeated positive condition were asked to complete an additional task on 5 separate days, between session one and two. Children received repeated exposure to positive modelling by completing the additional task, which involved children watching a positive video and answering a simple question about it (e.g., "was anyone in the video wearing glasses?"). As a minor incentive, children received a letter after watching each video, which after viewing all 5 videos, made a word ('panda'), that they could relay to the researcher at session two. Children were not given the vegetable snacks to consume after completing the task. Parents received a £5 voucher for completing the additional task.

Session two followed the same procedure as session one, for all conditions, but without watching the video. Parents also reported their children's broccoli and mangetout intake (cooked or uncooked) since session one. Finally, parents and children were debriefed, thanked for participating, and given the opportunity to ask questions. Children received a certificate and parents received a £15 online shopping voucher for participating. Each session lasted approximately 10 min and participation for parents and children was entirely remote; participants completed sessions one and two, and watched the videos, from a location of their choice.

2.5. Video analysis

Children's willingness to try, and frequency of tastes of broccoli and mangetout were coded using recorded videos of eating interactions. Though parents were asked not to prompt their child to eat, there were some instances where this occurred. Thus, to examine differences between conditions, the frequency of parental prompts to eat were recorded, defined as any direction from the parent towards the child trying the food (e.g., encouragement: "do you want to try it?"; or pressure to eat: "eat this now"). Two researchers coded the videos (KLE: session one; ZA: session two), from the presentation of vegetables, until the child indicated they were ready to move on (M duration = 150 s, SD = 150 s, range = 8–1170 s). Ten percent of videos were double coded to determine coder reliability (ZA: session one; KLE: session two). Intra-class correlation coefficients indicated excellent inter-rater reliability: willingness to try broccoli = 0.986 and mangetout = 0.996; tastes of broccoli = 0.990 and mangetout = 0.998. Discrepancy was discussed for parental prompts until agreement was reached, with intra-class correlation coefficients indicating good inter-rater reliability (0.786).

2.6. Statistical analysis

Hypotheses and the analytic plan were specified prior to data collection. Data were analysed using SPSS Version 26.

2.6.1. Covariate analyses

Potential covariates were examined for inclusion in the models. If measures differed significantly between conditions, they were entered as covariates in main analyses. Chi-square examined differences between conditions for child sex; and the time since children last ate before each session. One-way ANOVA examined differences between conditions for demographics; habitual fruit and vegetable intake; children's habitual intake and liking of cooked broccoli and mangetout; children's hunger rating; frequency of parental prompts; broccoli and mangetout intake between sessions; children's appetitive traits; food neophobia; and sensory processing. No covariates were necessary to include in the main analyses.

2.6.2. Main analyses

Mixed ANOVAs examined children's acceptance, intake and liking of the modelled vegetable (modelling effect) and non-modelled vegetable (generalised effect), separately, with condition (single positive, repeated positive, and control) and time (session one and session two). On few instances, the type of vegetable tasted could not be coded (session one $n = 4$; session two $n = 11$), thus, the number of tastes were recorded, and these scores were not included in analyses. The 'missing' function in SPSS was used to code missing data, thus these data points were not included in the relevant analyses. A priori, this study was sufficiently powered to examine a two-way interaction (factors = condition and time), with the expectation that results would be different for each vegetable, thus, vegetables were examined in separate ANOVAs. Bonferroni t-tests followed up significant main effects of condition and independent t-tests followed up significant interactions.

3. Results

3.1. Sample characteristics

In total, 161 parents and children participated. Eight participants were excluded due to inadequate experimental control (e.g., not following instructions or the presence of siblings). The final sample included 153 participants. Parents (149 women, 4 men) had a mean age of 38.4 years (range = 28–48) and mean BMI was in the overweight range (mean = 25.6, SD = 5.9). Parent ethnicity was 79.1 % White, 11.8 % Asian, 3.9 % mixed ethnicities, 2.0 % Black, 2.6 % 'other ethnic group', and 0.7 % 'prefer not to say'. The highest educational level achieved by parents was: 43.1 % undergraduate, 35.9 % postgraduate qualification, 15.0 % A-level (or equivalent), 3.9 % GCSE (or equivalent) and 2.0 % 'other'. Most parents reported having more than one child (83 %). Children (81 males, 72 females) had a mean age of 5.88 years (70.50 months; range = 61–83 months) and a mean BMIz score of 0.20 (range = −3.84-3.89). BMIz scores could not be calculated for 17 children due to missing height and weight data from parents, or incorrect data reported (i.e., a score that was not viable).

Sample characteristics were analysed; demographics measures, and habitual fruit and vegetable intake did not differ significantly between conditions (all *ps* > .05; Table 2). Child sex was not significantly different between conditions ($X^2(2, N = 153) = 5.32, p = .07$). There was no main effect of child sex on children's broccoli or mangetout intake, willingness to try, tastes, or liking (all *ps* > .05).

Children's habitual intake of cooked mangetout differed significantly between conditions,[1] but habitual intake of cooked broccoli did not (Table 3). Conditions were not significantly different for parent-reported child liking of cooked broccoli ($X^2(10, N = 154) = 12{,}76, p = .24$) or cooked mangetout ($X^2(8, N = 154) = 10.78, p = .22$). Finally, CEBQ subscales, food neophobia, or sensory processing were not significantly different between conditions (all *ps* > .05; Table 4).

3.2. Experimental sessions

The time since children last consumed food did not differ by condition before session one ($X^2(10, N = 153) = 12.68, p = .24$) or session two ($X^2(10, N = 153) = 17.13, p = .07$). Children's hunger rating did not differ by condition at session one ($F(2, 152) = 0.38, p = .68$) or session two ($F(2, 152) = 2.62, p = .08$). Most children correctly identified how the models felt in the single positive condition (73.1 %) and in the repeated positive condition (88.2 %). In the control condition, accuracy was above chance with children reporting that they thought models felt positive (48.0 %), neutral (46.0 %), or negative (6.0 %). Between sessions one and two, the number of times that children consumed broccoli and mangetout (cooked or uncooked) was not significantly different between conditions ($F(2, 152) = 0.69, p = .51$ and $F(2, 152) = 0.92, p = .40$, respectively).

Table 2
Mean (SD) sample characteristics for participants in each condition (one-way ANOVA).

		Single Positive ($n = 52$)	Repeated Positive ($n = 51$)	No-Food ($n = 50$)	*F*	*p*
Parent	Age (years)	38.29 (3.72)	38.43 (4.42)	38.39 (4.16)	0.02	.98
	BMI	24.56 (4.93)	27.10 (7.31)	24.98 (4.76)	2.82	.06
	Vegetable intake	2.41 (1.15)	2.68 (1.47)	2.69 (1.41)	0.69	.51
	Fruit intake	2.02 (0.88)	1.74 (1.14)	2.07 (1.05)	1.56	.21
Child	Males (%)	44.2	49.0	66.0	–	–
	Age (months)	70.25 (6.40)	70.96 (7.05)	70.30 (7.62)	0.16	.85
	BMIz	0.35 (1.61)	0.24 (1.76)	−0.02 (1.62)	0.60	.55
	Vegetable intake	2.06 (1.14)	2.33 (1.06)	2.14 (0.93)	0.94	.40
	Fruit intake	2.38 (0.92)	2.25 (1.09)	2.32 (1.06)	0.22	.81

Table 3
Habitual consumption of cooked broccoli and mangetout (Chi-square).

	Single Positive (n = 52)	Repeated Positive (n = 51)	Control (n = 50)	X^2	*p*
Cooked broccoli					
Never	12	6	6	14.78	.06
Once a month	10	13	5		
Once a week	24	17	29		
Several times a week	6	14	10		
Everyday	0	1	0		
Cooked mangetout					
Never	32	38	26	11.99	.02*
Once a month	20	11	18		
Once a week	0	2	6		
Several times a week	0	0	0		
Everyday	0	0	0		

* $p < .05$.

Table 4
Mean (SD) scores on measures assessing child characteristics, split by condition (one-way ANOVA).

	Single Positive (n = 52)	Repeated Positive (n = 51)	Control (n = 50)	*F*	*p*
CEBQ					
Enjoyment of Food	3.76 (0.84)	3.79 (0.69)	3.88 (0.69)	0.32	.73
Satiety Responsiveness	2.84 (0.70)	3.06 (0.64)	2.92 (0.61)	1.53	.22
Food Fussiness	2.99 (0.85)	2.91 (0.80)	2.94 (0.83)	0.16	.85
Food Responsiveness	3.00 (0.83)	2.96 (0.83)	2.89 (0.80)	0.24	.79
CFNS	25.27 (9.96)	25.31 (9.38)	24.52 (8.87)	0.11	.89
SEQ	0.75 (0.44)	0.63 (0.48)	0.54 (0.44)	2.78	.07

Note. Children's Eating Behaviour Questionnaire (CEBQ); Child Food Neophobia Scale (CFNS); Sensory Experiences Questionnaire (SEQ).

3.3. Compliance with experimental procedure

For most participants (86.9 %) sessions were 7 days apart. Twenty participants rescheduled session two due to unforeseen circumstances (e.g., ill health), but all sessions were 6–9 days apart. Few parents prompted their child to eat in session one (single positive n = 16; repeated positive $n = 10$; control $n = 16$) or session two (single positive $n = 14$; repeated positive $n = 6$; control $n = 8$), and parental prompts did not differ significantly between conditions in session one ($F(2, 145) = 1.67, p = .19$) or session two ($F(2, 150) = 1.35, p = .26$).

Fifty-one children were allocated to the repeated positive condition. Three children watched the positive video less than the required 6 times. An intention-to-treat analysis was used to minimise the risk of bias (McCoy, 2017), thus these 3 participants were included in analyses.

[1] Including habitual intake of cooked mangetout as a covariate did not change the significance of main analyses.

3.4. Main analysis: vegetable acceptance

Most children swallowed at least one bite of the broccoli and mangetout at session one (63.7 % and 71.6 %, respectively), and session two (61.1 % and 69.3 %, respectively).

For willingness to try broccoli, a 3 × 2 mixed ANOVA revealed there was no significant main effect of condition ($F(2, 129) = 1.31$, $p = .27$, $\eta_p^2 = 0.02$) or time ($F(1, 129) = 0.46$, $p = .50$, $\eta_p^2 = 0.00$), and no significant interaction between time and condition ($F(2, 129) = 0.25$, $p = .78$, $\eta_p^2 = 0.00$). For willingness to try mangetout, there was no main effect of condition ($F(2, 143) = 1.36$, $p = .26$, $\eta_p^2 = 0.02$) or time ($F(1, 143) = 0.51$, $p = .48$, $\eta_p^2 = 0.00$), and no significant condition by time interaction ($F(2, 143) = 0.03$, $p = .97$, $\eta_p^2 = 0.00$). See Table 5 for means.

For broccoli tastes, there was no significant main effect of condition ($F(2, 146) = 1.00$, $p = .37$, $\eta_p^2 = 0.01$) or time ($F(1, 146) = 0.27$, $p = .60$, $\eta_p^2 = 0.00$), and no significant condition by time interaction ($F(2, 146) = 0.40$, $p = .67$, $\eta_p^2 = 0.01$). For mangetout tastes, there was no main effect of condition ($F(2, 144) = 1.56$, $p = .21$, $\eta_p^2 = 0.02$) or time ($F(1, 144) = 0.44$, $p = .83$, $\eta_p^2 = 0.00$), and no significant interaction between condition and time ($F(2, 144) = 2.28$, $p = .11$, $\eta_p^2 = 0.03$). See Table 5 for means.

3.5. Main analysis: Vegetable intake

For broccoli intake, there was no significant main effect of condition ($F(2, 150) = 1.45$, $p = .24$, $\eta_p^2 = 0.02$) or time ($F(1, 150) = 0.13$, $p = .72$, $\eta_p^2 = 0.00$), however, the interaction between condition and time was significant ($F(2, 150) = 3.37$, $p = .04$, $\eta_p^2 = 0.04$; Fig. 2). Broccoli intake at session one did not differ significantly between the control condition ($M = 4.02$, SD = 8.12) and the repeated positive condition ($M = 5.74$, SD = 8.33; $t(99) = 1.05$, $p = .30$) or the single positive condition ($M = 5.46$, SD = 7.08; $t(100) = 0.96$, $p = .34$). Broccoli intake between the repeated positive and single positive condition was also not significantly different ($t(101) = -0.18$, $p = .86$). However, at session two, broccoli intake was significantly higher in the repeated positive condition ($M = 7.06$, SD = 9.86), than the single positive condition ($M = 3.62$, SD = 6.37; $t(101) = -2.11$, $p = .04$). At session two, broccoli intake in the control condition ($M = 4.00$, SD = 8.12) did not differ significantly compared to the repeated positive condition ($t(99) = 1.70$, $p = .09$) or the single positive condition ($t(100) = -0.27$, $p = .79$). See supplementary material for exploratory analyses where positive conditions (Exploratory analysis 1) and single exposure conditions are combined (Exploratory analysis 2).

Table 5
Mean (SE) vegetable acceptance, and liking in session one and two, split by condition.

		Single Positive	Repeated Positive	Control
Session one				
Willingness to try	Broccoli	5.60 (0.28)	5.64 (0.28)	4.95 (0.30)
	Mangetout	6.00 (0.28)	5.41 (0.29)	5.63 (0.28)
Number of tastes	Broccoli	3.18 (0.68)	3.37 (0.69)	1.96 (0.69)
	Mangetout	9.14 (1.48)	4.08 (1.49)	6.15 (1.51)
Liking	Broccoli	1.52 (0.11)	1.84 (0.11)	1.74 (0.12)
	Mangetout	2.27 (0.12)	2.08 (0.13)	2.10 (0.13)
Session two				
Willingness to try	Broccoli	5.43 (0.31)	5.47 (0.32)	5.00 (0.33)
	Mangetout	6.08 (0.27)	5.48 (0.28)	5.78 (0.27)
Number of tastes	Broccoli	3.02 (0.67)	3.49 (0.68)	2.47 (0.68)
	Mangetout	7.22 (1.43)	5.65 (1.44)	6.94 (1.46)
Liking	Broccoli	1.63 (0.11)	2.14 (0.12)	1.70 (0.11)
	Mangetout	2.13 (0.12)	2.08 (0.12)	2.32 (0.12)

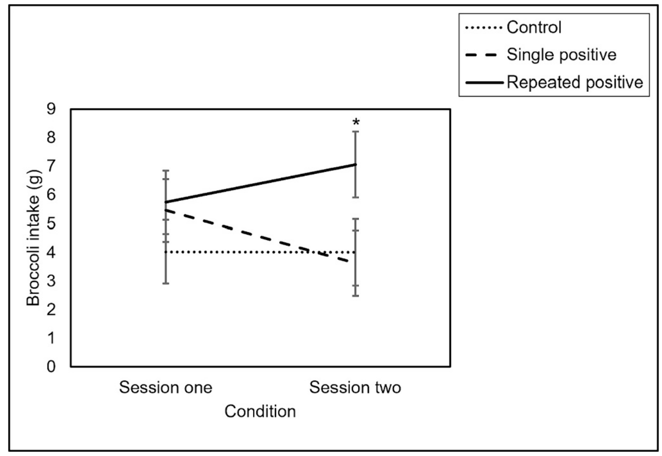

Fig. 2. Mean broccoli intake (g) split by condition and time (standard error). At session two, broccoli intake was significantly greater in the repeated exposure condition, compared to the single exposure condition. *$p < .05$.

For mangetout intake, there was a significant main effect of condition ($F(2, 150) = 3.71$, $p = .03$, $\eta_p^2 = 0.05$; Fig. 3). Bonferroni corrected t-tests showed mangetout intake was significantly higher in the single positive condition, compared to the repeated positive condition (9.8 g vs 4.9 g; $p = .02$), but not the control condition (7.3 g; $p = .52$). Mangetout intake was not significantly different between repeated positive and control conditions ($p = .55$). There was no significant main effect of time ($F(1, 150) = 0.25$, $p = .62$, $\eta_p^2 = 0.00$) and no significant time by condition interaction ($F(2, 150) = 0.92$, $p = .40$, $\eta_p^2 = 0.01$).

3.6. Main analysis: vegetable liking

For broccoli liking, there was a significant main effect of condition ($F(2, 150) = 4.75$, $p = .01$, $\eta_p^2 = 0.06$; Fig. 4). There was no significant main effect of time ($F(1, 150) = 3.88$, $p = .05$, $\eta_p^2 = 0.03$) nor condition by time interaction ($F(2, 150) = 2.36$, $p = .09$, $\eta_p^2 = 0.03$). Following up the main effect of condition, Bonferroni corrected t-tests showed significantly higher broccoli liking in the repeated positive condition, compared to

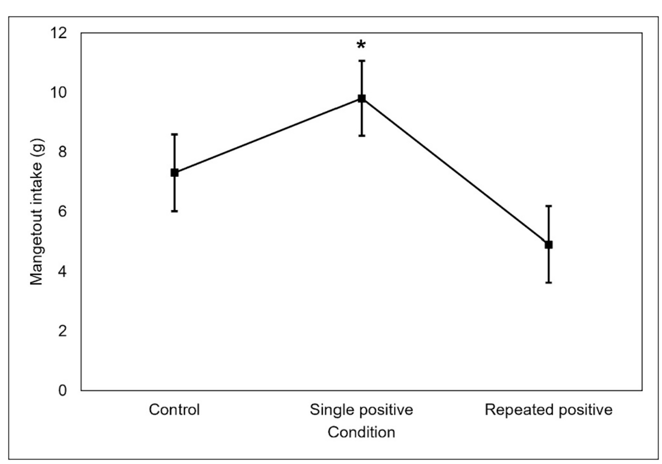

Fig. 3. Mean mangetout intake (g) split by condition (standard error). Mangetout intake was significantly greater in the single exposure condition, compared to the repeated exposure condition. *$p < .05$.

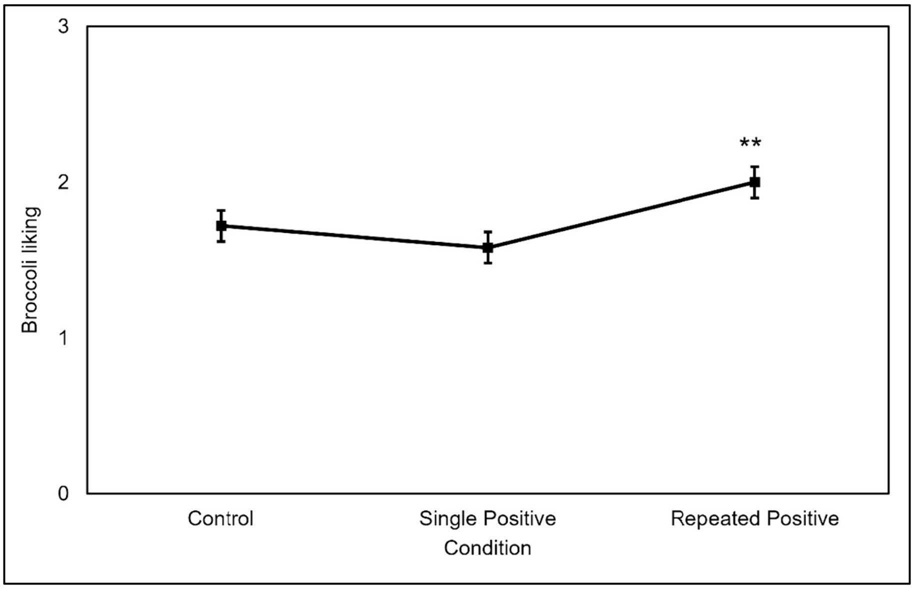

Fig. 4. Mean broccoli liking split by condition (standard error). Broccoli liking was significantly greater in the repeated, compared to the single, positive condition. $^{**}p < .01$.

the single positive condition ($p < .01$), but not the control condition ($p = .15$;). Broccoli liking was not significantly different between single positive and control conditions ($p = .89$).

For mangetout liking, there was no significant main effect of condition ($F(2, 149) = 0.42, p = .66, \eta_p^2 = 0.01$) or time ($F(1, 149) = 0.21, p = .65, \eta_p^2 = 0.00$), and no significant condition by time interaction ($F(2, 149) = 2.80, p = .06, \eta_p^2 = 0.04$). See Table 5 for means.

4. Discussion

This study aimed to examine the effect of single versus repeated exposure to videos of adults consuming raw broccoli whilst conveying positive FEs, on children's acceptance, intake and liking of a modelled and non-modelled vegetable. Children who were repeatedly exposed to adults' positive FEs consumed more of the modelled vegetable (broccoli), compared to children who only received a single exposure to positive FEs, and overall, had greater liking for broccoli. Findings showed that mangetout intake was lower in the repeated positive, compared to single positive, condition, but there were no effects of exposure on children's willingness to try, number of tastes, or liking of mangetout.

Children who repeatedly observed videos of adults showing enjoyment whilst eating broccoli had greater raw broccoli intake (7 g), than children who received a single exposure (4 g). This is consistent with previous research which showed that repeated exposures to modelling increased children's vegetable consumption (Horne et al., 2004; Horne et al., 2009; Lowe et al., 2004) and builds on these findings by showing that repeated exposures can be administered over short time periods (one week). Exposing children to food enjoyment may be a simple strategy that can be carried out in various environments (e.g., by parent models at home or by teacher models at school). However, more research is needed to determine whether these effects generalise when models are familiar, and to ascertain whether there is a point at which intake is permanently enhanced, without requiring further exposures. Moreover, whilst broccoli intake was significantly different between single and repeated exposure conditions at the second session, there was no statistically significant difference when compared with the control condition. One explanation for this is that between sessions one and two, broccoli intake decreased in the single exposure condition, but did not change in the control condition. Since children in the single exposure condition had observed the models enjoyment of broccoli one week earlier, this suggests that the effect of modelling may decrease over time. It is also possible that this study was not sufficiently powered to detect a statistically significant difference. Indeed, this study was powered with a medium effect size, based on previous research (Edwards et al., 2022), however effect sizes in this study were small. The absence of a significant difference between repeated positive and control conditions could also be explained by a limitation of the experimental conditions. Whilst the control condition, in which adults put pens away with a neutral FE, controlled for the mere presence of an adult, it did not allow us to identify whether the positive effects of the repeated exposure condition on children's consumption was influenced by the models' positive FEs alone or repeated visual exposure to broccoli, rather than the combination of observing vegetable consumption and positive FEs. Therefore, alternative control conditions, such as the inclusion of a non-food control condition with models putting pens away with positive FEs, are required, to determine whether it is positive FEs specifically, rather than repeated visual exposure, that is increasing children's vegetable intake.

In the present study, a single exposure to adults enjoying broccoli had no immediate or delayed effect on vegetable intake, which contrasts with our previous research (Edwards et al., 2022; see supplementary material for exploratory analysis 1). This could be explained by children receiving two vegetable snacks here, thus, the competition of a different, potentially more palatable vegetable, may have influenced broccoli consumption (i.e., presenting two snacks created a 'choice' scenario which could have resulted in different behaviour than when there is only one option). For example, children might have been satiated by eating mangetout, before they tried the broccoli.

Unlike intake, children's acceptance (when measured as willingness to try and the number of tastes, rather than actual intake) of the modelled vegetable was not influenced by models' positive FEs. Most children were willing to try the vegetables, regardless of condition, thus, scored highly irrespective of their intake. Therefore, the absence of an effect on willingness to try may be partially explained by lack of measurement sensitivity. Children's vegetable tastes were also not influenced by models' positive FEs, suggesting that effects on intake were not manifesting in more frequent tastes, but perhaps larger bites. Another explanation for the absence of an effect of positive FEs on vegetable acceptance is that in this sample, children's habitual vegetable intake was high, meaning they could have already learned to accept bitter tastes into their diet. Therefore, to establish whether exposure to positive FEs increases vegetable acceptance in children most in need of intervention, research is needed with samples of children who are less familiar with vegetables.

Children in the repeated positive condition had greater broccoli liking, rating it as 'okay', compared to children in the single positive condition who 'did not like it'. However, this effect was not dependent on time, which could be explained by limitations of the liking scale used. Vegetable liking was rated using a thumbs up and down scale, rather than the commonly used smiley face scale (van der Heijden et al., 2020), which was not appropriate in this study (i.e., children might have chosen the face that 'matched' the models' FE). However, children might not have understood the thumb scale, and/or it might not have accurately or sensitively reflected their vegetable liking. Indeed, positive modelling has been found to increase vegetable liking when measured using a smiley face scale (Appleton et al., 2019; Farrow et al., 2019). Thus, limitations of the scale could explain the lack of a significant condition by time interaction on broccoli liking.

Consistent with some previous research (Appleton et al., 2019), exposure to positive FEs had no generalised effect on children's eating of a non-modelled vegetable. This could be because children did not observe models consuming mangetout, thus concerns about food palatability, which relate to food neophobia, were not reduced (Dovey et al., 2008). This highlights the important role of observational learning in guiding children's eating. The absence of a generalised effect may also be an artefact of vegetable type. Whilst each vegetable was matched in colour, food group and energy-density, and was novel for children in its raw form, children might have consumed more mangetout, regardless of condition, because they found it to be more palatable than raw broccoli. One unexpected finding was that children consumed more mangetout in the single positive condition, than the repeated positive condition, which was not dependent on time. The meaning of this finding is unclear because at session one, single and repeated positive conditions were identical in procedure. Both parent-reported and self-reported liking of mangetout was not different between conditions, suggesting that liking cannot explain this finding. Further, whilst habitual intake of cooked mangetout differed between conditions, it was not different between single and repeated positive conditions, suggesting that children's familiarity with mangetout is not likely to explain the results. Therefore, to fully establish the generalised effect of positive FEs, research is needed using a wider buffet of vegetables or an experimental design where vegetable type is counterbalanced.

The remote methodology used has several strengths. In addition to, and perhaps because of, the convenience for families and researchers, an advantage of the remote design was the high compliance of participants attending both sessions, and completion of the daily task. The online sessions reduced the time burden for participants and the researcher (e.g., travelling to the laboratory), which is onerous when attending multiple sessions. Additionally, the remote methodology allowed families to participate in their home environment, which is a more ecologically valid eating environment than a laboratory setting. Video recordings using Zoom were good quality, with occasional data loss due to not being able to code videos (e.g., the camera not being positioned optimally to view all child eating behaviour). Furthermore, the use of video stimuli including unfamiliar adult models in this experimental study was advantageous. For example, it allowed the standardisation of the experimental manipulation, ensuring that all children were exposed to the same models conveying the same eating behaviour and facial reactions. Using unfamiliar models also allowed the use of standardised remote stimuli, which would not have been possible if familiar models were used. The present findings may not generalise to other populations since the sample comprised mostly families of White ethnicity where parents had a university education and children had relatively high habitual vegetable intake. Research has demonstrated that children with higher socioeconomic status are more likely to meet vegetable consumption guidelines (Spence et al., 2018). One way in which the lack of diversity in this sample could have influenced the results is due to children's familiarity with vegetables. Since children must learn to accept bitter tastes into their diets, children in this study might have been more accepting of vegetables due to already being familiar with bitter tastes. Children from poorer socioeconomic backgrounds are less likely to meet dietary guidelines (Buckland et al., 2023), thus it is important that future research specifically targets the recruitment of individuals from a range of socioeconomic backgrounds. Another limitation of this study is the similarity in appearance of raw broccoli and mangetout to cooked broccoli and mangetout, respectively. Thus, the effect on children's liking and intake of vegetables in this study could be explained by children's familiarity with cooked broccoli and mangetout, since children were not excluded if they had tried the vegetables in their cooked form. Whilst habitual cooked broccoli intake was not significantly different between conditions, habitual cooked mangetout intake was. However, including habitual cooked mangetout intake as a covariate in analyses did not change the significance of results, suggesting that habitual cooked broccoli and mangetout consumption is unlikely to have influenced the current findings. The experimental design was also limited since there was no inclusion of a free-eating session at baseline. Whilst it is unlikely to have affected the current conclusions due to the inclusion of a no-food control condition, and since both vegetables were novel to all children in their raw form, future experimental research should include a baseline free-eating session.

5. Conclusion

This study presents novel findings that repeatedly exposing children (5–6 years), to videos of adults enjoying eating raw broccoli, results in greater raw broccoli intake compared to children who received a single exposure to others' food enjoyment. This supports research suggesting that children need positive eating experiences to learn enjoyment of nutritious food (Haines et al., 2019; Marty et al., 2018). However, since the effect did not generalise to a similar, non-modelled vegetable in this study, children may need to observe others' enjoyment towards multiple vegetables. Further research is required to determine the longer-term effects of positive FEs on vegetable intake, and whether these effects generalise when models are live and familiar (e.g., parents).

Supplementary data to this article can be found online at https://doi.org/10.1016/j.eatbeh.2024.101872.

CRediT authorship contribution statement

Katie L. Edwards: Writing – review & editing, Writing – original draft, Visualization, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Jason M. Thomas:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Conceptualization. **Suzanne Higgs:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Jacqueline Blissett:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available upon request.

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Ethical statement

Ethical approval was obtained from Aston University Research Ethics Committee (#1790). Parents provided informed consent for their own and their child's participation, and children provided verbal assent.

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