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Eating vegetables at school lunchtimes: Pilot and feasibility studies testing strategies to improve intake

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ABSTRACT

Vegetable provision at schools in the UK has increased over recent years; however children still eat few of the vegetables that are served to them. Two experimental pilot and feasibility studies implemented a vegetables-served-first (study 1) plus experiential learning (study 2) approach to increase children's (3–5 years and 4–7 years respectively) vegetable consumption at school lunchtimes. Both studies involved vegetables-served-first 10-min before the rest of the meal, with experiential learning techniques (repeated exposure, "veg-first" dinner plates, vegetable songs, videos, and nutrition education) complementing the vegetable service in study 2. Study 1 (n = 38) found that vegetables-served-first, compared with serving all foods together, increased vegetable intake by ~12 g. Study 2 (n = 69) found that vegetable consumption depended on individual schools. Schools where vegetable intake was low showed increases in consumption during intervention weeks, whereas schools with high vegetable intake showed little change. Acceptability of interventions was found to be good for children and schools that participated, although concerns about time to serve vegetables first and COVID-related environmental restrictions reduced feasibility for some schools. Child engagement could also be improved by offering a wider variety of vegetables during repeated exposure to reduce monotony. Future research should design interventions using co-design methods including schools to suit their context best, whilst also addressing the problem with a systems approach. Interventions which focus on child learning through experience need to take account of specific school environments including curricular needs, resources available for school lunch (including both time and space), provision of food, support from teachers and parents, and the culture around eating (e.g. encouragement, pressure to eat, lunchtime competing with playtime). Joined-up systems approaches could enhance both provision and uptake of vegetables at school meals.

1. Background

In the UK, since 2008 early year settings (e.g. schools, nurseries) have been required to use healthy food procurement standards. This policy implementation has improved school's purchasing of fruits and vegetables, whilst reducing provision of foods high in fats, sugar, and salt (Afshin et al., 2015; Niebylski et al., 2014). Yet, whilst procurement has improved, much of the vegetables offered to pupils at lunchtime are wasted (Haroun, Harper, Wood, & Nelson, 2011). Meal service and experiential learning strategies are promising ways to increase children's low vegetable consumption at mealtimes (Poelman et al., 2020; Tani, Ochi, & Fujiwara, 2021). Meal service strategies manipulate how the meal is served (e.g. serving vegetables first or in larger portions), whereas experiential learning strategies focus on the child having new and positive learning experiences at eating occasions (e.g. through games or sensory play). Utilising different strategies at mealtimes may encourage children to consume larger portions of vegetables and to develop positive vegetable eating habits (Chawner & Hetherington, 2021). The current pilot studies examine the acceptability and feasibility of vegetables-served-first and experiential learning strategies on children's vegetable intake at school mealtimes.

Eating vegetables first at mealtimes (before other foods) is common in some cultures. Studies from Japan suggest that around 25% of preschool children eat vegetables first at every meal, with 52% "sometimes"

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eating vegetables first (Yang, Tani, Tobias, Ochi, & Fujiwara, 2020). This behaviour is associated with greater vegetable intake and lower incidence of overweight, compared with eating meat or fish at the beginning of the meal (Tani, Fujiwara, Ochi, Isumi, & Kato, 2018). Therefore, eating vegetables first at mealtimes may be a positive and healthful habit to teach children in the UK. Serving vegetables first ensures that other, more palatable foods are not present at the same time as vegetables. When more palatable, or "competitor" foods are available simultaneously, children may eat these foods instead of the vegetable portions on their plate (Correia, O'Connell, Irwin, & Henderson, 2014; Ishdorj, Capps Jr, Storey, & Murano, 2015; Leak et al., 2017). In an online study Chawner, Blundell-Birtill, and Hetherington (2022) found that children (8–11 years) were more likely to select a vegetable to accompany a meal when the vegetable was better liked than competitor options, or if the vegetable added a different food group to the existing meal (adding variety). If vegetables within a meal are less liked than other foods on the plate, serving vegetables at the start of the meal and without competitor foods may encourage vegetable intake by children.

Serving vegetables first has been tested in several ways. For example, by increasing the portion size (Spill, Birch, Roe, & Rolls, 2010) and by blending pureed vegetables into tomato soup (Spill, Birch, Roe, & Rolls, 2011) can increase vegetable intake by between ~40 g and ~128 g respectively. Yet, serving raw vegetables in the lunch line at school only increased vegetable intake by ~5 g (Elsbernd et al., 2016; Redden et al., 2015). Similarly, serving vegetables first alongside fruit only increased fruit intake (Harnack et al., 2012; Kral, Kabay, Roe, & Rolls, 2010). Differences in the amount eaten in these studies may reflect how vegetables were served, since more vegetables were consumed whilst sitting down, when hidden in other foods (vegetables provided by stealth), cooked, and no competing foods were present (e.g. fruits are often favoured over vegetables and may therefore 'compete' to be eaten). Alternatively, amount eaten may have been dependent on children's individual differences (e.g. increasing portion sizes does not work for fussy eaters) (Kral et al., 2010).

Offering vegetables first may facilitate intake due to removing competitor foods, or alternatively, leveraging hunger levels and readiness to eat. However, more general benefits to intake may be achieved through experiential learning, since this may improve liking of vegetables. Experiential learning strategies might offer taste exposure alongside play, touch, and smell activities to encourage children to become familiar with vegetables in a non-threatening way, which in turn promotes willingness to try and to taste these vegetables (Nekitsing, Hetherington, & Blundell-Birtill, 2018a). A recent systematic review demonstrated a variety of activities that are used as experiential learning strategies in research, including taste testing, games, creative activities, storybooks, food preparation, sensory play, and gardening (Varman et al., 2021). This review found largest effect sizes for increasing healthy eating behaviours where studies used a mixture of experiential learning approaches implemented within a short (single sessions up to 12 weeks), yet high intensity intervention (frequency, more than 1 session per-week may be considered as high intensity).

In the current pilot studies, the aim was to assess the effects of vegetables-served-first (study 1) and vegetables-served-first plus experiential learning (study 2) approaches on children's vegetable intake at lunchtimes in the school environment. Feasibility and acceptability for implementing these strategies were explored, specifically since this practice is not typical in UK schools and it is not clear whether this would be acceptable or practical. It was hypothesised that after a single exposure to serving vegetables first at mealtimes (with no additional changes to meal structure), children's vegetable intake would increase (study 1). We further hypothesised that children would consume larger amounts of vegetables when vegetables are served first whilst also engaging in positive, playful, repeated, and supportive activities (study 2).

2. Study 1: vegetables-served-first only

2.1. Methods

2.1.1. Participants

Participants were 38 nursery school children (20 girls) aged 3-5 y from two schools in the north of England. Schools were identified and approached through Phunky Foods, which is an early years programme that delivers healthy lifestyle curriculums and resources to educational settings. Parents were invited to consent for their child to participate in this study. Children whose parents did not consent still received the study foods and procedure, but data was not collected for these children. This was due to the group nature of the intervention at the nursery mealtime.

2.1.2. Design and materials

The design and analyses were pre-specified prior to data collection. Parents were invited to complete a survey including questions about them and their child, for example, how often their child eats certain foods (Food Frequency Questionnaire: Hammond, Nelson, Chinn, & Rona, 1993), how much their child likes those foods (parental perceived liking), the Child Eating Behaviour Questionnaire (CEBQ, 5 subscales: Food fussiness, Enjoyment of food, Slowness of eating, Satiety responsiveness and Food responsiveness) (Wardle, Guthrie, Sanderson, & Rapoport, 2001), the Parent Mealtime Action Scale-Revised (PMAS-R, 4 subscales: Positive persuasion, Use of rewards, Insistence on eating and Child selected meals) (Musher-Eizenman & Holub, 2007), and demographic information. These measures were collected to describe the sample and to examine the potential effects of liking and familiarity on food intakes at lunchtimes.

Two separate experimental meals were served to children in nursery at their usual lunchtime, using a crossover design (Table 1). Meals were served either with all foods served together or vegetables-served-first (as a starter). The same meal constituents were served twice with a one week washout period between meals. The meals consisted of fish fingers (50–60 g), potato wedges (70 g), cooked peas (40–60 g) and cooked carrots (40–60 g). Peas and carrots were chosen as target vegetables as the aim of the strategy was to increase intake (not familiarity or willingness to try), and peas and carrots are already familiar to UK children (Chawner, Blundell-Birtill, & Hetherington, 2021). Appropriate portion sizes were guided by UK government portion size recommendations (PHE, 2018). The outcome variables of interest were the mass (g) and energy content (kcal) of each food eaten.

2.1.3. Procedure

At lunchtimes, children entered the nursery dining area as usual, before being served either the full meal or vegetables-served-first. All foods were weighed before being served. Children then ate the meal as usual. If vegetables were served first, after 10-min any leftovers were removed and replaced with the remaining non-vegetable food items. After the meal had ended, plates were removed and leftovers were weighed. The next week, the same foods were served using the other experimental presentation of vegetables. All experimental procedures took place during the COVID-19 pandemic (July 2021) and therefore the research team was not permitted to enter schools. Consequently, school staff and Phunky Foods Early Development Co-ordinators (EDCs) were trained using remote methods (e.g. over the telephone) on how to weigh and serve the meals. School staff and EDCs were further provided with written and pictorial instructions of how to weigh foods separately using food scales, and data collection sheets indicating the amounts served and amount remaining (waste) at the end of the meal. Reliability of food measurements was checked by the Phunky Foods EDCs who were working on behalf of the research team.

2.1.4. Data analyses

Amounts of each food served and eaten (g and kcal) and how much

Table 1
A timeline of study procedures and measurements taken.

Pre-study	Week 1	Week 2
Consent and Parental questionnaires	Control	Control
	Vegetables-first	Vegetables-first
	Weighed food intake (g)	

was eaten as a percentage of what was served, were calculated. Energy intake was estimated using the nutrition information on the food packaging (Table 2). For vegetable items, children often mixed peas and carrots in their meal, therefore energy of vegetables was estimated using the average energy of peas and carrots (mixed vegetables were estimated as 54 kcal/100 g of vegetables).

Meal data were then examined with hierarchical regression models, using cluster robust standard errors to account for the repeated measures from individual children. Three models were conducted with different outcome variables in each model: total vegetables eaten (g) [model 1]; total competitor foods eaten (g) [model 2]; and total energy eaten (kcal) [model 3]. This was to examine both changes to vegetable intake and potential changes to intake of other food items and energy consumed in the meal. Models were built hierarchically and comparisons between models were made using Likelihood Ratio Tests. Vegetable portions were combined to assess total vegetable intake (carrots + peas), and an aggregated item "competitor foods" was used to assess the total intake of the other available foods (fish fingers + potato wedges). After controlling for school (factor variable) and amount of vegetables or competitor foods served (g or kcal, continuous variable), presentation of vegetables (vegetables-served-first or together, factor) was added to the model as a predictor of intake.

Data were prepared and analysed in R version 4.1.0, using packages tidyverse 1.3.1, car 3.1–0, lmtest 0.9–40, sandwich 3.1–0, and sjPlot 2.8.11.

2.2. Results

2.2.1. Participants and survey data

Eighteen surveys were returned by parents of nursery children (47% return rate). Of the parents that returned the survey, all were of white ethnicity, 16 were mothers, with various levels of education (high school/college = 7, diploma/degree level or above = 8, did not answer = 3) and household incomes (<£49,999 = 10, >£50,000 = 4, did not answer = 4). Parents rated their children towards the higher end of the CEBQ food fussiness subscale ($M = 3.2$, $SD = 0.4$). Full sample characteristics are presented in **Supplemental material 1**.

2.2.2. Foods served

Weighed food intake was collected for both meals for 37 children, and for only one meal for one child. Across both conditions, portion sizes could not be kept constant due to COVID-19 restrictions and data procedures implemented entirely by school staff. Individual children therefore received varying portion sizes of each food. This resulted in school 1 serving around two portions of vegetables (together – $M = 86.6$ g, $SD = 9.92$, vegetables-first – $M = 79.1$ g, $SD = 7.8$), whereas school 2 generally served only one portion of vegetables (together – $M = 46.1$ g, $SD = 13.7$, vegetables-first – $M = 43.5$ g, $SD = 6.24$); yet each school served consistently across the two weeks (school 1 - $r = 0.5$, $p = 0.02$; school 2 – $r = 0.57$, $p = 0.04$). Aggregated portion sizes served across both schools are detailed in Table 2.

2.2.3. Amounts eaten

Across both experimental conditions, children ate similar proportions of fish fingers and potato wedges served to them. In the vegetables-served-first condition, children ate a larger proportion of vegetables served (compared with vegetables served together with the meal), with a median difference of 12 g ($Mdiff = 6$ g, 16% larger proportion) (Table 3). Fig. 1 illustrates the amount of vegetables served and eaten in each condition (top row), as well as the difference between amount served and eaten in each condition (bottom row). Fig. 1 (top row) suggests that more children ate 100% of the portion served to them in the vegetables-served-first condition, with fewer children consuming none of the vegetable portion served to them. Children that have intake between these two groups (i.e. plate clearers and non-eaters) may increase their overall intake of vegetables when served-first. Fig. 1 (bottom row) illustrates that despite slightly smaller portions of vegetables being served in the vegetables-served-first condition (data to the left of the vertical black line), a larger number of children consumed more vegetables in this condition (data above the horizontal green line).

When predicting the total vegetables eaten (g) at each meal, children from school 2 ate larger portions of vegetables when controlling for portion size served. Portion sizes of vegetables served predicted intake, with larger portions of vegetables served predicting larger amounts of vegetables eaten by children. After adding condition as a predictor in the model, model fit improved. The model suggests that children ate 13 g more vegetables in the vegetables-served-first condition, compared with all foods served together, when controlling for serving size and school effects (Table 4).

The model for amount of competitor foods eaten (**Supplemental material 2**) also suggests a portion size effect, the larger the portions of competitor foods served, the larger the portion eaten. However, there was no effect of school or serving vegetables first on the intake (g) of competitor foods. Similarly, when total energy intake (kcal) was examined (**Supplemental material 3**), the more energy served from competitor foods, but not from vegetables, predicted an increase in the

Table 2
The columns on the left of the table show the estimated energy and nutrient composition of the foods used. Columns on the right report descriptive statistics for the actual portion sizes served to children by school staff.

Item	Estimated energy and nutrient composition					Amount served to children by schools		
	Energy (kcal/100 g)	Fat (g/100 g)	CHO (g/100 g)	Sugars (g/100 g)	Protein (g/100 g)	Range (g)	Mean (g)	SD (g)
Fish fingers	223	9	14	0	12	31–83	58	13.7
Potato wedges	145	5	35	1	3	34–117	56	15.6
Cooked peas	79	2	11	2	7	15–50	34	8.7
Cooked carrots	29	1	6	6	1	10–58	34	14.5

Table 3
Descriptive statistics for the Range, Mean and Mean proportion (of the portion served) of each food eaten by children across the two experimental conditions.

Food	All foods served *together*			Vegetables-served-*first*		
	Range (g) eaten	*M*/Median/*SD* (g) eaten	*M* proportion eaten	Range (g) eaten	*M*/Median/*SD* (g) eaten	*M* proportion eaten
Fish fingers	0–83	52/47/18.1	92%	9–70	55/62/16.2	93%
Potato wedges	0–92	38/42/25.9	61%	0–66	36/44/20.3	70%
Vegetables (combined)	0–93	36/30/28.0	49%	0–86	42/42/25.1	65%

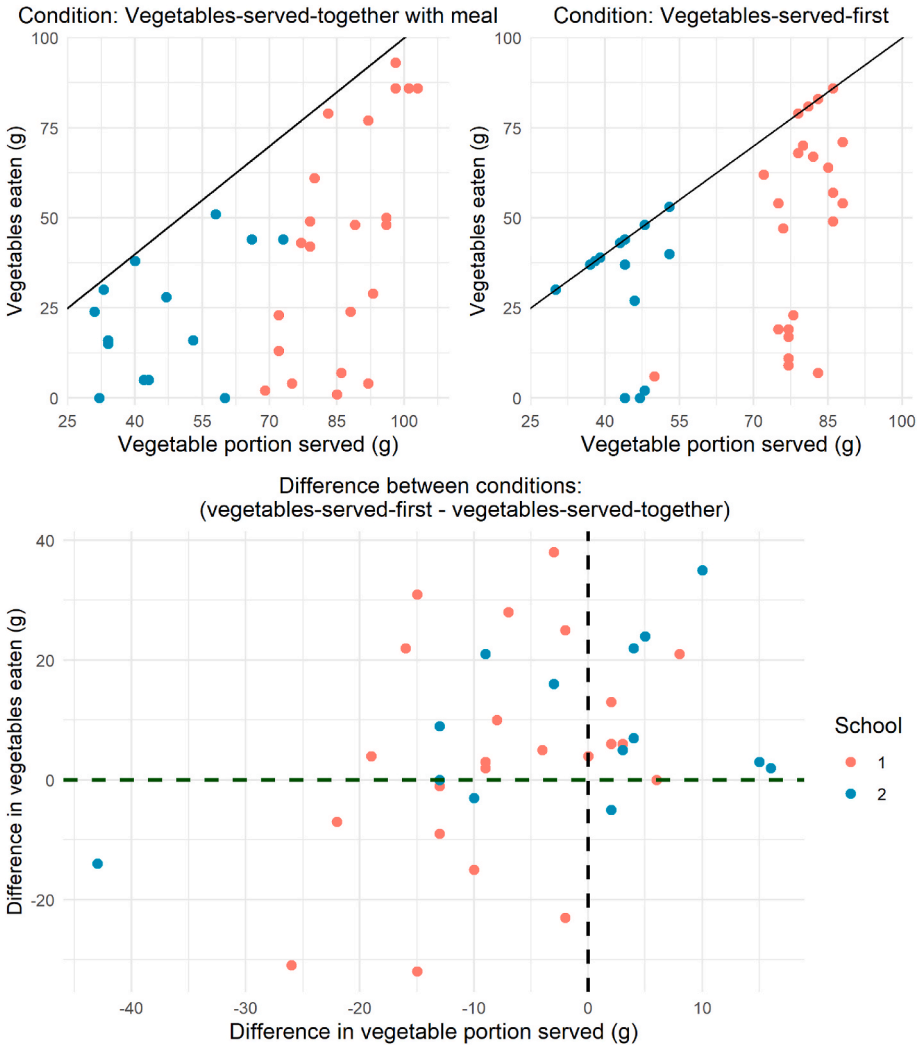

Fig. 1. Scatter plots illustrating the amount of vegetables served to and eaten by children in each condition. The top row presents intake by children from both schools for the vegetables-served-together (left) and vegetables-served-first (right) conditions. The black diagonal line indicates 100% of the vegetable portion served. The second row illustrates the difference scores between both conditions (vegetables-served-first minus vegetables-served-together). Points above the green horizontal dashed line indicate more vegetables were eaten in the vegetables-served-first condition. Points to the right of the black vertical dashed line indicate a higher portion was served in the vegetables-served-first condition.

total energy consumed. There was also an experimental effect on the amount of energy consumed by children, with more total energy consumed during the vegetables-served-first condition.

2.3. Summary of study 1

Study 1 set out to examine whether serving vegetables first at school mealtimes could increase vegetable intake by children in a real world eating context. It was found that higher intakes of vegetables were consumed by children in the vegetables-served-first condition, compared with all foods served together. This is consistent with findings from other studies examining vegetables-served-first techniques (Spill et al., 2010). A naturalistic portion size effect was also observed (this was not intentionally manipulated), with larger vegetable intakes being recorded when larger portions of vegetables were served (Reale et al., 2019). These findings suggest that one exposure to vegetables being served first can increase vegetable intake at that mealtime. Study 2 aims to explore this effect over multiple exposures to serving vegetables first, coupled with the potential to enhance the effect with the concurrent use of experiential learning techniques.

Table 4
Results of hierarchical regression models (with cluster robust standard errors) predicting total vegetable intake (g) by children in each experimental condition.

	Total vegetables eaten in g							
	Model 1				Model 2			
Predictors	*B [SE]*	*CI*	*t-stat*	*p-val*	*B [SE]*	*CI*	*t-stat*	*p-val*
(Intercept)	−37.32 [20.25]	−83.09–8.45	−1.84	0.069	−59.43 [21.03]	−107.52–11.34	−2.83	**0.006**
School 2 (ref = school 1)	19.75 [11.44]	−3.79–43.28	1.73	0.089	26.72 [11.45]	3.17–50.28	2.33	**0.022**
Amount of vegetables served (g)	1.00 [0.24]	0.46–1.55	4.17	<0.001	1.19 [0.25]	0.64–1.74	4.84	**<0.001**
Vegetables-served-first (ref = served together)					12.91 [3.06]	2.08–23.74	4.23	**<0.001**
$N_{Participant\ [Observations]}$		38 [75]				38 [75]		
R^2/R^2 adjusted		0.26/0.23				0.31/0.281		
F		$F(2,72) = 12.32$, $P <$ **0.001**				$F(3,71) = 10.62$, $P =$ **0.001**		
ΔR^2						0.05/0.051		
$\Delta\chi^2$						$F = 5.65$, (df = −1), $\mathbf{p < 0.02}$		

3. Study 2: vegetables-served-first plus experiential learning

3.1. Methods

3.1.1. Design

The design and analyses of the main trial were pre-registered prior to data collection (https://doi.org/10.17605/OSF.IO/9 × 7U8). Study 2 forms a pilot study prior to the main trial and used the same treatment vs control with partial crossover design, with each condition cluster randomised to different schools (stratified based on the number of pupils participating from each school). Independent variables were the presentation of vegetables at each meal (one level: Vegetables presented as a starter) and whether experiential learning was provided or not (two levels). Partial crossover was used so that both groups had the same baseline and test conditions, with all foods served together. The study lasted 5 weeks, with weeks 1 and 5 being test weeks (vegetables were served together with the meal) and weeks 2–4 experimental weeks (3 exposures each week to vegetables served first only or plus experiential learning). Three exposures per-week was chosen so the intervention could achieve 9 exposures in a short period of time. This addresses Varman et al.'s (2021) finding that short duration and high intensity interventions have better outcomes, whilst also meeting the recommended 5–10 exposures for repeated exposure alone to increase vegetable intake by children (Nekitsing, Blundell-Birtill, Cockroft, & Hetherington, 2018b). Additionally, having only 3 exposures per-week reduces the effect of monotony on the intervention, as children have a break from eating the same vegetables in-between intervention days.

It was not possible to blind schools to the condition they were assigned; however they were blinded to the conditions and protocols of the other schools. The main outcome for all conditions was the proportion of vegetables consumed (of those served) at the meal. Ratings were made for the amount eaten by each child (None, ¼, ½, ¾, all) by EDCs from Phunky Foods. Each of these five proportion categories incorporates the range of proportion closest to the category (i.e. 0 – 12.5%, 12.5–37.5%, 37.5–62.5%, 62.5–87.5%, and 87.5–100% respectively). Similarly, the categories can be roughly translated to grams based on 80 g of vegetables being served to children (None = ~ 0 g–10 g; ¼ = ~10 g–30 g; ½ = ~30 g–50 g; ¾ = ~50 g–70 g; all = ~70 g–80 g). Ratings were chosen as findings from study 1 illustrated that weighed intake would not be feasible in schools, and counting number of pieces of vegetables consumed could not be controlled during COVID-19 (e.g. controlling the size of each vegetable piece).

A process evaluation was conducted after the study with school staff involved. All study procedures took part soon after the main COVID-19 restrictions were lifted in the UK (February–July 2022).

3.1.2. Participants

As a pilot and feasibility study, we aimed to recruit 6 schools to participate (a full size study would require a minimum of 12 clusters with 20 participants each). Schools were identified and approached through contacts with Phunky Foods, since these were schools already receiving nutrition education activities in their curriculum. Children aged between 4 and 7 years (UK reception to year 2 classes) were eligible to participate. School aged children were targeted for this study as children are in attendance each day, maximising the number of exposures to the intervention, whereas children in nurseries (study 1) may not attend every day.

3.1.3. Materials

Foods. Schools provided their usual meals on each of the intervention days. The research team provided two portions of vegetables in addition to the child's usual meal; 1/3 cup (~40 g) of carrots and 1/3 cup (~40 g) of peas per child. Carrots and peas were chosen so that findings would be comparable with study 1. These vegetables were also chosen for practical reasons, as foods were provided to the schools during COVID-19. Therefore, to comply with health and safety regulations and to reduce waste from supplying fresh vegetables, tinned vegetables were supplied. Measuring cups were provided to schools to ensure less variability in vegetable portion sizes between schools than observed in study 1.

Dinner plates. As part of serving vegetables first, schools in the control condition were provided with blank white plates in which to serve vegetables in isolation. Schools in the experiential learning condition were provided with "Veg first" plates.

Experiential learning resources. Schools were provided with a vegetables-first video showing children interacting with vegetables and singing a song including the message "vegetables are eaten first". The song was also provided to schools for children to sing before lunch times. Short nutrition education about why vegetables are good for us was additionally provided before each lunchtime. The teacher session plan for the experiential learning condition is provided in **Supplemental material 4**.

3.1.4. Procedure

Head teachers were approached to consent for their schools to participate. Parents were subsequently informed and given opportunity to opt their child out of data collection. An opt-out procedure was used since procedures only differed in normal food provision via order (vegetables first) and accompanying experiential learning, without gathering personal, identifiable, or sensitive data.

Week one involved one test meal (baseline), serving vegetables alongside the child's regular school meal. At each meal, only vegetable items were controlled for. Two portions of vegetables (cooked peas and carrots) were served alongside the usual school menu items, ensuring vegetable availability for children.

In weeks 2–4, schools in each condition implemented the intervention three times per-week (e.g. Monday, Wednesday and Friday). In the control group, vegetables were served first for 10 min before being replaced with the other regular meal options. In the experiential learning condition, strategies were introduced in the classroom 5 min before lunchtime, including brief nutrition education, watching a

vegetables-first video, and singing a vegetables-eaten-first song). Vegetables were then served alone on the specially designed "veg-first" plates (for 10 min – sample Fig. 2), before being replaced with the rest of their meal. After 9 exposures over 3 weeks, a test meal identical to the baseline meal was served, and intake assessed.

Weekly lunchtime vegetable consumption was assessed across five time points. Proportion of vegetables eaten was the outcome due to practical constraints reported by schools in study 1 (time taken to weigh foods). EDCs were trained to rate intake for each meal, which involved comparing vegetable leftovers to a photographed standard meal for that mealtime. Intakes were rated on a five point scale: None, ¼, ½, ¾, or All, was consumed (**Supplemental material 5**). A sample of meals (n = 3–5 per-school per-measurement time) were photographed before and after eating for validation and to assess consistency between schools and across weeks. A procedural timeline is presented in Table 5.

Upon study completion, a process evaluation (**Supplemental material 6**) was conducted via semi-structured telephone interviews to assess intervention practicality and feasibility. School staff involved offered feedback on contextual factors (factors that shape how the intervention works, as well as how the intervention may affect the usual context), implementation factors (how delivery and training was achieved; what was delivered in terms of fidelity and any adaptations), and potential mechanisms of impact (what were children's responses to, and engagement with, the intervention; were there any unexpected consequences).

3.1.5. Data analyses

Data are presented descriptively as this pilot and feasibility study would lack power to estimate proportion of vegetables eaten using ordinal models. Participants were excluded from analyses if they had fewer than three data points from the five study weeks. Acceptability of the study was assessed by school recruitment (school staff), process evaluation completion (schools), numbers of parental opt-out (parents), data sheets completed (EDCs), and process evaluation interviews (interviews were transcribed and reported descriptively due to low uptake).

3.2. Results

3.2.1. Participants

Four schools were recruited to take part, with 74 children participating in the study. 69 children had outcome data for three or more weeks, with a total of 306 observations at eating occasions (maximum of five per child, data missing for 39 eating occasions). No parents opted their child out of data collection. Of the four participating schools, school 1 was assigned to the control condition (20 children) and schools 2, 3 and 4 were assigned to the intervention condition (20, 23 and 6 children respectively). Two schools were located in the midlands and two in the north of England.

A further four recruited schools did not participate for the following reasons: Two schools noted staffing issues due to COVID-19; One school indicated that seating arrangements due to COVID were not compatible with the study; One school expressed concern about insufficient time to serve vegetables first, suggesting it would disrupt the lunch queue and reduce teaching time. All four schools dropped out after expressing interest to participate but before data collection, resulting in unbalanced number of schools and children in each experimental condition.

Table 5
A timeline of study 2 procedures, measurements taken and experimental conditions.

Week 1	Week 2	Week 3	Week 4	Week 5
Baseline session	1st – 3rd intervention sessions	4th – 6th intervention sessions	7th – 9th intervention sessions	Test session
Test Meal (all foods served together)	***Experimental condition meal*** Vegetables-served-first ***Or*** Vegetables-served-first plus experiential learning			***Test Meal*** (all foods served together)

Rated vegetable intake plus pictures of selected meals before and after eating.

3.2.2. Eating outcomes

EDCs completed all datasheets fully and recorded photographs of sample meals at each data collection time, suggesting good acceptability of outcome measures. From the descriptive data, each participating school had distinct profiles regarding weekly vegetable proportions consumed. Fig. 3 illustrates that in school 1 (control condition) 50% of children ate all of the vegetables served to them each week, with very low levels of vegetable refusal. Children from school 2 ate slightly higher proportions of vegetables as the study progressed (indicated on Fig. 3 by smaller red coloured proportions). In school 3, children appeared to have high levels of vegetable refusal, with higher proportions of vegetables consumed during the intervention sessions (weeks 2–4: indicated on Fig. 3 with larger green coloured proportions). Lastly, children from school 4 ate larger proportions of vegetables in weeks 3 and 4, before reducing the proportion eaten in the test week. Although week 5 (test day) provides no suggestion of the effect of the intervention, it does provide an indication of whether effects may carry over when the intervention is not implemented. The horizontal dashed line in Fig. 3 highlights the median proportion of vegetables eaten at each school each week.

3.2.3. Process evaluation

Two of the four participating schools (schools 3 and 4) agreed to provide feedback via process evaluation. Teacher's scheduling issues meant that the other two schools did not have time for interview.

Contextual factors. In school 3, children queue up for lunch, have the choice of food options (and salad) and are served dessert alongside their main meal. Despite having 1 h to eat, they are often hurried so that other year groups can access the dining hall. Children can go outside to

Fig. 2. Example plates when vegetables were served first at mealtimes: before eating (left), after eating (middle – ¾ eaten; right - ¼ eaten).

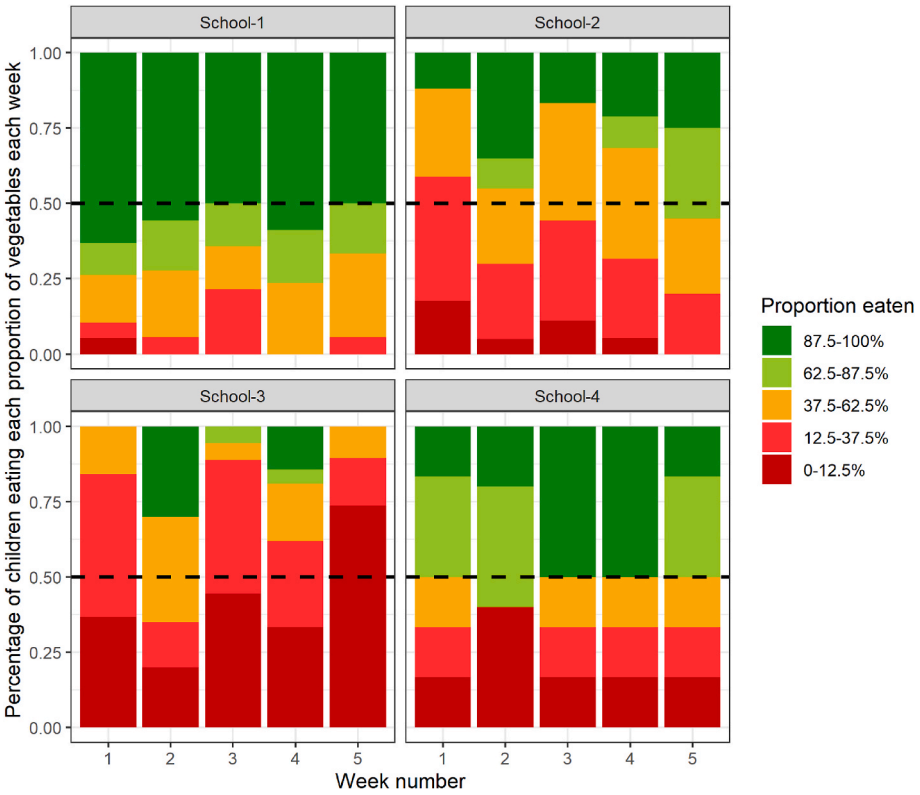

Fig. 3. The percentage of children from each school consuming different proportions of vegetables served to them during the study. For weeks 1 and 5, vegetables were served together with other foods on the plate. In weeks 2, 3 and 4, vegetables were served first. School 1 was assigned to the control condition during weeks 2, 3 and 4, with the other three schools receiving experiential learning during these weeks. A full portion was 80 g (40 g carrots, 40 g peas). The horizontal black dashed line highlights the median portion consumed. For gram intake conversions: 0–12.5% = ~ 0 g–10 g; 12.5–37.5% = ~10 g–30 g; 37.5–62.5% = ~30 g–50 g; 62.5–87.5% = ~50 g–70 g; 87.5–100% = ~70 g–80 g.

play when finished eating. Meals were less hurried in school 4, with fewer children, yet children tried to finish eating quickly to play afterward. Those having school dinners and packed lunches sit separately and staff check whether children have eaten 'enough' before they can go to play.

School 4 reported that serving vegetables first fit well with the usual mealtime process, with reception children already going to lunch 10 min early. However, had other year groups participated, logistically the study would have been difficult to implement. School 3 stated that due to the study, the participating class went into the dining hall slightly early. Children queued for their vegetables first and then re-queued for their main meal.

Implementation factors. In both schools, staff were enthusiastic to implement the study. Staff from school 3 were particularly eager to encourage vegetable intake since the school is in a deprived area and many of the children had low vegetable intake (vegetables were available at school lunchtimes, however uptake was low and vegetables were not always provided in variety; many vegetables were hidden in composite dishes). Staff reported following the protocol exactly, with no adaptations needed. Staff in schools described the Phunky foods EDC as helpful to keep the schools on track with the study, but both schools reported becoming familiar with the procedures very quickly. Both schools stated that the lessons fit well with the curriculum and there was little to no extra burden on staff during the study. The only difficulty in school 3 was the timing of lunch slots for all children (different year groups access the dining hall in intervals).

With regards to materials, school 3 liked the "Veg first" dinner plates as they were colourful and separate from the usual meal. The videos were fun to watch and all materials were appropriate and pitched at the right age. The materials were similar to regular classroom activities, as children are used to being involved with singing and watching YouTube. School 4 reported that the song and video were played in the dining hall.

Potential mechanisms of action. School 3 reported that many of their children had never tried vegetables before this study. Most children were therefore trying the vegetables before deciding whether they liked them and how much to eat. The school reported that the study procedures were different from the usual mealtime and fun to participate in, which may have facilitated trying the vegetables. Children were continuing to sing the song on non-study days, however teachers suggest that the novelty of serving vegetables first may have worn off after two weeks. Teachers also noted that the video included a variety of vegetables, yet the study did not. More variety may have encouraged further vegetable intake, with one teacher suggesting that monotony may have been more important than liking of vegetables.

Teachers in school 3 reported an unexpected consequence as children did not view the vegetables as part of the meal. The teacher suggested that some children may not have understood that the vegetables were a starter and that they would receive the rest of their meal afterward. Consequently, some children ate their vegetables quickly as they thought it was their main meal, yet after the second week, some children would wait for their main meal once they understood the procedure. The teacher further reported that they thought the children ate more of their main meal when vegetables were served first. The teacher from school 4 further stated that the study was easier to manage than they thought it would be and they were happy that parents were supportive of the study.

3.3. *Summary of study 2*

Study 2 explored the use of serving-vegetables-first and experiential learning techniques on children's intake of vegetables at school lunchtimes. Each participating school had different descriptive eating profiles, with school 1 children already eating lots of vegetables, school 2 eating

larger proportions as the study progressed, school 3 only eating larger proportions during intervention weeks (yet still very low intake), and school 4 vegetable intake showing little change.

Feedback from process evaluation indicated good acceptability by staff who participated, despite some apprehensiveness about difficulty to implement and time burden before the study. Staff also reported good acceptability by children yet suggested that future activities may benefit from including a wider variety of target vegetables and accounting for effects of contextual factors on the intervention. Conversely, other measures may suggest low acceptability, given that four of eight schools that agreed to participate dropped out before data collection. However, it could be argued that the decision to pull out of the study were due to staffing, teacher and schedule time constraints, as well as COVID restrictions, rather than only the implementation of the intervention. Acceptability is expected to be highest where school staff believe the activities can fit into their everyday curriculum, with little additional burden and where schools are free from the restrictions placed on them post-COVID. A common theme for lower acceptability was the time to eat and extra time that it would take to serve vegetables first to multiple classes.

4. General discussion

The pilot and feasibility studies presented here illustrate that serving vegetables first (study 1) combined with experiential learning (study 2) has potential to increase vegetable intake by children at school mealtimes. Acceptability of the interventions was good for teachers EDCs, and children, who took part. However it is necessary to include a variety of target vegetables and strategies to increase children's acceptability and engagement further (Chawner & Hetherington, 2021). For example, unless sensory play is combined with vegetables-served-first, young children might not understand the healthy eating message with provision alone (study 2). Both studies also reported good feasibility, with few exceptions. Firstly, weighed intake of foods at mealtimes would not be sustainable for school staff due to time taken (study 1). Yet, without weighed intake, assessing proportions of vegetables eaten (study-2) is unlikely to detect smaller intervention effects, such as improved willingness to try vegetables (school 3 teachers reported that they observed children trying the vegetables, but not all children liked and ate them). Additionally, study 2 procedures may not be feasible in certain schools, where the lunchtime context may involve queuing multiple times for food and reducing the time children have available to them to eat.

The success of school vegetable interventions may be determined by the general school culture and the child's response to the school environment at lunchtimes. Whilst strategies and experiences are needed to increase exposure and accessibility to healthy foods (Birch, McPhee, Shoba, Pirok, & Steinberg, 1987), previous research suggests interventions may be most successful when eating environments are positive and engaging, children have more time and space to eat (no overcrowding), fewer social constraints (e.g. segregating children eating school dinners and packed lunches), and when eating lunch does not compete with play time (Moore, Murphy, Tapper, & Moore, 2010). These aspects of school culture and context could explain the differences observed between schools (study 2) and why the intervention activities may have worked better in some schools than others. Future studies are required to separate contextual factors of school mealtimes from intervention effects, or consider how contextual factors affect intervention delivery and outcomes.

The GENIUS network in the UK recommends a systems approach to make changes to school food intake by children. This includes examining food policies and standards, procurement and provision of foods, the environment at lunchtimes, and healthy eating interventions (Woodside, Adamson, Spence, Baker, & McKinley, 2021). An ecological model such as that proposed by Davison and Birch (2001) might suggest that eating interventions conducted within schools are embedded within the context of the wider school system. Consuming more of the vegetables procured by schools will succeed only when schools pair their procurement policies and provision of vegetables with a positive eating environment, and commitment from key stakeholders (school staff, parents and children). For example, the current studies recruited schools with staff that agreed with the importance of children consuming vegetables. This is important as enthusiasm from teachers can affect both the adherence to the intervention implementation and children's responses (Griffin et al., 2015; Kafatos, Peponaras, Linardakis, & Kafatos, 2004). As children's eating behaviour at school is embedded within these contexts, intervention success is contingent on school management, lunchtime practices, comfortable and conducive environments, and a commitment to healthy eating and avoidance of waste.

4.1. Strengths and limitations

Whilst the current studies offer the significant advantage of real-world application of vegetable eating strategies in schools, the studies were also implemented during COVID-19 restrictions and therefore have some limitations to note. In study 1, despite utilising a crossover design the cluster effect of school cannot be disentangled from potential serving order effects. Whilst the school was a significant predictor of vegetable intake, this could be due to either the school itself and the environment the intervention was conducted in, or the effect could be due to serving order effects. Therefore, the 13 g (*Median*) difference between conditions is only suggestive of a potential effect size for this intervention. Findings from study 2 further corroborate that schools can be very different from each other in terms of both children and environment, which could have a large impact on intervention success.

A second point to consider is that different portion sizes were served between schools in study 1, which diverged from what is recommended. Despite larger portions encouraging consumption, when controlling for portion sizes serving-vegetables-first still increased vegetable intake. However, when portions were small (school 2) there may have been ceiling effects and some children could have consumed larger portions if more vegetables were available. Furthermore, as portion sizes were variable, it cannot be ascertained whether children were aware of differences in serving sizes, whether children asked for smaller portions, or whether staff served portions based on what they thought each child might eat. All of which could potentially influence intervention outcomes.

For study 2, few schools took part and four schools dropped out before data collection. Due to logistics of school preparation, consent, and implementation, different schools started the procedures during different weeks (also with unequal numbers of pupils). This meant that allocation to control or experimental conditions was uneven, limiting further analyses of the data and comparisons between conditions. Scheduling issues and teacher time also reduced the amount of feedback received from process evaluation, which would have been useful for future intervention planning.

Lastly, environmental noise was not controlled in either study. For example, staff enthusiasm, time to eat, re-queuing, portion sizes, and encouragement to eat by lunchtime staff varied by school. Although experimental control is lost by not controlling for these factors, meaning that the factors could have had a larger impact on vegetable consumption than the intervention, pragmatically for real life application these issues cannot be controlled and therefore they illustrate the challenging and dynamic nature of implementing eating strategies within schools. If interventions are to increase vegetable intake in schools, it would be necessary to demonstrate that the intervention could work despite the environmental differences between schools, including serving different foods and different amounts of vegetables. Without this, policy to change school lunchtime environments is needed. Policy could align both learning in classrooms about support healthy eating lunchtime practices in the dining area. Such policies could produce environments more favourable for applying what has been learned in the classroom to food choice decisions.

4.2. Future research

Studies 1 and 2 both indicate positive intervention effects during exposure days, although after the novelty effect, vegetable consumption may decrease (e.g. Horne et al., 2009; Just & Price, 2013; Kessler, 2016). However, novelty is central to experiential learning theory (Kolb, 2014), meaning that these first experiences could be built on to become lunchtime habit with different vegetables. Examining how eating vegetables at lunchtimes can be learnt through different activities reflecting on, and thinking about, the experiences in the intervention may be useful. Additionally, research may explore ways to build similar interventions into the daily school lunchtime using co-design methods. Designing healthy eating interventions around the culture and context of the school lunchtime with stakeholders will ensure that interventions are effective, appropriate to the context, sustainable, and engaging for children over the longer term.

5. Conclusion

Study 1 found that serving vegetables first at school lunchtimes increased children's intake of vegetables, compared with serving all foods together. Study 2 found that vegetable intake was largely dependent on differences between schools. For schools with low vegetable intake, larger proportions of vegetables were eaten across the intervention weeks; yet schools with children already eating vegetables showed little change in consumption. Good acceptability was achieved for both study procedures, although a compromise between weighing food items (study 1) and rating proportions eaten (study 2) may be beneficial for outcome measurement in busy schools. Similarly, child engagement may be improved if a variety of target vegetables are included in longer-term interventions. Feasibility of procedures may differ across schools, as four schools dropped out (study 2) due to low staffing issues, extra time to implement, and COVID restrictions. Findings highlight the need for interventions to be designed and developed alongside school staff, children, and parents - ensuring that interventions work within the context of the school eating environment. Adopting a joined-up, whole systems approach may be beneficial to account for the varying factors that impact children's vegetable intake at school.

Ethics approval and consent to participate

Ethics approval was provided by the University of Leeds School of Psychology Ethical Review Committee for Study 1 (Reference: PSYC-211, June 20, 2021) and Study 2 (Reference: PSYC-461, February 08, 2022).

Consent for publication

All authors have read and approved the final version of this manuscript.

Availability of data and materials

All data and materials will be available from the author upon reasonable request.

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Ethical statement

Ethics approval was provided by the University of Leeds School of Psychology Ethical Review Committee for Study 1 (Reference: PSYC-211, June 20, 2021) and Study 2 (Reference: PSYC-461, February 08, 2022).

CRediT authorship contribution statement

L.R. Chawner: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **P. Birtill:** Writing – review & editing, Supervision, Methodology, Conceptualization. **J.E. Cockroft:** Writing – review & editing, Supervision, Resources, Methodology, Conceptualization. **M.M. Hetherington:** Writing – review & editing, Supervision, Methodology, Conceptualization.

Declaration of competing interest

None.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2024.107622.

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