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RESEARCH
Original Research

Increasing Intake of an Unfamiliar Vegetable in Preschool Children Through Learning Using Storybooks and Sensory Play: A Cluster Randomized Trial

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ABSTRACT

Background Most children eat fewer vegetables than recommended. Storybooks and sensory play may increase vegetable intake.

Objective This study tested the effects on intake of learning about an unfamiliar vegetable (celeriac) through storybooks and sensory play. It was predicted that an illustrated, congruent storybook would increase intake of celeriac compared to an incongruent storybook (carrot); and that adding congruent sensory play with celeriac to the storybook would produce a synergistic effect on intake of celeriac.

Design Children from 12 UK preschools were randomly assigned by clusters to four intervention conditions using a 2×2 factorial design. The factors were vegetable congruency (sensory play and/or storybook were congruent, or incongruent [carrot] with celeriac) and intervention type (storybook only or storybook combined with sensory play).

Participants/setting Three hundred and thirty-seven children aged 2 to 5 years were recruited to take part in November 2017.

Intervention Over a 2-week period, children in all four conditions were read a vegetable storybook featuring celeriac or carrot. In addition, two conditions received sensory play with either carrot or celeriac added to the storybook method.

Main outcome measures Intake of the unfamiliar vegetable (celeriac) was measured at baseline and after the 2-week intervention.

Statistical analysis performed Complex samples logistic regression and general linear modeling were performed to examine group differences at post-intervention.

Results Children receiving the congruent (celeriac) storybook had higher odds of eating celeriac compared to children who received the incongruent (carrot) storybook. Receiving congruent sensory play increased the odds of eating celeriac, whereas receiving incongruent sensory play did not. From the 267 children who completed both baseline and post-intervention assessments, 85 ate no celeriac at baseline and were classed as non-eaters. Sensory play (congruent or incongruent) increased the odds of eating some celeriac in non-eaters compared to storybook only conditions.

Conclusions Congruency between storybook and vegetable increased intake; sensory play with celeriac increased the likelihood of eating celeriac. Storybooks and sensory play are simple interventions to increase willingness to try an unfamiliar vegetable.

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EATING HABITS DEVELOPED IN THE EARLY YEARS tend to persist into later life.[1,2] Therefore, much attention has been focused on encouraging healthy food choices in childhood.[3] It is well documented that many children in Western countries eat fewer than the daily recommended intakes (200 g; five portions) of fruits and vegetables.[4-6] Eating vegetables confers a greater protective health benefit than eating fruits.[7] Also, most vegetables are low in energy density and naturally occurring sugars compared to fruits. However, vegetables are less preferred than fruits, possibly due to unappealing appearance and texture, and/or bitter taste, hence increasing their intake remains a challenge.[8,9] This may be especially difficult if vegetables are unfamiliar to the children. However, interventions are more effective in increasing intake of unfamiliar or disliked vegetables than familiar/liked vegetables.[10]

Preschools are appropriate environments in which to encourage children to try new foods.[11] However, education programs implemented in preschools to promote healthy eating tend to focus on vegetables that are already familiar to the children. These programs are designed to be fun, interactive, and engaging, yet their effects on increasing vegetable

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intake are small.[10,12,13] This may be attributed to the indirect nature of how children are exposed to vegetables in these programs (ie, reading about them but not handling or eating them). Learning about vegetables may increase recognition of different vegetables, but may not translate to a behavioral outcome, such as tasting or consuming these vegetables. It is therefore important to know whether intake of an unfamiliar vegetable might be encouraged by combining direct and indirect exposures to an unfamiliar vegetable. Furthermore, it is not clear whether this type of learning also benefits from being specific to a single vegetable (congruent learning) or whether learning about any vegetable encourages intake of an unfamiliar vegetable (incongruent learning).

Strategies such as repeated taste exposure have been successful in increasing intake of a specific unfamiliar vegetable in preschools and at home.[10,14-16] Repeated exposure is generally congruent to the target, and so familiarization is achieved through multiple trials with the same vegetable. This strategy is known to increase intake more than others and generally involves at least 5 to 10 exposures.[10] However outside of these systematic studies, parents may not achieve enough taste exposures to establish liking.[17] In addition, children aged 2 years and older are likely to experience neophobia in response to unfamiliar foods and therefore will often refuse foods before tasting.[18] For these reasons, further research is needed to support parents and caregivers to introduce unfamiliar vegetables and to test the effectiveness of alternative exposure techniques, which may facilitate eventual intake.[19]

One way to engage with and motivate children is through picture/storybooks.[20-23] Most children enjoy story times because these are shared interactive sessions that allow them to be active participants. Earlier research has shown that repeatedly exposing toddlers to vegetables using picture books increased their willingness to taste the depicted foods.[21-23] Research by de Droog and colleagues[20,24] has demonstrated that storybooks with characters and embedded social norm messages, such as "eating carrots will make you fit and strong" can appeal to young children. For example, in their storybook, an animal character (Rabbit) was only able to rescue his friend after eating carrots. The authors reported an increase in children's carrot consumption and they proposed that these books effect a change by means of "narrative involvement" and "character imitation." These studies used a storybook approach to promote carrot consumption, but the use of a familiar, well-liked, and commonly consumed vegetable might have limited the effect size of the intervention. Therefore, a next step is to employ illustrated storybooks for unfamiliar vegetables.

A more direct strategy to increase vegetable acceptance in preschools is sensory play.[25-27] Vegetables are disliked, in part, due to their unfamiliar odor and unusual texture, therefore, activities incorporating tactile play with vegetables may be effective as a means to reduce novelty and fear of new foods in young children.[25,27] These activities may particularly help children going through a food neophobia or fussy eating phase.[28-30] A study by Coulthard and Sealy[25] found that children tried more fruits and vegetables after sensory play compared to children who participated in a non-food sensory play task or those who merely watched the sensory activity (visual exposure). The study was well designed and included eight different fruits and vegetables, but the sample size was small (approximately 20 children per group) and the outcome measure was willingness to try rather than actual intake, with no baseline intake measures of foods. Therefore, measuring actual intake (in grams) before and after this strategy is warranted.

The present study sought to examine the combined effects of learning about an unfamiliar vegetable through illustrated storybooks (the term *storybook* refers to an illustrated narrative storybook throughout) with sensory play on recognition and intake of that "target" vegetable. The effect of congruency of the storybook with sensory play was predicted to produce a synergistic effect on intake. Here congruence refers to whether the vegetable featured in the storybook and used in sensory play matched or differed from the target vegetable. Congruency may facilitate learning about the unfamiliar vegetable through cognitive processes, such as improved recognition and through linking the storybook to sensory play to establish perceptual learning. In particular, the study aimed to assess whether these strategies were effective in increasing intake of an unfamiliar vegetable in children who are fussy eaters. There were two hypotheses tested: the first hypothesis was that an illustrated, congruent storybook would increase intake of an unfamiliar vegetable (celeriac) compared to an incongruent storybook (carrot); and second, that adding congruent sensory play to the storybook would produce a synergistic effect on intake of celeriac. It was predicted that the interaction between a congruent storybook with sensory play would produce a synergistic effect by encouraging awareness and recognition both indirectly, through the narrative about that specific vegetable, and directly, through experiential learning about the appearance; smell; texture; and taste of the vegetable through play. Thus, synergy was expected over and above additive effects due to combining congruency through direct and indirect learning. Also, recognition of celeriac was predicted to improve in the congruent conditions compared to the incongruent conditions through increased awareness and experiential learning of this particular, unfamiliar vegetable.

RESEARCH SNAPSHOT

Research Questions: Is intake of an unfamiliar vegetable (celeriac) in preschool children increased more by using storybooks and sensory play featuring this specific vegetable rather than a different vegetable (carrot)? Is there any benefit to combining storybooks with sensory play for increasing intake of the unfamiliar vegetable?

Key Findings: Children were more likely to eat an unfamiliar vegetable (celeriac) if they were read a storybook about that specific vegetable, compared to a storybook about a different vegetable. Adding congruent sensory play to the congruent storybook also increased willingness to taste celeriac, more than if the storybook and sensory play included a different, incongruent vegetable (carrot). Children categorized as "non-eaters" at baseline were more likely to eat the unfamiliar vegetable if they had sensory play with either vegetable (congruent or incongruent) than if they had only the storybooks.

MATERIALS AND METHODS

Study Design

This study used a 2×2 factorial, parallel design, which was conducted in a cluster randomized controlled trial. The first factor concerned whether the congruency of a vegetable was important in encouraging intake of that vegetable. Children were given experiences with either celeriac (congruent) or carrot (incongruent), and the effect on intake of celeriac was examined. The second factor concerned whether adding sensory play would impact the effect of a storybook on intake of a vegetable. The intervention was conducted over 2 weeks. The main outcome measure was celeriac intake (measured in grams), assessed in two sessions, before the intervention and after the intervention. The study was conducted in preschools and the childcare staff were required to deliver the intervention. Therefore, for convenience, ease of intervention delivery, feasibility, condition concealment, and to avoid disappointment in children, the same experience was delivered within each preschool using a cluster randomized design. The design is set out in Figure 1. The present study was registered on the ClinicalTrials.gov, identifier NCT03003923. Ethics approval was granted by the University of Leeds, School of Psychology Research Ethics Committee; reference number 17-0251.

Sample Size, Enrollment, and Participants

The effect of clustering was not taken into consideration when determining the sample size because a previous cluster randomized trial of a nutrition intervention reported that clustering did not influence the outcomes in preschool children.[31] Using G*Power to calculate the sample size for factorial analysis of variance, to observe a small-medium effect size (Cohen's f=0.20), with 80% power and α=.05, the total sample size needed to be 199 (at least 50 children in each condition).[32] It was predicted that a minimum of three preschools per condition would be needed to meet this target.

Sixteen private preschools from Leeds, Brighouse, and Halifax (West Yorkshire, UK) were approached in September 2017. Preschools were eligible to take part if they were able to integrate the study requirements into their curriculum over 2 weeks in November 2017. Preschools were told that they could keep the illustrated, vegetable storybook used for the study (see details below) as a small incentive for taking part in the research. Twelve preschools (with 22 classrooms) that agreed to participate in the study were randomly assigned to one of four conditions; (1) congruent storybook only, (2) congruent storybook plus congruent sensory play; (3) incongruent storybook only; and (4) incongruent storybook plus incongruent sensory play. The children in the congruent conditions learned about the unfamiliar "target" vegetable (celeriac), whereas the children in the incongruent conditions learned about a familiar vegetable (carrot).

Figure 2 shows the flow of the preschools and participants through the trial. The preschools varied in size, therefore, stratified randomization was used.[33] The preschools were divided into three strata, with the four largest in one strata and the four smallest in another strata. One preschool in each strata was allocated to each condition, using a random number generation function within Excel. Children included in the assessments were those who attended on the date when the intake assessment sessions were conducted. The optimal timing of this was determined by preschool managers. Preschool managers and staff were unaware of the study design and condition assignment was concealed between clusters. Staff were told that the intervention would include reading a story about vegetables and possibly some sensory play. Parents were given a list of possible study vegetables that could be used in the study (this included the unfamiliar target vegetable).

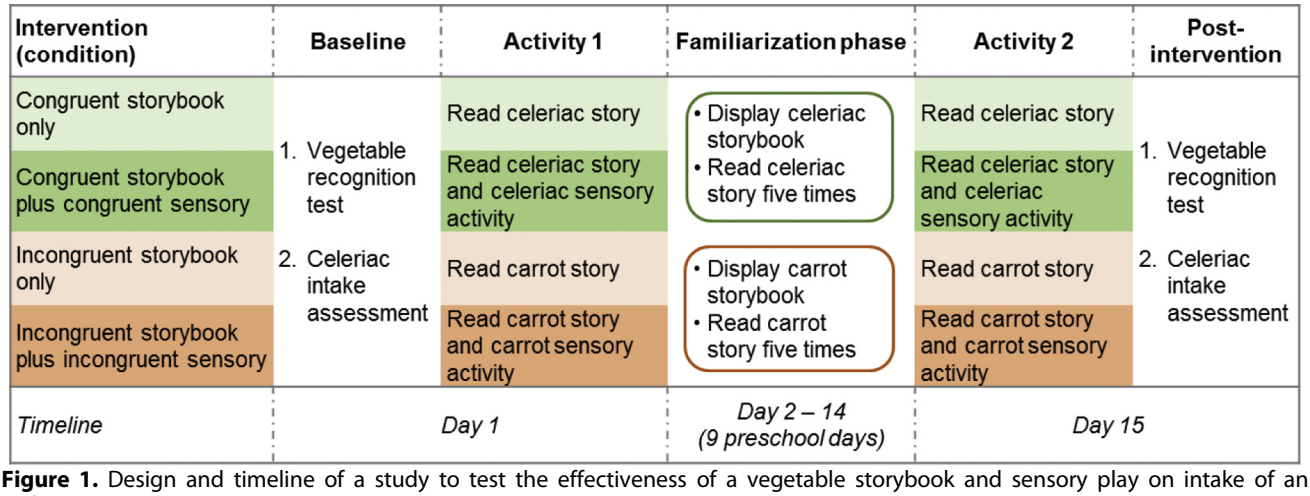

Figure 1. Design and timeline of a study to test the effectiveness of a vegetable storybook and sensory play on intake of an unfamiliar vegetable (celeriac) in 267 preschool children, aged 2 to 5 years. Celeriac was the congruent vegetable and carrot was the incongruent vegetable. Intake of celeriac was measured at baseline and post-intervention. Children's ability to recognize both celeriac and carrot was recorded at both time points. The intervention phase consisted of two activity sessions, which included a story session or story session with sensory play, depending on the condition allocation and a familiarization phase. During the familiarization phase storybook was displayed in the preschools and children were repeatedly read their allocated storybook.

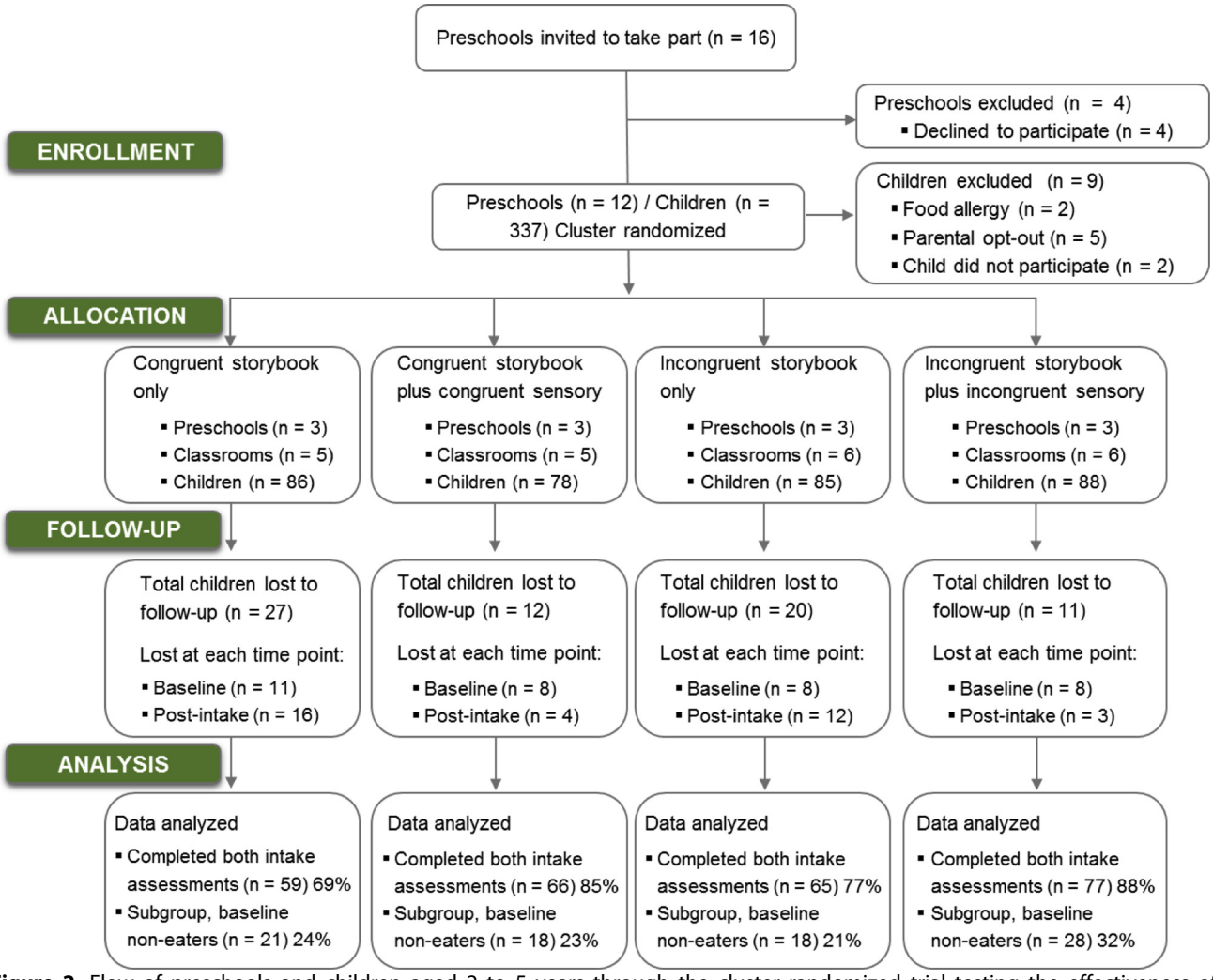

Figure 2. Flow of preschools and children aged 2 to 5 years through the cluster randomized trial testing the effectiveness of vegetable storybook and sensory play on intake of an unfamiliar vegetable (celeriac). No clusters were lost to follow-up or excluded from the analysis. Children were classified as lost to follow-up and excluded from the analysis if they were away for either of the intake assessment days. Subgroup analyses were performed with children who were non-eaters at the baseline (0 g intake).

A total of 337 children were enrolled in the study and the expected sample size was achieved for the primary analysis. Consent to participate was sought from the preschool manager at the cluster level and individually from parents using an opt-out approach in 11 preschools and opt-in approach in 1 preschool (parents were required to sign consent forms in this preschool and only 1 parent did not consent). The preschool managers signed consent forms and during the activities children were able to decline to take part. As most children were involved in the present study using an opt-out approach (complete inclusion of eligible children), the selection bias was minimized. Children were eligible to take part if they were aged 2 to 5 years and attended the preschool class on the celeriac intake assessment days. They were excluded from the study if they had any relevant food allergies, a medical condition that prevented them from eating the study vegetable, their parents did not want them to participate, or if the child indicated that they did not want to participate at the time of assessments (Figure 2).

Target Vegetable

In order to determine which unfamiliar vegetable would form the "target" for this study, seven relatively rarely eaten vegetables in their raw form and that are available through the winter season in the United Kingdom were selected for sensory testing by four researchers (two senior academic researchers, a postgraduate research student, and a public health nutrition and dietetics practitioner). Researchers tasted butternut squash, cauliflower, celeriac, chayote, mild pink radish, Romanesco cauliflower, and turnip. Each vegetable was rated for visual acceptability, texture, flavor, odor, and suitability to eat raw by small children. Based on these criteria, ratings indicated that celeriac would be a suitable target raw vegetable.

Illustrated Storybooks

The storybooks were specifically designed for the present study and were the main experimental stimuli (see Figure 3). The books

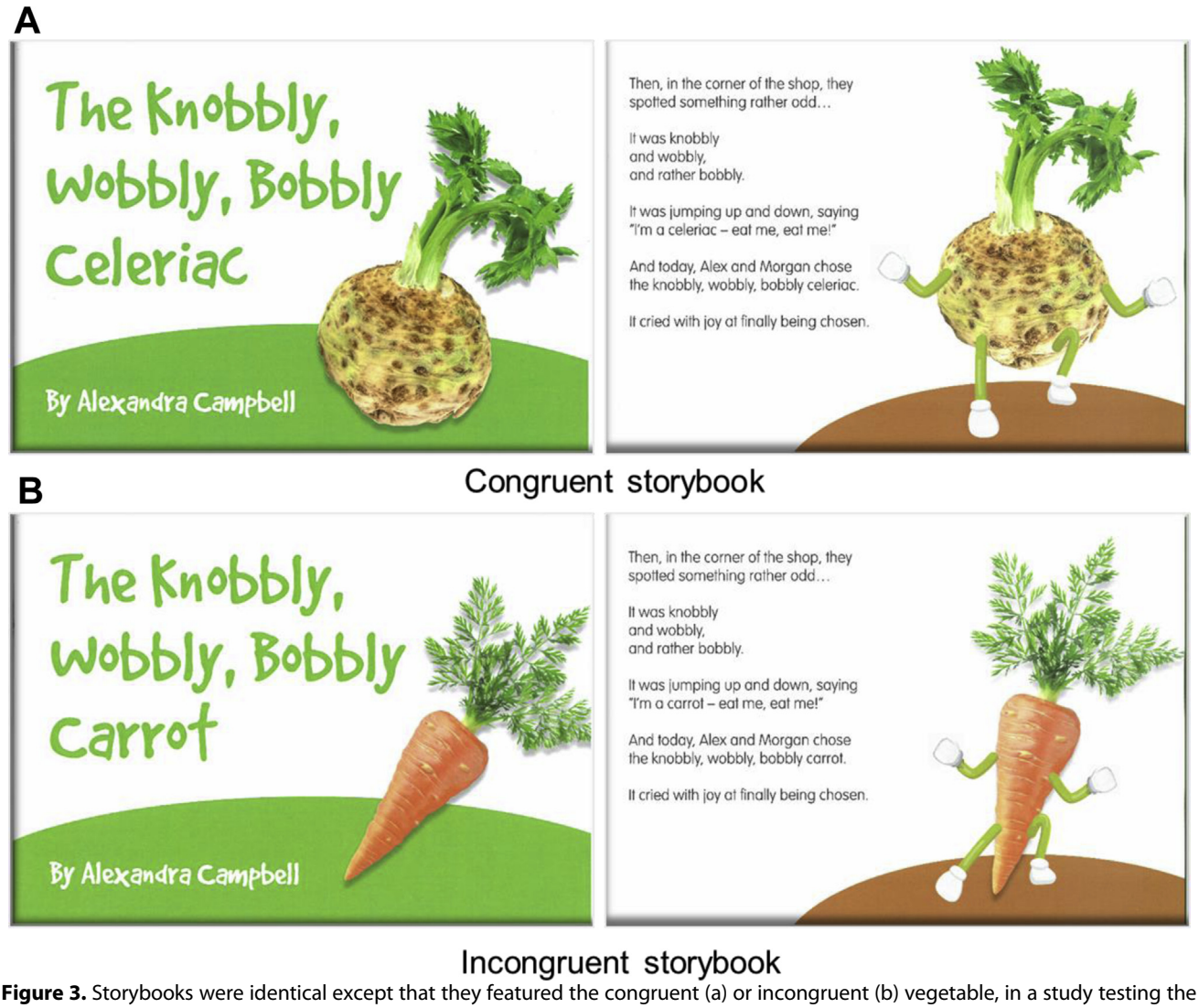

Figure 3. Storybooks were identical except that they featured the congruent (a) or incongruent (b) vegetable, in a study testing the effectiveness of a vegetable storybook and sensory play on intake of an unfamiliar vegetable (celeriac) in 267 preschool children, aged 2 to 5 years. Celeriac was the congruent vegetable and carrot was the incongruent vegetable. (The storybooks are copyright ©PhunkyFoods and these images are used with permission.)

featured four other vegetables (runner bean, beetroot, squash, and leek) in addition to the target (celeriac) or familiar (carrot) vegetable, but their presence was less emphasized. A professional illustrator created two identical A4 size (landscape) storybooks differing only in the main vegetable character (celeriac or carrot). The cover page of the story included a picture of the celeriac or carrot and was displayed in the classroom during the 2-week period (between test sessions). This was done to increase familiarity. The picture of the main vegetable story character was made from a photograph of the real vegetable (not a cartoon), with the addition of little hands and feet (see Figure 3). This suggestion was made by some preschool managers who advised that vegetables should be realistic for the storybook and would be better for children's learning than a book featuring cartoon characters, which children sometimes struggle to recognize. The narrative was written by a consultant teacher, who incorporated repetition and rhyming to keep the children attentive and involved. A professional editor specializing in books for young children helped with suitable phrasing, vocabulary, and length. The storybook was entitled *The Knobbly Wobbly Bobbly Celeriac* (or *Carrot*) and was designed to be fun, colorful, and engaging.

Sensory Play

The staff were provided with a kit that included six different forms of celeriac or carrot, along with some instructions on how to use them for the sensory activity. Vegetable forms provided for the sensory play included the whole vegetable (uncut); a half vegetable; and sliced, stick, grated, and spiralized forms of the vegetable. The activities included sound (listen to the vegetable name, tapping the vegetable to hear a sound), sight (look at different versions of the vegetable and describe the color), touch (feel the texture of the different forms), and smell (pick and sniff the different forms), but not taste (see Figure 1 in Nekitsing and colleagues[13]). The staff were asked to encourage every child to participate in these activities.

Procedure

The preschool staff were provided with all the necessary resources and some basic instructions to deliver the intervention to children in their classrooms. On the first day of the intervention, immediately after the baseline vegetable recognition test and intake assessment, the allocated storybook was read to the children. The children in the two congruent (target) conditions were read the celeriac story and children allocated to the incongruent (control) conditions were read the carrot story (see Figure 1, under Activity 1 and Activity 2). Children who were also allocated to the sensory play conditions were encouraged to explore and play with the respective vegetable. Over the next 14 days (9 preschool days) staff were requested to keep the storybooks on the clear acrylic stands provided to increase visual exposure and to read their designated storybooks a minimum of five times. The recommended number of storybook sessions was based on previous research.[24] The staff were free to read the book when it suited their curriculum, but were asked to aim for times when most of the study children were likely to be present (different children attend preschools on different days). The staff were also asked to keep a register of attendance so that children who were absent during the story times could be identified. On average, individual children were read their story on five occasions (ranging from two to seven) and this did not vary by condition. On the final day of the intervention, procedures of the first day were repeated. This was immediately followed by a post-intervention vegetable recognition test and intake assessment.

The researcher was present to observe preschool staff on days 1 and 15, as well as several interceding occasions, taking notes on delivery and compliance with the intervention. The story session lasted between 5 and 12 minutes, depending on the children's age, attention span, and interest in the story.

Parents were given questionnaires to take home from preschool. Parents were asked to report their child's usual intake of carrot and celeriac over the last month using ratings on a 9-point scale that ranged from never or less than once per month to six plus per day, adapted from the EPIC (European Prospective Investigation of Cancer)-Norfolk Food Frequency Questionnaire.[34] Parents also completed the six items of the Food Fussiness subscale (α=.92), of the Child Eating Behaviour Questionnaire.[35] Mostly parents provided the information for food fussiness (n=217), however, for some children the preschool staff member completed the questionnaire (n=26). An independent groups comparison indicated no difference in mean ratings by parents or the preschool staff.

Baseline and Post-Intervention Intake Assessment Procedure

On the first day of the study, immediately before the intervention began, the children were offered 40 g of the raw celeriac and were encouraged to eat as much as they wanted.

Fresh celeriac was peeled and cut into chunks, placed into a food processor (Veggie Bullet by NutriBullet, VBR-1001) and cut into thin (approximately 0.4-mm) bite-sized slices. Forty grams (1 of their "5 a day") of the celeriac was placed in clear snack bags then labeled for each child and weighed individually (to the nearest 0.01 g), before and after eating sessions using a digital scale (Mettler, PJ4000) by the researcher. During transit, the snack bags were placed in a cool bag with ice packs and were delivered to the preschools at least 45 minutes before the eating session. Staff were advised to store the celeriac in the cool bag provided before and after consumption in order to prevent any moisture loss. Also, the staff were asked to ensure that children did not swap or share their snack and any remaining food was returned back to the child's clear, plastic snack bag. However, all measurements of the celeriac intake were made by the researcher. The time of the assessment procedure was agreed upon with the preschool staff, and was at a time when the children would usually have a snack (morning or afternoon). It was assumed that because this was a typical snack time, children would be hungry.

Data Collection and Measures

The outcome variables were measured at an individual level because factors such as child's eating traits, which can affect vegetable intake, vary between children.

Primary Outcome

The prespecified primary outcome was celeriac intake. This was assessed in two ways: the likelihood of children eating any celeriac after the intervention and the change in weight consumed from baseline (day 1) to post-intervention (day 15).

Secondary Outcome

Children's ability to recognize the target vegetable was a prespecified secondary outcome. All children were tested for their ability to name the congruent vegetable (celeriac) and incongruent vegetable (carrot) at baseline (day 1) and post-intervention (day 15). Children were shown two photo cards, one with a picture of the celeriac and the other with a carrot (images used for the photo cards were same as the picture on the front cover of the storybooks, see Figure 3). The order in which the photo cards were shown to children was randomized. Children were individually asked by the preschool teacher to name each vegetable. The response of the child was then recorded for each vegetable.

Other Measures

Data for children's age and sex were provided by the preschool managers. No specific predictions were made about age or sex, but data were collected for descriptive purposes.

Intervention Evaluation Measures

As part of the evaluation process of the interventions, staff from 22 classrooms within the 12 preschools were asked for feedback using open and closed questions on a questionnaire that was left with staff to complete at the end of the intervention. Staff were asked about suitability, user engagement, integration, challenges, and effectiveness of the storybooks and sensory play, depending on the condition allocation.

Statistical Analysis

Children were excluded from the analysis if intake data were missing from baseline (n=35) or from post-intervention (n=35). Figure 2 shows the number of clusters and children included in each analysis by condition. Chi-square and analysis of variance were conducted to check for differences in

sex, age, food fussiness, and baseline celeriac intake between those children whose data were included and those who were originally recruited. As children were recruited using a cluster design, complex sample models in SPSS[36] were used to take account of the clustering into preschools. Intake data from both time points were positively skewed, as many children ate none of the celeriac. Therefore, children were classified as "eaters" if they consumed some celeriac after the intervention, and "non-eaters" if they ate no celeriac after the intervention. A two-part statistical analysis was conducted in which a logistic regression analysis was used to examine what factors predicted intake of at least some of the celeriac (classed as "eaters"). In this analysis, factors such as congruency of intervention, sensory play, and their interaction with covariates of age in months and pre-intervention (baseline) consumption, were tested as predictors of classification as eaters or non-eaters.

Next, a general linear analysis was conducted to examine whether these same predictors (congruency, sensory play, their interaction) influenced intake by children within the eater category, controlling for age and baseline consumption. It is accepted that there are issues of regression to the mean, but there is no reason to think this will be differentially affected by the different conditions.

In order to examine whether the intervention was effective specifically for those children who ate nothing at the baseline test (baseline non-eaters), a subgroup analysis was performed with 85 children who ate none of the celeriac at baseline. Again there may be a tendency for regression to the mean, but no reason to believe this would differ by condition. Therefore, it is useful to examine the effect of intervention on this subgroup.

For the secondary outcome, a χ^2 test was used to determine whether there was a significant difference between groups at post-intervention in children's ability to recognize the target vegetable. Data were analyzed using IBM SPSS Statistics, version 24.[36] The α-value was set to .05.

RESULTS

Participant Characteristics

Table 1 summarizes the sample characteristics and at-home vegetable intake of the children who took part in the intervention. Two hundred and sixty-seven children (148 boys and 119 girls) with a mean age of 38.9±0.5 months were included in the final analyses (Figure 2). There were no differences observed between conditions for age, sex, or food fussiness scores. Also, no differences in baseline characteristics were observed for children who completed the intervention and those who were lost to follow-up (see Table 2).

Post-Intervention Intake

Median data for celeriac intake in grams at baseline and at post-intervention by condition are shown in Figure 4, and the proportion of children categorized as eaters and non-eaters by intervention conditions at baseline and post-intervention are shown in Table 3 (see also Table 4 for intake category by the 2×2 factorial parallel design). The distribution of children by eating category at baseline was similar across the four conditions (χ^2[3]=5.689; P=0.434). In the two incongruent storybook conditions, the percentage of children who ate the celeriac was relatively constant from baseline (68%) to post-intervention (70%). In contrast, in the two congruent storybook conditions, the percentage of eaters increased from baseline (69%) to post-intervention (83%). The distribution of eater category post-intervention was different by condition assignment (χ^2 [3]=12.47; P=0.003).

Logistic regression analysis demonstrated that at post-intervention, children in the congruent storybook conditions were slightly more likely to be eaters than children in the incongruent storybook conditions (odds ratio [OR] 1.16; 95% CI 0.56 to 2.40; χ^2[1]=16.60; P<0.001). It should be noted here that although the Wald test is highly significant, the OR crosses the null boundary, suggesting this should be interpreted with caution. The sensory play had no effect on whether children ate any celeriac (OR 0.78; 95% CI 0.38 to 1.57; χ^2 [1]=2.70; P=0.1). However, there was an interaction between storybook and sensory play, such that children receiving the combined congruent storybook plus congruent sensory play condition were more likely to be eaters than any of the other conditions (OR 3.25; 95% CI 1.47 to 7.23; χ^2 [1]= 9.45; P=0.002). These findings show that combining the storybook with congruent sensory play increased the likelihood of eating some celeriac.

A second analysis was conducted to examine what predicted intake post-intervention among eaters. The mean intakes (±standard deviation) in each condition were as follows: congruent storybook intake=8.45±10.53 g; congruent storybook with congruent sensory play intake=11.27±14.63 g; incongruent storybook intake=10.79±14.65 g; and incongruent storybook with incongruent sensory play intake=9.31±10.47 g. There were no effects of congruency, or sensory play, or any interaction (largest F=1.76; P=0.199) on these intakes. However, there were effects of age (b=0.24; F[1,21]=5.4; P=0.03) and of baseline intake (b=0.68; F[1,21]= 90.53; P<0.001). These findings suggest that those already willing to eat celeriac at baseline continued to do so at post-intervention and they tended to be older.

Subgroup Analysis with Baseline Non-Eaters

Among the 85 children who ate none of the celeriac at baseline, the percentage of those who ate something after the intervention was slightly higher in the congruent storybook conditions (59%) compared to incongruent storybook conditions (56%) (OR 1.45; 95% CI 0.61 to 3.45; χ^2[1]=6.36; P=0.012). While the Wald test was significant, the OR included the null, so this should be interpreted with caution. However, children were more likely to be eaters at post-intervention if they had either type of sensory play (63%) compared to children who received the storybook-only intervention (38%) (OR 2.28; 95% CI 1.09 to 4.72; χ^2[1]= 17.55; P<0.001). There was no interaction between congruency and sensory play on the likelihood of being an eater at post-intervention in this subgroup (OR 2.04; 95% CI 0.62 to 6.68; χ^2[1]=1.58; P=0.21). This suggests that among the children who ate none of the celeriac at baseline, sensory play with either vegetable alongside storybooks was more effective in encouraging some intake than the storybooks alone.

Vegetable Recognition Tests

In total, 261 children completed the vegetable recognition test at both assessment points for carrot and celeriac. At

Table 1. Information about the 267 preschool-aged (2 to 5 years) children participating in a trial testing the effectiveness of vegetable storybook and sensory play on intake of an unfamiliar vegetable (celeriac)[a]

Variable	Congruent[b] storybook only	Congruent[b] storybook plus congruent sensory play	Incongruent[c] storybook only	Incongruent[c] storybook plus incongruent sensory play	Test of group difference	*P* value
n[d]	59	66	65	77	—	—
	←——— *n per cluster* ———→					
Preschool 1	12	21	6	20	—	—
Preschool 2	17	22	24	28	—	—
Preschool 3	30	23	35	29	—	—
	←——— *n* ———→					
Child sex, girl/boy	32/27	26/40	30/35	31/46	χ^2=3.59	0.309
	←——— *mean±SEM*[e] ———→					
Age, mo	39.6±0.9	39.8±0.9	37.7±1.0	38.8±0.8	F[f]=1.03	0.381
Food fussiness score (range=1 to 5)[g]	2.87±0.1	2.64±0.1	2.7±0.1	2.85±0.1	F[f]=1.058	0.367
Proportion of children who eat these vegetables more than once/mo at home[h]	←——— *%* ———→					
Carrot	94	97	94	95	χ^2=0.60	0.898
Celeriac	7	12	14	8	χ^2=1.91	0.591
Proportion of children who correctly recognized these vegetables						
Baseline						
Carrot	86	97	84	96	χ^2=10.51	0.015
Celeriac	0	0	0	0	—	—
Post-intervention						
Carrot	91	100	94	99	χ^2=8.55	0.036
Celeriac	50	88	0	0	χ^2=163.10	<0.001

[a]Details include sample size for each condition, sample size for each cluster (preschool), and characteristics of the children.
[b]Celeriac was the congruent vegetable.
[c]Carrot was the incongruent vegetable.
[d]Number of children included in the analysis with complete data: celeriac intake (n=267); recognition test (n=261); food fussiness (n=243); and FFQ (n=216).
[e]SEM=standard error of the mean.
[f]Analysis of variance.
[g]Food fussiness score measured using the Food Fussiness subscale of the Child Eating Behaviour Questionnaire.[35]
[h]FFQ=food frequency questionnaire provides the percentage of children eating the selected vegetables more than once per month at home. Note: FFQ celeriac intake may be over-reported by some parents, as it seemed to be confused with celery.

baseline, almost all children (91%; n=238) correctly recognized carrot, whereas none recognized the celeriac (Table 1). At post-intervention, 86 (33%) of the 261 children recognized the celeriac. Celeriac was correctly named by 70% of the children who were read the congruent storybook, compared to 0% of the children who were read the incongruent storybook (χ^2[1]=143.62; P<0.0001). This shows that storybook congruency improved recognition of the target vegetable. Moreover, 88% of the children in the congruent storybook plus congruent sensory play condition named the vegetable correctly compared to 50% in the congruent storybook only condition (χ^2[1]=20.25; P<0.0001), this indicates that congruent sensory play may further improve children's ability to recognize the vegetable through increasing familiarity.

Intervention Evaluation

Feedback was received from all 22 classrooms within the 12 preschools. See Table 5 for ratings from the evaluation feedback. The feedback from preschool staff was mostly positive. All respondents reported that they planned to continue to

Table 2. Baseline characteristics and celeriac intake of children who were retained in the study to test the effectiveness of vegetable storybook and sensory play on intake of an unfamiliar vegetable (celeriac), and those lost to follow-up[a]

Characteristic	Data analyzed	Lost to follow-up	Test of group differences	*P* value
	←———*n*———→			
Sex, girl/boy	119/148	38/32	χ^2=2.28	0.084
	←———*mean±standard error*———→			
Age, mo	38.9±0.5	38.4±0.9	F[c]=0.43	0.512
Food fussiness (CEBQ[b])	2.8±0.1	2.7±0.1	F[c]=0.27	0.601
Celeriac baseline intake, g	3.9±0.5	2.4±1.2	F[c]=0.92	0.338

[a]There were no differences observed in baseline characteristics and celeriac intake of children who were retained in the study and those who were lost to follow-up.
[b]CEBQ=Child Eating Behaviour Questionnaire.
[c]Analysis of variance.

read the storybook in their preschools after the study and recommended using vegetable storybooks to increase vegetable intake in children. Staff noticed that children were more enthusiastic to taste the vegetable if they had experienced sensory play. Staff rated their overall experience as more positive in the two congruent conditions than in the incongruent conditions.

All respondents confirmed that it would be feasible to deliver interventions such as storybooks and sensory play in preschools. However, staff noted that resources to support the storybook and sensory play, such as other vegetable stories; puppets; food spiralizers; and extra vegetables for play would help to implement these activities in preschool. Staff suggestions for making improvements to the study included offering a variety of vegetables and additional opportunities to taste the target vegetable.

DISCUSSION

To our knowledge, this is the first cluster randomized trial investigating the effects of a storybook combined with non-taste sensory play on intake of an unfamiliar vegetable in preschool children aged 2 to 5 years. The findings from the present study partially supported the primary hypothesis that providing experience of an unfamiliar vegetable (celeriac) through an illustrated storybook together with sensory play would increase intake of that vegetable compared to a similar intervention using a different vegetable. For the full sample of children, storybook congruency increased the likelihood of children eating some celeriac. The congruent storybook combined with congruent sensory play increased the likelihood of eating celeriac more than the other conditions, but had no effect on the change in amount consumed. This suggests that the congruency of a storybook is important for encouraging children to try a novel vegetable, but multiple repetitions of the story over 10 days were not effective in promoting increased intake as measured immediately after the intervention. In addition, two sessions of sensory play with the unfamiliar vegetable encouraged the children to try eating it, but did not lead them to eat a greater amount compared to children in the other conditions. For the subgroup of children who ate no celeriac at baseline, exposure to the congruent storybook increased the likelihood of the children eating some celeriac. Surprisingly, sensory play with either the congruent or the incongruent vegetable also increased the likelihood of eating some celeriac.

Children who received the congruent storybook and sensory play improved in their recognition of the unfamiliar vegetable, but there was no change for children in the incongruent conditions. The best outcomes for likelihood to eat and recognition were observed when congruency of the storybook was combined with congruent sensory play. Although the intervention did not differentially affect the amount the children ate, it did increase the probability of eating some celeriac, and this could be a means to get children to consume vegetables in order to increase intake further via repeated exposures.[14-16]

Previous studies have shown that vegetable story/picture books increase willingness to taste vegetables in toddlers.[21-24] The present study confirms that congruency is important in using a storybook approach. In addition, the present study demonstrates that sensory play with either vegetable encouraged intake of celeriac in children categorized as non-eaters. Previous studies have also found some generalization from playing with a specific vegetable to greater acceptance of other vegetables not included in the sensory activity.[25,37] There are several possible explanations for this, including that sensory play offers the opportunity for children to explore the vegetables using all senses (eg, Sapere taste education[27]). Through this type of exploration, children become familiar with the appearance, smell, feel, and taste of a particular vegetable, which extends to other vegetables through reduced fear of novelty. Another possible explanation is through "unitization," a feature of perceptual learning in which learning about a new object is facilitated by the fusion of pre-existing and shared features of that object.[38] Thus, sensory play with one vegetable with particular sensory features (rough exterior, cold to the touch, earthy smell) facilitates learning about other vegetables. In the present study, both vegetables are root vegetables sharing some features but differing in color, odor, and flavor. Another explanation for this might be a priming effect, that is, exposing children to food cues in the environment stimulates their desire to consume this or other related foods, similar to food consumption observed in children after television advertisements.[39]

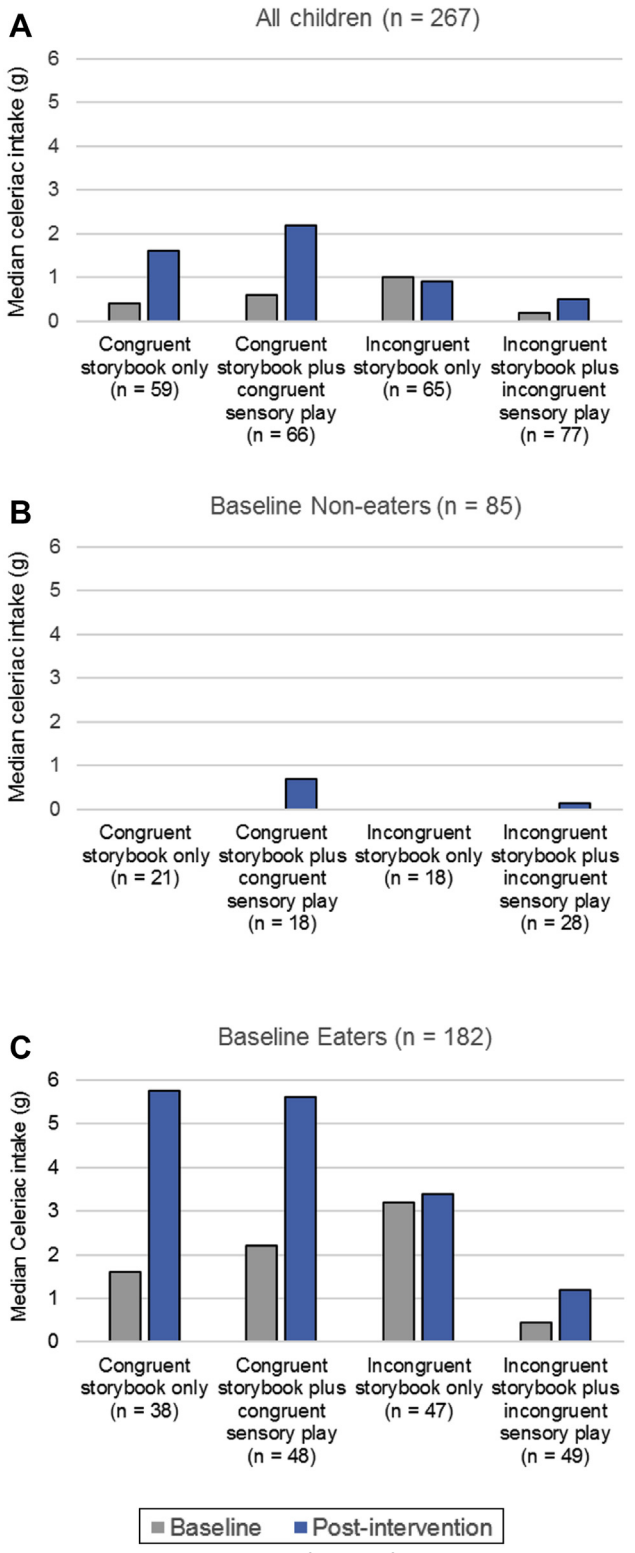

Figure 4. Median intake (g) of the unfamiliar vegetable (celeriac) at baseline and post-intervention by condition for (A) all children (n=267) then divided by eater category: (B) baseline non-eaters (0 g intake; n=85), (C) baseline eaters (>0 g; n=182). The number of children in each condition is given below the bars.

Just learning about vegetables either by storybook or sensory play may not necessarily bridge the "knowledge-behavior gap." According to a systematic research review, a study by Witt and colleagues,[40] which included sensory play within a nutrition education intervention had a greater effect size for vegetable consumption than nine other educational interventions.[10] Embedding sensory activity within educational programs in preschools may enhance children's willingness to try new vegetables and may present another step on the way to familiarization.

To date, taste-exposure interventions have been reported to be most successful for increasing vegetable intake.[10,41] However, children often refuse foods before tasting, as demonstrated in this study by the high number of non-eaters. Repeated exposure is contingent on the child's willingness to taste the food, which is required for establishing food liking.[18,42] Therefore storybooks and sensory play constitute first steps toward achieving repeated exposure. A study by Owen and colleagues[21] used targeted picture books before tasting sessions and found this facilitated tasting of disliked foods. Children assigned to the storybook and taste exposure condition liked and ate more of the target vegetable than those just receiving taste exposure. Also, storybooks were associated with smaller increases in neophobia and food fussiness over the course of the study, suggesting that familiarization through the storybook provided additional benefits over taste exposure alone.

In the future, longitudinal research should investigate specific benefits of storybooks and sensory play alongside repeated taste exposure on vegetable intake. The effects of taste exposure are limited to the target foods,[43] however, combining vegetable storybooks and sensory play with taste exposure may have a synergistic effect to increase acceptance of other vegetables.

Strengths and Limitations

The strengths of this study include randomization, concealing condition allocations between clusters, reduced selection bias at the individual level, ecological validity, objective data collection, and a good sample size to ensure sufficient power. However, results should be considered in the context of some limitations. First, as many children were eating a small amount at baseline and post-intervention, there was a problem of skewness in data, therefore, analyses were performed in two separate stages to address this problem. Second, the short time frame of the study may have limited effects on intake because larger effects on intake are observed with 10 exposures over 10 weeks,[10] but this study was conducted in a more compressed time frame. Finally, there was no control group because all children received a storybook. This means that the independent effect of the storybook on intake compared to mere exposure cannot be determined. A cluster design was implemented and this was taken into account in the analysis, however, preschool staff varied in the extent to which they engaged the children and in their enthusiasm for the storybook and sensory tasks. Therefore, in the future, a greater number of clusters should be recruited to account for this inconsistency. More emphasis could be placed on how the

Table 3. Proportion of preschool children in each intake category by intervention condition in a study investigating the effects of storybook and sensory play on intake of an unfamiliar vegetable (celeriac)[a]

Variable	Congruent[b] storybook only	Congruent[b] storybook plus congruent sensory play	Incongruent[c] storybook only	Incongruent[c] storybook plus incongruent sensory play
All children	←	*n (%)*		→
Baseline[d]				
Non-eaters	21 (36)	18 (27)	18 (28)	28 (36)
Eaters	38 (64)	48 (73)	47 (72)	49 (64)
Post-intervention[d]				
Non-eaters	14 (24)	7 (11)	15 (23)	27 (35)
Eaters	45 (76)	59 (89)	50 (77)	50 (65)
Baseline non-eaters subgroup only				
Post-intervention[e]				
Non-eaters	12 (57)	4 (22)	12 (67)	13 (46)
Eaters	9 (43)	14 (78)	6 (33)	15 (54)

[a]Children were categorized (n) according to their baseline and post-intervention celeriac intake.
[b]Celeriac was the congruent vegetable.
[c]Carrot was the incongruent vegetable.
[d]Children were categorized as non-eaters (0 g intake) and eaters (>0 g intake) based on their baseline celeriac intake.
[e]Children were categorized as non-eaters (0 g intake) and eaters (>0 g intake) based on their post-intervention celeriac intake.

storybook and sensory tasks should be delivered using a video demonstration to minimize variability in delivery. Also, future intervention studies could collect systematic, evaluative feedback from preschool staff, as this would give a more complete perspective on the experience of delivering the intervention. Overall, more research is needed to understand use of sensory play in the preschool and at home, especially with food-fussy children, and how effects

Table 4. Proportion of children in each intake category reported by the 2×2 factorial parallel design[a] in a trial testing the effectiveness of vegetable storybook and sensory play on intake of an unfamiliar vegetable (celeriac)

Variable	Congruent[b] storybook	Incongruent[c] storybook	Storybook only	Storybook plus sensory play
All children	←	*n (%)*		→
Baseline[d]				
Non-eaters	39 (31)	46 (32)	39 (31)	46 (32)
Eaters	86 (69)	96 (68)	85 (69)	97 (68)
Post-intervention[e]				
Non-eaters	21 (17)	42 (30)	29 (23)	34 (24)
Eaters	104 (83)	100 (70)	95 (77)	109 (76)
Baseline non-eaters subgroup only				
Post-intervention[e]				
Non-eaters	16 (41)	25 (54)	24 (62)	17 (37)
Eaters	23 (59)	21 (46)	15 (38)	29 (63)

[a]Categorization of children (n) according to baseline celeriac intake and by post-intervention celeriac intake. The distribution of children by eating category at baseline was similar across conditions. At post-intervention percentage of non-eaters was lower in the congruent book conditions compared to incongruent book conditions. For children who were non-eaters at the baseline, sensory play with either vegetable (alongside storybook) was more effective for increasing intake of the unfamiliar vegetable than storybooks alone.
[b]Celeriac as the congruent vegetable.
[c]Carrot as the incongruent vegetable.
[d]Children categorized as non-eaters (0 g intake), and eaters (>0 g intake) based on baseline celeriac intake.
[e]Children categorized as non-eaters (0 g intake), and eaters (>0 g intake) based on post-intervention celeriac intake.

Table 5. Process evaluation from 22 preschool staff[a] by condition to indicate suitability, user engagement, integration, challenges, and effectiveness of a storybook and sensory play intervention[b]

Variable	Congruent[c] storybook only	Congruent[c] storybook plus congruent sensory play	Incongruent[d] storybook only	Incongruent[d] storybook plus incongruent sensory play	Overall
Study was interesting	4.0	4.4	3.2	3.8	3.8
Study was not a hassle to deliver	4.0	4.0	3.1	4.3	3.9
Able to integrate study requirements into curriculum	4.0	3.8	4.0	3.8	3.9
Children were engaged during the story time	4.2	4.4	4.7	4.5	4.5
Recommend vegetable stories to increase vegetable intake	4.0	4.4	4.0	4.3	4.2
Will continue to read the story	4.2	4.6	4.3	4.7	4.5
Children were engaged during the sensory activity	NA[e]	4.6	NA	4.7	4.6
Recommend sensory activity to increase vegetable intake	NA	4.6	NA	4.5	4.5
Noticed change in knowledge of celeriac	3.6	4.6	2.3	2.5	3.2
Noticed change in knowledge of other story vegetables	3.0	4.2	3.2	3.5	3.5
Children engaged and enthusiastic during tasting session	3.6	4.0	3.3	4.0	3.7
Noticed change in intake of celeriac from pre-intake to post-intake	3.6	3.6	2.7	2.5	3.0
Overall experience[b]	8.0	9.6	7.5	7.0	8.0

[a]The response rate was 100%. Staff from 22 classrooms within 12 preschools completed the evaluation survey.
[b]Mean ratings are presented. Higher scores indicate a more positive experience. Evaluation questions were mostly rated on a 5-point Likert scale ranging from 1=strongly disagree to 5=strongly agree, except for the question on "overall experience of participation," for which a 10-point Likert scale ranging from 1=extremely negative to 10=extremely positive was used.
[c]Celeriac was the congruent vegetable.
[d]Carrot was the incongruent vegetable.
[e]NA=not applicable.

of sensory play can be enhanced when combined with other successful strategies, such as repeated taste exposure and reward.

CONCLUSIONS AND IMPLICATIONS

In conclusion, congruent storybooks read to children increased the likelihood of the children eating an unfamiliar vegetable. The congruent storybook combined with congruent sensory play further increased the likelihood of the children eating and recognizing celeriac. Among non-eaters, sensory play with vegetables (alongside a storybook) also increased the likelihood of the children eating some of the celeriac, regardless of the congruency of the vegetable used, indicating sensory play with any vegetable may increase children's willingness to eat a different unfamiliar vegetable. These findings could be incorporated into nutrition education programs to increase vegetable intake and recognition of unfamiliar vegetables in preschool children.

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STATEMENT OF POTENTIAL CONFLICT OF INTEREST

No potential conflict of interest was reported by the authors.

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AUTHOR CONTRIBUTIONS

C. Nekitsing, P. Blundell-Birtill, and M. M. Hetherington formulated the research questions and designed the study and were responsible for study oversight. C. Nekitsing conducted the research. A. Fildes assisted with data analysis. C. Nekitsing and P. Blundell-Birtill performed the statistical analysis. C. Nekitsing drafted the manuscript and all authors contributed to this. All authors read and approved the final manuscript.