Appetite 113 (2017) 84–90

Contents lists available at ScienceDirect

Appetite

journal homepage: www.elsevier.com/locate/appet

Play with your food! Sensory play is associated with tasting of fruits and vegetables in preschool children

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ARTICLE INFO

Article history:
Received 16 September 2016
Received in revised form
6 January 2017
Accepted 3 February 2017
Available online 12 February 2017

Keywords:
Fruit and vegetable
Sensory
Exposure
Child
Games

ABSTRACT

The objective of the current study was to ascertain whether taking part in a sensory play activity with real fruits and vegetables (FV) can encourage tasting in preschool children, compared to a non-food activity or visual exposure to the activity. Three to four year old pre-school children (N = 62) were recruited from three preschool nursery classes from a school in Northamptonshire, UK. A between participants experimental study was conducted with each class assigned to one of three conditions; sensory FV play, sensory non-food play and visual FV exposure. Parental report of several baseline variables were taken; child baseline liking of the foods used in the study, parental and child FV consumption (portions/day), child neophobia and child tactile sensitivity. Outcome measures were the number of fruits and vegetables tasted in a post experiment taste test which featured (n = 5) or did not feature (n = 3) in the task. Analyses of covariance controlling for food neophobia and baseline liking of foods, showed that after the activity children in the sensory FV play condition tried more FV than both children in the non-food sensory play task ($p < 0.001$) and children in the visual FV exposure task ($p < 0.001$). This was true not only for five foods used in the activity ($p < 0.001$), but also three foods that were not used in the activity ($p < 0.05$). Sensory play activities using fruits and vegetables may encourage FV tasting in preschool children more than non food play or visual exposure alone. Long term intervention studies need to be carried out to see if these effects can be sustained over time.

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1. Introduction

Many children do not consume the recommended daily intake of fruit and vegetables (FV) which are a good source of vitamins and minerals (World Health Organisation, 2003) and have been found in multiple epidemiological studies to be associated with a lower risk of chronic health conditions (Dauchet, Amouyel, Hercberg et al., 2006). It is estimated that only 16% of pre-school children in the UK eat the recommended daily allowance of five portions of FV, (Health Survey for England, 2008) and fruits and vegetables are the most commonly rejected food groups in this age group (Cooke, Wardle, & Gibson, 2003; Russell & Worsely, 2008). Research has found that both pre-school and home environments can improve young children's FV consumption through repeated and frequent tasting known as taste exposure (Caton et al., 2012; Parmer, Salisbury-Glennon, Shannon et al., 2009; Holley, Haycraft, & Farrow, 2015). It has long been believed that tasting is the most important means to establishing FV preference, and children have to taste foods in order to make the unfamiliar familiar (Birch et al., 1987).

There is a developmental trajectory of the number of tasting occasions (exposures) needed to establish preference (Sullivan & Birch, 1994), with young infants showing a preference after fewer exposures in comparison to older children from 2 years onwards (Howard et al., 2012; Maier, Chabanet, Schaal et al., 2007; Sullivan & Birch, 1990). Child refusal of new foods however is often translated by caregivers as a genuine dislike for the foods which prevents them from carrying out the requisite number of exposures (Campbell & Crawford, 2001; Skinner et al., 2002). In addition actually getting children to taste, and therefore be exposed to, novel foods can be challenging, as young children will reject on sight rather than taste (Dovey et al., 2012). As most healthy eating interventions rely on taste exposure, coupled with other proven strategies such as modelling and rewards (Holley et al., 2015; Horne et al., 2011), it is important to strike a balance between

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http://dx.doi.org/10.1016/j.appet.2017.02.003
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encouragement to taste and prompting/pressure to eat, which can have a detrimental effect on tasting (Osborne & Forestell, 2012).

Recently it has been suggested that interventions should add an element of non-taste sensory exposure, to encourage familiarisation with the sensory properties of fruits and vegetables (Dazeley, Houston-Price, & Hill, 2012). Some intervention studies have looked at activities, that can be carried out prior to tasting, to examine whether these can encourage children to overcome their natural neophobic reaction (e.g. Witt & Dunn, 2012). Some studies have focussed on sensory education, in 'Classes de Gout' where children are educated about evaluating the sensory taste properties of food (Mustonen & Tuorila, 2010; Reverdy et al., 2008). These studies, whilst successful, have been aimed at older children who can understand the terminology and format of sensory education sessions. Recent interventions, looking at multisensory educational tasks in preschool children, such as exploring the insides of fruits, have found some increases in fruit and vegetable acceptance (Dazeley & Houston-Price, 2015; Hoppu et al., 2015). Other interventions, such as 'Color me Healthy' which have used imaginative physical games (for example pretending to climb a mountain, make a camp and then making a vegetable stew), and have been more successful in increasing consumption, perhaps because they have a greater element of fun and reward built into the intervention (Witt & Dunn, 2012). Although these intervention studies have been successful in increasing tasting and preference for foods, it is unclear what aspects of these multifaceted interventions are responsible for the observed improvements.

Some recent behavioural studies have attempted to isolate aspects of sensory exposure, and have found that children's enjoyment ratings of the feel of non-food substances (jelly and mashed potatoes; Coulthard & Thakker, 2015) and a range of food andnon-food substances (e.g. Hair gel, cookie dough, shrimp crackers, sand paper; Nederkoorn, Jansen & Havermans, 2015) is associated with lower food neophobia. Although these studies were correlational, they suggest that there is an association between enjoyment of touch and food acceptance, and both authors suggest that expected mouth-feel, the sensation of foods in the mouth, may be the reason behind this association. Some experiments looking at sensory rating of FV in school children have examined which sensory domain is the most important factor in determining food rejection and acceptance, have found developmental differences, with younger children rejecting according to visual cues and older children using olfactory cues when deciding to try or reject a novel fruit or vegetable (Dovey et al., 2012; Coulthard, Palfreyman & Morizet, 2016b). Intervention studies with visual exposure to FV using picture books, has been found to successfully increase tasting and liking of FV (Heath, Houston-Price, & Kennedy, 2011; Houston-Price, Butler, & Shiba, 2009; Osborne & Forestell, 2012).

The main purpose of the present study was to examine whether a creative multi-sensory play game using fruits and vegetables carried out prior to a tasting session, can influence tasting behaviour in young children. Children who take part in a sensory play task, where they create pictures using real FV stimuli (Sensory FV play), will be more likely to try FV afterwards, than children who take part in a sensory play task with non-food items (sensory non-food play) or watching the researcher carry out the FV play task (visual FV exposure). In addition it is expected that children in the visual exposure condition where they are exposed to real FV, will try more FV than those in a tactile non-food play condition.

2. Experimental methods

2.1. Participants

One hundred and twenty recruitment letters and questionnaire packs were distributed to all the parents of preschool children from three different classes who attended a local government-run nursery in Northamptonshire, UK. Sixty-eight parents returned the baseline questionnaires, of which six were not present on the day or were excluded as they had known food allergies. The final sample comprised sixty-two children (27 boys and 35 girls) with a mean age of 3.36 ($\pm$0.52) years. Parents' ages ranged from 22 to 45 years of age, with a mean age of 34.20 ($\pm$6.25) years. The majority of the sample ($n = 61$) were White-British, with the exception of one child and parent who were of Chinese origin. The study was approved by De Montfort University Ethics Committee and all parents gave their informed consent prior to data collection. A G power a priori analysis indicated that for moderate to large effect sizes, a sample of 17–40 participants in each condition was needed.

2.2. Design

The study was a cross-sectional, between-participants experimental design. The dependent variable was the number of foods tasted by the children after the experimental task. The factor was the condition the child was in (FV play task, non-food play control vs visual exposure control). Each class was randomly allocated to one condition by picking numbers from a hat. This clustered randomisation was adopted to prevent children from being exposed to the other experimental conditions. There were several covariates which were examined, including child food neophobia, parent & child FV daily portions, child tactile sensitivity and child baseline liking of experimental foods.

3. Materials and methods

3.1. Parental report measures

All parents were given a questionnaire pack, along with information about the study, a week before the experimental tasks were carried out. Children were included in the study if their parents filled in the questionnaires and gave informed consent for their child to be included.

3.1.1. Child neophobia food scale (CFNS)

The CFNS (Pliner & Hobden, 1992) adapted by Wardle, Carnell, and Cooke (2005) measures willingness to eat novel foods and is viewed as reliable and valid (Ritchey et al., 2003; Cooke et al., 2004). The scale consists of six statements, for example '*My child is afraid to try food they have never had before*' rated using a 4 point response scale from *strongly agree* (4) to *strongly disagree* (1*)*, with overall scores ranging from 6 to 24 with a higher score indicating higher levels of food neophobia. This score was referred to as child food neophobia.

3.1.2. Tactile sensitivity (Sensory Profile)

Child's tactile sensitivity, was measured using twelve items from a subsection of Dunn's Sensory Profile (Dunn, 1997) which has been used with both non-clinical and clinical samples of children (Miller-Kuhaneck et al., 2007; Tomchek & Dunn, 2007) and in previous studies relating to food acceptance (Coulthard & Blissett, 2009). An example of a statement is, *"My child becomes irritated by shoes or socks".* Statements were rated by parents using a 5 point Likert scale, from *always* (5) to *never* (1) with the items scored in this study so that higher scores indicated high sensitivity to tactile stimuli. Cronbach's Alpha for the scale in the current study was 0.69, which was considered acceptable.

3.1.3. Fruit & vegetable portions (child and parent)

The amount of FV consumed by parents and children was measured using estimated recall which has been used in other studies (Coulthard & Blissett, 2009) and has been validated against 4-day diaries (Bingham et al., 1994). There was one scale for the mother to fill in about herself, and then a second scale to complete in relation to her childs typical consumption, Mothers were asked to report how many portions of fruits, and then vegetables (not potatoes) 1) they consumed in a typical week and then 2) their child consumed in a typical week. The size of a portion was clearly defined in the instructions, based on UK guidelines (NHS 5 day, 2013). For both the parent score and the child score the fruit and vegetable consumption scores were summed and divided by 7, to give a daily FV score. These are referred to as child FV portion and parent FV portion.

3.1.4. Experimental study

In each condition, children were tested in a single half day session at a similar time shortly after they had been dropped off. Children were seated at a table in a group of four-five, and were asked to rate their liking of eight pictures of foods used in the taste tests. Then they carried out the sensory task (sensory FV play, sensory non-food play, visual FV exposure). The children then left the table, and the researcher cleaned away all the play materials. Finally, one at a time, children were invited to sit down individually for the tasting task.

3.1.5. Baseline liking for the experimental foods

The eight foods used in study as fruits and vegetables were used in the taste tests were *carrots, banana, cucumber, tomatoes, blueberries pomegranate, kiwi,* and *melon*. A sheet of paper with colour 5 cm & 5 cm images of the eight foods were presented to each child with a three point smiley face rating scale, and the child was asked to indicate how much they liked each of the foods (Carraway-Stage et al., 2014). The photographs were taken from stock images, and represented a prototype photograph of each of the stimuli foods. Baseline liking of these foods was calculated by indicated whether the child liked (score = 1) or didn't like/ was neutral towards (score = 0) the food. Each child obtained a score of 0–8 for baseline liking of the experimental foods.

3.1.6. Experimental tasks

Materials: Eleven FVs were used in the sensory FV play and visual exposure conditions. The prepared FV for the play activity was placed on the table in individual transparent containers and included *broccoli, carrots, spinach, banana, radishes, green beans, oranges, lemons, cucumber, tomatoes,* and *blueberries*. The materials for the non-food sensory play were items placed in bowls in the middle of the table were glues and eleven substances such as pompoms, sequins, foam shapes, feathers, lollipop sticks, glitter and pipe cleaners.

Procedure: The duration of the task and researcher carrying out the task was consistent across all three conditions. The content of the tasks differed slightly between the three conditions. In two of the tasks (FV play and non-food play) which involved children creating a sensory picture, the format of the task was identical. Children were asked to sit in a group of 5 children with the researcher at an activity table. In order to give the children some ideas for their creation there were printed images from the *Very Hungry Caterpillar* (Carle, 1969), which is a classic and well known children's' book in the UK which features FV. The researcher named the materials (FV or non-food), and then talked about making some pictures on the plates provided. Children were encouraged to feel comfortable and engage in conversation during the task if they wished to. Each child was given an 8″ paper plate on which to create their picture. Each child created their pictures for 5–10 min alongside the researcher who modelled a picture of the *Very Hungry Caterpillar* on their own plate. They had no implements to pick up the substances, so in order to create a picture they had to pick up the items with their fingers. Children were encouraged to squash or reshape the foods if they wanted to. They were not encouraged to taste the foods in the FV sensory play task, as the primary object of the task was non taste exposure. They were given the opportunity to wash their hands after the experimental task.

In the *Visual Exposure to FV* condition, the groups of children watched the researcher make a picture of the *Very Hungry Caterpillar* with the fruits and vegetables on a paper plate. The format of the task was similar except the researcher modelled the creation of the picture, and the children were not given an opportunity to complete the task themselves.

3.1.7. Post activity taste test

Eight foods were given to children to taste in the post activity taste test, and were chosen on the basis that they could be eaten raw. Altogether there were was one root vegetable, two salad vegetables and five fruits. Five of the fruits and vegetables had been used in the FV play and visual exposure task (*carrots, banana, cucumber, tomatoes, blueberries*) and three fruits that had not featured in any of the conditions *(pomegranate, kiwi,* and *melon*). Foods were prepared in a conventional format, depending on the food in question. Banana, carrot, tomatoes and kiwi were presented sliced, melon was presented cubed, blueberries were presented whole and pomegranates were presented as individual seeds.

Once the children had finished making a picture (or watching the researcher make the picture), they were tested individually and asked "whether they wanted to taste some fruits and vegetables". The children were given a napkin and offered the eight FV to taste. Whether or not the child tasted the fruit was recorded on the taste record sheet. Each food was given a score of 1 if the child placed it in their mouths, regardless of whether it was swallowed. The number of foods tasted was given an overall score (range 0–8), a score for foods featured in conditions 1 and 3 (range 0–5) and a score for foods tasted not featured in any condition (range 0–3).

4. Data analysis

All data analyses were carried out on IBM SPSS version 22 (IBM, 2013). Normality tests indicated that the variables were normally distributed across the sample, so parametric statistics were carried out on the data. Pearson's correlations were carried out to examine relationships between the baseline variables (tactile sensitivity, food neophobia, FV consumption) and the tasting measures. One way ANOVAs were carried out to examine differences in the baseline variables of demographics (age and sex), food consumption variables (FV portions, FV range, child food neophobia, baseline liking of foods in taste activity) and child tactile sensitivity, between the three conditions. Brown Forsyth corrections were used if Levene's test indicated homogeneity of variance could not be assumed ($p < 0.05$). Bonferroni post hoc tests were carried out to examine the mean differences between the different conditions. Three analyses of covariance were carried out, as it was found that tasting foods in the final condition was associated with child food neophobia scores and baseline liking of foods in the experimental conditions, therefore these two variables were entered as covariates into the equation. The three dependent variables were the total number of foods tasted ($n = 8$), the foods tasted featured in the experimental task ($n = 5$) and the foods tasted not featured in the experimental tasks ($n = 3$). Custom interaction models were carried out and it was found that the assumptions of linearity were met in all three interactions ($p > 0.05$). Finally Chi Square analyses were carried out to examine whether there were differences in tasting between the groups according to the food stimuli (blueberry, pomegranate, melon, kiwi, banana, carrot, tomatoes, cucumber).

5. Results

The descriptive statistics for the baseline characteristics of the sample are given in Table 1. The average portions of FV consumed by both parent and child participants in the study was found to be similar to government statistical reports (Health Survey for England, 2008), with 24% of children and 18% of parents in this study achieving five portions of fruit and vegetables a day. The mean daily consumption rates of 3.4 portions/d for children and 3.0 portions/d for parents was broadly in line with the mean UK average of 2.8 portions/d, (Health Survey for England, 2008) and consumption rates found in other studies (Coulthard & Blissett, 2009; Wardle et al., 2005).

There was no difference in baseline measures of tactile sensitivity, food neophobia, parental FV consumption, child FV consumption, and baseline liking between the three conditions (Table 2). Pearson product moment correlations carried out to look at associations between the tasting variables and parental report measures, found that food neophobia was negatively associated with tasting whilst baseline liking of foods was positively associated with tasting (Table 3).

Pearson's product moment correlations were carried out to examine associations between baseline measures of food acceptance and child tactile processing (see Table 4). It was found that there were negative associations with FV consumption variables (child and parent) and child neophobia. Tactile sensitivity was positively associated with food neophobia and negatively associated baseline FV liking, and also with the daily FV portions consumed by both parents and children.

Three analyses of covariance (ANCOVA) were carried out to examine whether there were differences in of the number of foods tasted in particular 1) all foods, 2) foods that featured in the task and 3) foods that didn't feature in the task (see Table 5). Child food neophobia and baseline FV liking were entered into the analyses as covariates as they were found to be associated with the number of foods tasted in correlation analyses (see Table 3). After controlling for the covariates there was a difference between the number of foods tasted across the three groups, F (2, 57) = 12.08, p=0.001, $\eta_p^2 = 0.29$, which indicated a large effect size. Bonferroni post hoc analyses indicated that children in the sensory play FV condition tasted more FV than children in the sensory play non-food condition ($p < 0.001$) or the visual FV exposure condition ($p < 0.001$). There was no difference in tasting of all foods between children in the sensory play non-food condition and children in the visual FV exposure condition.

For the foods tasted which featured in the experimental task, there was a difference between tasting across the three groups, F(2, 57) = 13.78, $p < 0.001$, $\eta_p^2 = 0.32$ which indicated a large effect size. Post hoc Bonferroni analyses indicated that children in the sensory play FV condition tasted more FV than children in the sensory play non-food condition ($p < 0.05$) or the visual FV exposure condition ($p < 0.001$). There was no difference in tasting of featured foods between children in the sensory play non-food condition and children in the visual FV exposure condition.

For the foods tasted that were not featured in the experimental task there was a difference between tasting across the three groups, F (2, 57) = 4.17, $p < 0.05$, $\eta_p^2 = 0.13$, which indicated a moderate effect size. Post hoc Bonferroni analyses indicated that children in the sensory play FV condition tasted more FV than children in the sensory play non-food condition ($p < 0.05$) or the visual FV exposure condition ($p < 0.05$). There was no difference in tasting of non-featured foods between children in the sensory play non-food condition and children in the visual FV exposure condition.

Examination of the pattern of foods tasted across the experimental groups showed that some foods were accepted more readily than others (see Table 6). In particular, children in the sensory FV play group tasted more cucumber, blueberries, pomegranate and kiwi. There were no significant differences in tasting for banana, carrots, tomatoes and melon.

6. Discussion

The main aim of this study was to examine whether pre-school children who took part in a multisensory play activity with fruits and vegetables, without pressure to eat or to try the foods, would taste more FV than children engaged in a non-food activity or those visually exposed to the activity. It was found that children in the sensory FV play condition tried significantly more fruits and vegetables post activity than children in the other two conditions, even after controlling for the covariates of child food neophobia and baseline liking of featured foods. In addition this effect was found for both FV featured in the tasks, and FV not featured in the tasks. A possible explanation for these findings is that children in the sensory play group had the time to familiarise themselves and interact with FV, which would suggest that exposure does not have to be based on taste alone, but familiarity can be increased through exposure to the non-taste sensory properties of fruits and vegetables. It was apparent in our study, that the largest benefits were seen for foods that are less familiar, such as pomegranate and kiwi. This finding supports previous studies which found an association between tactile play and food neophobia (Coulthard & Sahota, 2016; Coulthard & Thakker, 2015). It also supports the findings of intervention studies that have included an element of sensory play such as the ‘Color me healthy’ intervention programme (Witt & Dunn, 2012) as well as sensory education programmes aimed at preschool (Dazeley & Houston-Price, 2015) and older children (Mustonen & Tuorila, 2010).

The main difference between previous intervention research and the present study was the adoption of an experimental design to isolate one task that could featue a multi-sensory intervention, and examine its efficacy in encouraging tasting in the short term. Although many previous studies have examined sensory education in preschool children (Dazeley & Houston-Price, 2015; Hoppu et al., 2015) we decided to examine fun, game based activities which don't have an explicit educational component (Witt & Dunn, 2012). We concluded that taking part in a sensory activity with FV actually

Table 1
Parent and child demographic and FV consumption characteristics in a sample of 3–4 year old children (N = 62).

	Parent characteristics	Child characteristics
Sex	62 females (mothers)	35 females, 27 males
Mean age ± standard deviation	34.20 ± 6.25 years	3.36 ± 0.52 years
Mean daily fruit and vegetable portions± standard deviation	3.05 ± 1.78 portions	3.43 ± 1.78 portions
Range daily fruit and vegetable portions	0.28–7 portions	0.43–7 portions
% achieving 5 portions of fruits and vegetables a day	18%	24%
Ethnicity	98% White British (n = 61)2% (n = 1) Chinese	

Table 2
Differences in baseline variables across the three play conditions (sensory FV play, sensory non-food play and visual FV exposure) in a sample of 3–4 year old children (N = 62).

	FV Sensory play (n = 21)	non FV play (n = 20)	FV visual exposure (n = 21)	F, p value
	Mean (SD)	Mean (SD)	Mean (SD)	
Child Age (years)	3.43 (0.51)	3.45 (0.61)	3.24 (0.44)	1.17, p = 0.32
Parental age (years)	33.45 (5.17)	34.65 (7.14)	34.46 (6.50)	0.21,p = 0.81
Parental FV (portion/day)	3.13 (2.09)	3.72 (1.35)	3.30 (1.52)	0.54, p = 0.59
Child FV (portion/day)	3.33 (1.92)	3.18 (1.84)	3.65 (1.71)	0.60, p = 0.55
Tactile sensitivity	15.43 (4.51)	17.35 (4.48)	14.80 (4.90)	1.75. p = 0.18
Child food neophobia	14.57 (3.71)	14.90 (4.47)	13.72 (4.65)	0.46, p = 0.64
Baseline FV liking	3.62 (1.69)	3.85 (1.50)	3.76 (1.55)	0.11, p = 0.89

Table 3
Pearson's product moment correlation coefficients to show associations between child tasting behaviour and parental report variables in a sample of 3–4 year old children (N = 62).

	Total foods tasted	Foods tasted (featured in task)	Foods tasted (not featured in task)
Child Food Neophobia	−0.45**	−0.27**	−0.34**
Tactile Sensitivity	−0.14	−0.06	−0.16
Child FV portion	0.08	−0.03	0.04
Parent FV portion	−0.00	0.09	0.14
Baseline FV liking	0.33**	0.10	0.26**

*p < 0 0.05,**p < 0.01.

Table 4
Pearson's product moment correlation coefficients to show associations between child tactile sensitivity, child food neophobia and FV acceptance in a sample of 3–4 year old children (N = 62).

	Child food neophobia	Tactile sensitivity	Child FV portion	Parent FV portion	Child FV range
Tactile Sensitivity	0.41**				
Child FV portion	−0.40**	−0.21*			
Parent FV portion	−0.40**	−0.25*	0.84**		
Baseline FV liking	−0.44**	−0.25*	0.56**	0.48**	0.66**

*p < 0.05, **p < 0.001.

Table 5
Differences in child FV tasting between the experimental conditions in a sample of 3–4 year old children (N = 62), after controlling for food neophobia and baseline liking of foods.

	FV Sensory play (n = 21)	Control (non FV play) (n = 20)	Control 2 (FV visual exposure) (n = 21)
	Mean (SD)	Mean (SD)	Mean (SD)
Number of activity foods tasted (n = 5[a])	3.43 (1.33)	2.30 (1.13)*	1.76 (0.83)**
Number of foods not in activity tasted (n = 3[b])	1.43 (1.21)	0.60 (0.88)*	0.67 (1.06)*
Total number of foods tasted (n = 8[a,b])	4.71 (2.24)	2.75 (1.89)**	2.43 (1.43)**

*p < 0.05, **p < 0.001(differences in tasting compared to sensory FV play condition).
[a] Carrots, banana, cucumber, tomatoes, blueberries.
[b] *Pomegranate, kiwi, melon.*

Table 6
Differences in the percentages of each food tasted between the experimental conditions in a sample of 3–4 year old children (N = 62).

	FV Sensory play (n = 21)	Control (non FV play) (n = 20)	Control 2(FV visual exposure) (n = 21)	χ^2
Banana	95%	90%	81%	2.19
Carrots	86%	65%	62%	3.39
Cucumber	62%	35%	24%	6.68*
Blueberries	81%	25%	10%	24.92**
Tomatoes	19%	15%	0%	4.21
Pomegranate	57%	15%	19%	10.57*
Melon	38%	30%	19%	1.86
Kiwi	48%	15%	29%	5.19*

*p < 0.05, **p < 0.001.

encourages tasting and that that tasks using real FV are more effective than general sensory play tasks (Coulthard & Sahota, 2016) or visual exposure to FV (Heath et al., 2011). It was expected that visual exposure alone, in watching the researcher carry out the tasks with the foods, would increase tasting relative to the non-food sensory task. Previous research has proposed that visual exposure can be an important contributor to tasting (Houston-Price et al., 2009) and visual modelling of consumption is widely used in interventions to increase FV consumption in children (Horne et al., 2011). However we did not find that visual exposure to real FV was more effective in encouraging tasting than tactile play with non-food substances. This discrepancy may be explained by the fact that previous research examining visual exposure, has used repeated exposure to the fruits and vegetables, for example parents reading a picture book multiple times (Houston-Price et al.), which more accurately mirrors classic repeated exposure studies (Sullivan & Birch, 1994; Maier et al., 2007). Our study was the first to use a single session multisensory task, which may indicate that using multisensory exposure may lead to more rapid acceptance than visual exposure. It could be argued, however, that children in our sample in the visual exposure condition may have felt they missed out by watching the task rather than being an agent within the task. Future studies should compare games using visual images of foods vs real foods, to ascertain whether visual exposure alone can effectively encourage tasting in children.

Previous research has found associations with tactile sensory processing and food neophobia, in particular that children who are more sensitive to tactile sensation in the environment are more reluctant to eat novel foods both as babies (Coulthard, Fogel, & Harris, 2016a), as children (Coulthard & Thakker, 2015) and as adults (Coulthard & Sahota, 2016). The association between the dislike of the feel of substances on the skin, in particular on the hands in messy play activities and reluctance to eat novel foods, may be due to dislike of the 'mouth feel' of unfamiliar foods (Smith, Roux, Naidoo, & Venter, 2005). Although an association has consistently been found between food neophobia and sensory sensitivity, often there has been no association between the amount of FV consumed in daily portions and tactile processing (Coulthard & Blissett, 2009). In the present sample tactile sensitivity was negatively associated with baseline FV liking and the portions of FV consumed by parents and children. It may be in younger samples, tactile sensitivity is more strongly associated with aversion to the feel of fruits and vegetables leading to reduced consumption. As children get older, they may eat greater amounts of a few 'safe' fruits and vegetables if they are food neophobic. Interestingly, parental reports of tactile sensitivity were not associated with the number of foods tasted after the sensory tasks. This could be because some of the foods featured in the tasks were relatively familiar foods, and if we had used foods with more 'challenging' textures such as passion fruit and lychee, we may have found an association between baseline tactile processing and FV tasting. More research is needed to examine the relationship between the tactile processing and food acceptance, especially in relation to food texture, in terms the variety and amount of food consumed, across the lifespan.

There is a considerable amount of research that suggests prompting or pressure to try novel or disliked foods can have an adverse effect on willingness to taste and liking (Osborne & Forestell, 2012). This is one of the problems of interventions to increase healthy eating, most of which rely on tasting as the main goal of any task (Ahern et al., 2014) and it may explain why so many taste exposures are needed to overcome the neophobic food response in children aged 2–4 years (Sullivan & Birch, 1994). In our sensory play conditions, there was no mention of tasting the foods; the goal of the task was to engage with the food, and create something from it. This is true non taste sensory exposure, and it may be that these types of activities may actually increase the likelihood of tasting by getting children to associate the foods themselves with pleasurable, reward based activities. It would be interesting to examine non-taste sensory exposure in combination with other effective strategies such as modelling and rewards (Holley et al., 2015).

There are many strengths of the present research, in particular the experimental design and the variety of food items used. There were several limitations, however, which need to be acknowledged. Firstly, there were more fruits than vegetables featured in the tasks and taste tests, especially in the category of foods not featured in the tasks. This was mainly because we needed foods that could be eaten raw. However future research should look at fruits and vegetables separately, as there is a drive for researchers and health professionals to view them as distinct but related food groups (Osborne & Forestell, 2012). Secondly, although we had a child-report of whether they liked the foods in the study prior to the tasks, we did not include a pre taste measure of the foods. It is possible that some children are more likely to taste foods in front of a relatively unknown researcher, so a true baseline measure of tasting, preferably carried out a week prior to the sensory play tasks, would be essential in future research. Thirdly, a second researcher should have rated the tasting task, although we felt that the overt behaviour of tasting vs not tasting the fruit or vegetable was felt to be a relatively straightforward behaviour to judge. Lastly, we didn't have a separate control group that neither took part in a sensory activity or a visual exposure activity. Previous research has found these two activities to be associated with tasting (Coulthard & Thakker, 2015; Heath et al., 2011). Although this research suggests that such activities are less effective than the use of real FV in activities, it could be that visual exposure and non-food tactile play may also encourage tasting and food acceptance. In addition, experiments of this nature, which are based on short term outcomes, do not measure the efficacy of these tasks over time. Although the experimental design ensures that it cannot simply be the attention of taking part in a game with a novel adult that encourages compliance in tasting, it could be that the relative novelty of being encouraged to play with food (as opposed to more familiar messy non-food play tasks), may have added an element of novelty which may diminish over repeated sessions. It could be argued that anything which encourages initial exposure in this particularly difficult age group will facilitate the adoption of healthful FV consumption. Future research should track the success of these strategies repeated over time, compared to strategies which vary in novelty.

This is one of the first studies to experimentally examine whether playing a creative non taste exposure activity with children, can encourage tasting of featured foods in a subsequent taste session. Any activity which encourages initial tasting in this age group, who are known to be often reluctant to taste fruits and vegetables, may potentially be used to facilitate taste exposure and eventual liking. We have found that creating pictures with fruits and vegetables was more effective in encouraging tasting than watching the researcher create a picture or playing a non-food sensory play game. This finding suggests that introducing food in a play environment which allows children to see, handle and smell foods, developing non taste sensory familiarisation, should be embedded in strategies to increase FV consumption. Further research should aim to examine the relative contribution of the different sensory aspects of multisensory programmes, to examine what aspects of touching, smelling, seeing and hearing foods leads to greater acceptance. It is apparent that, in the future, interventions need to be constructed that embed these activities in school and preschool environments, to ascertain whether such tasks will lead to increases in the portions and variety of FV consumed by children.

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