



Research report

Increasing pre-school children's consumption of fruit and vegetables. A modelling and rewards intervention

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ARTICLE INFO

Article history:

Received 3 July 2010

Received in revised form 28 October 2010

Accepted 19 November 2010

Available online 26 November 2010

Keywords:

Pre-school children

Fruit

Vegetables

Positive modelling

Rewards

Exposure

Consumption

Generalisation

Intrinsic motivation

ABSTRACT

Using a repeated measures design, in a nursery setting, a modelling and rewards intervention targeted preschool children's consumption of 8 fruit and 8 vegetables (presented as 4 different food sets, each comprising 2 fruit and 2 vegetables). During the 16-day Baseline 1, and subsequent baselines, the children received a different food set daily, first at snacktime and again at lunchtime; consumption of these foods was not rewarded. In the 32-day fruit intervention phase, Food Set 2 and Food Set 3 were presented on alternate days; rewards were presented only at snacktime, and only for consumption of the fruit components. Following Baseline 2 and Baseline 3, the intervention targeted snack consumption of the vegetable components of Food Sets 1 and 4. Finally, Baseline 4, and 6-month Follow up were conducted. The interventions produced large and significant increases in target fruit and vegetable consumption with smaller, but significant, increases for the paired, opposite category, non-target foods. Immediately after each intervention, increases based on within-category generalisation were also evident. All increases generalised strongly to the no-rewards lunchtime context. Contrary to theories predicting response decrements, the increases in preschoolers' fruit and vegetable consumption were maintained at Follow up, six months after rewards were withdrawn.

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Introduction

The past few decades have seen a steep rise in child obesity in the United States (U.S.) and throughout Europe (Baker, Olson, & Sorenson, 2007; Birch & Fisher, 1998; Broyles et al., 2010; Lobstein & Baur, 2005), with one third of U.S. children becoming overweight or obese by the time they are 2 years old (and even higher levels among children from low income families). This excess adiposity, in turn, has taken its toll on children's physical and psychological health (Drake, Smith, Betts, Crowne, & Shield, 2002; Freedman, Dietz, Srinivasan, & Berenson, 1999; Freedman, Mei, Srinivasan, Berenson, & Dietz, 2007; Strauss, 2000; Wojcicki & Heyman, 2010; Zimetkin, Zoon, Klein, & Munson, 2004). Given also that child obesity and its health impacts track into adulthood (Clarke & Lauer, 1993; Freedman, Khan, Dietz, Srinivasan, & Berenson, 2001; Freedman et al., 2008; Renehan, Tyson, Egger, Heller, & Zwahlen, 2008; Serdula et al., 1993; Whitaker, Wright, Pepe, Seidel, & Dietz, 1997), preventing obesity from an early age has become a major public health priority in the developed world.

In order to deal effectively with this widespread obesity epidemic, it is important to identify its determinants. Recently, twin studies in children have reported high heritability estimates for Body Mass Index (BMI; in kg/m²), waist circumference, and satiety responsiveness (e.g., Wardle, Carnell, Haworth, Farrow, et al., 2008; Wardle, Carnell, Haworth, & Plomin, 2008). Clearly, some individuals are more biologically predisposed to obesity than others. However, genes in human populations cannot have changed over the past few decades; what *has* changed over this time period is the kind of environment with which those genes interact. Throughout the developed world, the everyday environment now provides a surfeit of inexpensive, energy dense foods that consumers are biologically predisposed to choose to eat at the expense of less caloric options (Ostan, Poljsak, Simcic, & Tijssens, 2010). At the same time, lifestyles have become increasingly sedentary. To redress the resulting imbalance between energy intake and expenditure, in the shorter term, we need to change what we choose to consume from the current "obesogenic" environment, but in the longer term we must also change the environment itself so as to support healthier eating and increased activity.

There is now good evidence that increasing fruit and vegetable intake has associated health benefits (Antova et al., 2003; Gaziano et al., 1995; Gillman, 1996; Joshipura et al., 2001; Key, Thorogood, Appleby, & Burr, 1996; Maynard, Gunnell, Emmett, Frankel, &

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Davey-Smith, 2003; Steinmetz & Potter, 1996). In addition, consuming more fruit and vegetables at mealtime can protect against excess gain in weight (Epstein et al., 2000; McCrory et al., 1999; Rolls, Roe, & Meengs, 2004). However, children's consumption of fruit and vegetables is far lower than the recommended five portions per day (e.g., Baranowski et al., 2000; Dennison, Rockwell, & Baker, 1998; Department of Health, 2000; Guenther, Dodd, Reedy, & Krebs-Smith, 2006; Heimendinger & Van Duhn, 1995; Krebs-Smith et al., 1996; Nicklas et al., 2004; U.S. Department of Health and Human Services, 1996). Indeed, recent surveys of children's food preferences show that vegetables are the least-liked food category (Cashdan, 1998; Perez-Rodrigo, Ribas, Serra-Majem, & Aranceta, 2003; Skinner, Caruth, Bounds, & Ziegler, 2002), and dislike of fruit and vegetables is particularly apparent in the 20–30% of young children with high scores on a "neophobia" scale (Cooke, Wardle, & Gibson, 2003; Wardle & Cooke, 2008). Given that young children show little inclination to spend time eating these foods, it is important to find ways to encourage them to do so.

Over the past 30 years, research on children's food preferences has identified several variables that can influence their liking and consumption of different foods. According to the social learning account of Bandura (1977), modelling by significant others can be very influential in establishing behaviour change. Children are likely to imitate a particular behaviour when they (i) like or admire the person performing it, (ii) see that person being rewarded for that behaviour, (iii) are themselves rewarded for imitating the behaviour, and (iv) see it modelled by more than one person. A number of studies have found that children's acceptance of new foods can be increased when they see their parents (Harper & Sanders, 1975; Jansen & Tenney, 2001), teachers (Hendy & Raudenbusch, 2000), other adults (Addesi, Galloway, Visalberghi, & Birch, 2005; Harper & Sanders, 1975) and other children (Birch, 1980; Duncker, 1938; Greenhalgh et al., 2009; Marinho, 1942) modelling consumption of those foods. However, peers are more effective models than adults (Hendy & Raudenbusch, 2000) and children are more likely to align their own food preferences with peers who are older than themselves (Birch, 1980; Duncker, 1938), or have higher social status (Marinho, 1942). Although peers can influence acceptance of new foods, they are even more effective at establishing food rejection that, in 3–4 year olds, is difficult to reverse (Greenhalgh et al., 2009). It is important therefore to ensure that children are not exposed to social environments where rejection of fruit and vegetables is the norm.

Another influential variable is taste exposure. There is evidence that repeated tasting of novel foods results in their increased consumption, and verbal preference for them (Birch, Gunder, Grimm-Thomas, & Laing, 1998; Birch & Marlin, 1982; Birch, McPhee, Shoba, Pirok, & Steinberg, 1987; Sullivan & Birch, 1990). However, in order to achieve the requisite exposures, particularly in children old enough to make their own food selections, some form of encouragement to taste the new foods is required. Indeed, some more recent studies, that set out to measure the effects of taste exposure, used just such incentives. For example, Wardle, Herrera, Cooke, and Gibson (2003) report the effects of exposure to red pepper on children's liking and consumption of that food. However, in the first session of their procedure, the experimenter first ate a piece of the red pepper before inviting the child to do likewise and thereafter to eat as many pieces as he or she liked. This is actually a *modelling and exposure* condition, so does not provide a measure of exposure alone, particularly given that, in all subsequent "exposure" sessions, the very same experimenter invited the child to consume the target food before administering a liking test (and see Greenhalgh et al., 2009, p. 7, for a discussion of the implicit demand characteristics of such procedures). In a second study, Wardle, Cooke, et al. (2003) and Wardle, Herrera,

et al. (2003) investigated the effects of parent-led exposure to green pepper on children's liking and consumption of that vegetable. This intervention was conducted in each child's home and parents were required to offer their child a taste of the target vegetable on 14 consecutive days. In order to encourage tasting, the experimenters suggested that parents try a bit of the target food themselves then say to the child "Now I've done it, can you do it too?" Once again, there is a strong, repeated modelling component embedded in this "exposure" procedure. Yet another incentive for tasting was provided in this study: each child was also given a "face" sticker to record in a colourful "vegetable" diary their liking of the target food each day. In other words, the children were provided with a tangible reward each day contingent on tasting the green pepper. In sum, in the latter study, Wardle and colleagues actually presented a modelling and rewards intervention rather than simple exposure to the target food. That the role of rewards in their procedure has received little prominence is most likely due to concerns that using rewards to encourage consumption of foods may be counterproductive. For example, it has been argued that providing a reward for performing a task will undermine intrinsic motivation for performing that task in the future (e.g., see Deci, Koestner, & Ryan, 1999). However, Deci et al. (1999) themselves point out that, "the undermining phenomenon has always been specified as applying only to interesting tasks insofar as with boring tasks there is little or no intrinsic motivation to undermine" (p. 633). This is a crucial distinction for the rewards decrement debate as it has been applied to fruit and vegetable consumption: the evidence to date suggests that most children and many adults in the developed world have very low interest in eating fruit and vegetables, in which case there is little or no intrinsic motivation to diminish.

This leaves us with the pragmatic aim of encouraging children to eat more fruit and vegetables. An effective and economic way of increasing children's consumption of these foods is to target this behaviour in the school setting. One whole-school intervention that has been very successful at increasing the fruit and vegetable consumption of primary school aged children is the Food Dudes Healthy Eating programme (Horne et al., 2009; Horne, Lowe, Bowdery, & Egerton, 1998; Horne, Lowe, Fleming, & Dowey, 1995; Horne, Tapper, et al., 2004; Lowe, Dowey, & Horne, 1998; Lowe, Horne, Tapper, Bowdery, & Egerton, 2004). This intervention is based on three core principles derived from the literature on the determinants of children's food preferences: (i) role-modelling; (ii) rewards; and (iii) repeated tasting. Role modelling of the target behaviour is provided by a video series showing four charismatic child characters, the Food Dudes, in battle with General Junk and his Junk Punks, whose aim is to deprive children of healthy foods. The combination of video peer modelling and the reward contingency motivates the children to overcome their reluctance to taste the fruit and vegetables and, through repeated tasting, develop a lasting liking of these foods. Extrinsic rewards are gradually withdrawn as children come to find the flavours of these foods *intrinsically* rewarding, and as their peers' support for eating fruit and vegetables increases. All studies conducted to date show large and lasting increases in children's fruit and vegetables consumption, which generalise to the home setting. Increases were even greater in children who ate little fruit and vegetables from the outset; poorest eaters in the control schools, however, showed no change. Particularly interesting, given a substantial rising trend in snack consumption over the past 25 years (St-Onge, Keller, & Heymsfield, 2003) is that unhealthy snacks were displaced from children's diets as their fruit and vegetable intake increased (and see Epstein et al., 2000; Horne et al., 1998; Lowe, Horne, Hardman & Pears, 2009; Presti, Zaffanella, Milani, & Moderato,

Table 1

The 16 experimental foods and the configuration of each food set presented in the study.

Food set	Fruit pair	Vegetables pair
1	Dragon fruit + mango (non-target fruit)	Green beans + baby sweetcorn (target vegetables)
2	Kiwi fruit + pawpaw (target fruit)	Baby carrots + courgette (non-target vegetables)
3	Star fruit + sharon fruit (target fruit)	Cucumber + yam (non-target vegetables)
4	Water melon + prune (non-target fruit)	Swede + mangetout (target vegetables)

2009). All studies conducted so far, whether in the home or in schools, found that repeated exposure to fruit and vegetables had no effect on their consumption.

The present study investigated whether an intervention based on modelling and rewards would be effective at increasing fruit and vegetable consumption in a cohort of 20 2–4 year olds in a day care nursery setting.

Method

Ethical approval

Permission to conduct the study was granted by the School of Psychology Ethics Committee, Bangor University.

Participants

Participants at the start were 8 boys and 12 girls, with a mean age of 34 months (range: 24–52 months), who attended the Bangor University Day Care Nursery. Twelve children attended on 5 days, two on 4 days, two on 3 days and four on 2 days per week, and parents gave written consent for their child's participation in the study. Six of the 5-day participants, three boys and three girls, left the nursery after Baseline 4 (see section "Method").

Foods

Sixteen foods, 8 fruit and 8 vegetables, were selected for presentation throughout the study. These were foods consumed at >50% by no more than half the participants (median 6, range 0–10 over the 16 foods) when presented in the pre-baseline phase. Foods that met this criterion were randomly assigned to four food sets, each consisting of two fruit and two vegetables, that remained fixed for the duration of the study. Table 1 shows the fruit and vegetable pairs in each food set, and which food pairs served as target (intervention) foods and which as non-target foods (controls).

All foods were fresh and cut into 4 standardised, uniform-sized pieces; average portion weight per food was 25 g. They were served raw, except for carrot, courgette, green beans, mange-tout, swede, and yam, which were first cooked in a microwave until "al dente". Foods were presented in 20 mm × 80 mm stainless steel, twin portion, serving dishes, each permanently labelled with the name of the corresponding participant. To facilitate children's discrimination of the target food category during the intervention phases (see section "Procedure"), a red sticker, denoting fruit, was placed next to one compartment of the serving dish and a blue sticker, denoting vegetables, was placed adjacent to the other compartment.

Intervention videos

The intervention videos were produced in-house. They featured two animated characters, Jess and Jarvis, and two target foods per video. In each video, Jess and Jarvis named each featured target food and also gave its category label (i.e., "fruit" or "vegetable"). They enthusiastically modelled eating each food, described the

reward contingencies that applied for eating the target foods, and urged the children to "eat them up to be big and strong". The videos were approximately 5.5 min long and were shown on a Panasonic 27 in. television and video recorder in the nursery playroom.

Supporting letters

Prior to presenting the intervention video each day, a nursery nurse read out a letter from Jess and Jarvis, to remind the children of the target foods of the day, give general feedback on their consumption on the previous day, and promise rewards for all children who ate their fruit/vegetables when next presented at snacktime. A second letter was read out at the end of snacktime to reiterate the reward criteria.

Rewards

Three types of rewards were available during the study. Children who ate 1–3 pieces of a target food each received a rectangular wall chart sticker, which they stuck onto the rungs of ladders (on a large wall chart) leading to a treasure chest (fixed to the wall) containing a group prize. Children who ate 4–7 pieces received a wall chart sticker *and* a Jess and Jarvis "Fruit Eater" or "Veggie Tot" adhesive badge to wear. Children who ate all 8 pieces received the stickers *and* a brick from a toy construction kit, purchased for each child. The toy's box, bearing an illustration of the toy that could be constructed, was given to the child with the first brick earned.

Measures

The dependent variable was the amount of each fruit and vegetable consumed daily by each child, at snacktime and at lunchtime, throughout all phases of the study. Consumption was defined as food being taken into the mouth and ingested; food placed in the mouth and spat out did not qualify. The amount consumed of the four pieces of each food was calculated by visual estimation of residual food on a five-point scale (i.e., 0; 1; 2; 3; or 4) to the nearest piece. Two researchers independently rated the residues in each food container. Inter observer agreement was 100% in all experimental phases. Floors were checked at the end of each session to ensure that plate waste constituted a reliable basis for measurement of children's consumption of the fruit and vegetables.

Experimental design

A repeated measures design was employed (see Table 2). Short-term carryover effects of the intervention were estimated by comparing consumption in each of four food groups (target fruit; non-target fruit; target vegetables; and non-target vegetables; and see Table 1) in the baseline that immediately preceded each intervention with that in the immediately following baseline. Relative change per food group was also measured within each phase. Effects of contingent reward as opposed to mere association with reward were estimated by comparing consumption levels of target food versus paired non-target food during each intervention

Table 2
Phase duration and schedule of food presentation per phase throughout the study.

Phase	Duration	Snack presentations	Lunch presentations
Baseline 1	16 days	All 4 Food Sets	All 4 Food Sets
Fruit intervention	30 days	Food Sets 2 and 3	Food Sets 2 and 3
Baseline 2	16 days	All 4 Food Sets	All 4 Food Sets
Christmas break (four weeks)			
Baseline 3	16 days	All 4 Food Sets	All 4 Food Sets
Vegetable intervention	30 days	Food Sets 1 and 4	Food Sets 1 and 4
Baseline 4	16 days	All 4 Food Sets	All 4 Food Sets
Six-month Follow up	16 days	All 4 Food Sets	All 4 Food Sets

phase. Changes in consumption within and between phases for all foods at lunchtime measured generalisation of the snacktime interventions to the no-reward lunch context. Longer-term behaviour change was measured at 6-month Follow up, conducted under baseline conditions.

Procedure

Training specific names and category names for each food

Given that the first intervention targeted the category fruit, but not vegetables, and the second intervention targeted vegetables, but not fruit, it was important to ensure that the participants could discriminate fruit from vegetables from the outset. Each morning, the nursery nurse pointed to each cut and whole food in turn, giving the specific name and category name as she did so (e.g., "This is a [piece of/whole] carrot and it's a vegetable") and then asked the children to repeat the names after her. Next, she repeated the procedure, but with prompts for the names (i.e., "What's this?"). The children's responses were corrected when necessary.

Baseline phases

A different food set was presented at snacktime each day, on a fixed 4-day cycle, until each set had been presented four times; every day, the food set scheduled for snacktime was presented again at lunchtime.

Snacktime. Participants were seated at a table in the playroom supervised by their designated nursery nurse who presented each of them with a drink of milk and the scheduled set of experimental foods in a stainless steel dish. Nursery nurses first asked each participant to indicate which foods were fruit and which were vegetables and then invited the children to eat their snack food. The nurses were asked to respond in a neutral way to questions and comments from the participants about the experimental foods. When staff indicated that all the children had finished eating, the dishes were removed, for consumption to be assessed.

Lunchtime. The children were seated at tables in the dining room and the stainless steel dishes containing the experimental foods were presented for 5 min between the main course and dessert before they were removed for assessment. Consumption was neither encouraged nor discouraged. Food consumption at lunch was never subjected to the modelling and rewards intervention.

Intervention phases

On the first intervention day, a nursery nurse read out a letter from Jess and Jarvis that explained the experimental procedures. On subsequent days, the letters from Jess and Jarvis contained general feedback on the previous day's consumption, along with encouragement to continue eating fruit/vegetables. The children then watched the scheduled fruit/vegetable video featuring the

target foods presented that day. At the end of the film the children were seated at their tables and snack procedures were as described for the baseline phases.

After snacktime, the rewards were delivered by a nursery nurse in the playroom. The children who received toy bricks put them with the others in their toy kit box and those with wall stickers lined up to stick them on the ladder of the wall chart. Whenever the stickers reached the top of the ladders, a group prize was delivered.

Lunchtime procedures were the same as in Baseline.

Follow up

The foods were presented on the plates routinely used in the nursery. No categorisation procedures took place and no intervention procedures were implemented. Follow up measures of fruit and vegetable consumption at both snack and lunch were taken over the final 16 days under baseline conditions.

Results

In order to address the main hypotheses, children's food consumption data in each phase were combined into the following 4 food groups (see Table 1): *target fruit* (fruit components of Food Sets 2 and 3); *non-target fruit* (fruit components of Food Sets 1 and 4); *target vegetables* (vegetable components of Food Sets 1 and 4); *non-target vegetables* (vegetable components of Food Sets 2 and 3). Given the large number of phases (see Table 2), and the expectation that baselines would rise following each intervention, comparisons were restricted to planned contrasts between and within phases. The data met the requirements for parametric analyses. Preliminary analyses found no significant correlations between consumption at any time point and either age at start (Pearson's $p > .05$), or number of days attending nursery per week ($p > .05$). Twenty children provided data from Baseline 1 through to the end of Baseline 4, and 14 of those continued to 6-month Follow up. In all phases, the last two data points per food were used to calculate means. An alpha level of .05 was applied throughout, with Bonferroni corrections where appropriate.

Baseline 1

Fig. 1 shows mean consumption per food group per phase. An ANOVA verified that there were no significant differences in snacktime consumption between these four food groups at Baseline 1 (means: target fruit, 24.9%; non-target fruit, 24.4%; target vegetables, 25.2%; and non-target vegetables, 25.5%; $F_{(3,57)} = .015$, $p = .997$).

Fruit intervention

Snacktime fruit intervention effects

Relative to Baseline 1, there was a significant increase in consumption during the fruit intervention both for target fruit (from 24.9% to 76.5%; $t_{(19)} = 8.26$; $p < .001$; Cohen's $d = 2.21$), and the paired non-target vegetables (25.5–45.1%; $t_{(19)} = 3.75$; $p = .001$; $d = .91$). The difference between target fruit and non-target vegetables was significant ($t_{(19)} = 5.44$; $p < .001$; $d = 1.24$).

Snacktime intervention effects at Baseline 2

Relative to Baseline 1, there was a significant increase in consumption in Baseline 2 of target fruit (24.9–68.0%, showing good carryover from the intervention; $t_{(19)} = 6.76$; $p < .001$; $d = 1.78$), non-target fruit (24.4–45.0%; $t_{(19)} = 3.43$; $p = .003$; $d = .78$), and non-target vegetables (25.5–41.4%; $t_{(19)} = 2.89$; $p = .009$; $d = .72$), but not target vegetables ($t_{(19)} = 1.47$; $p = .160$).

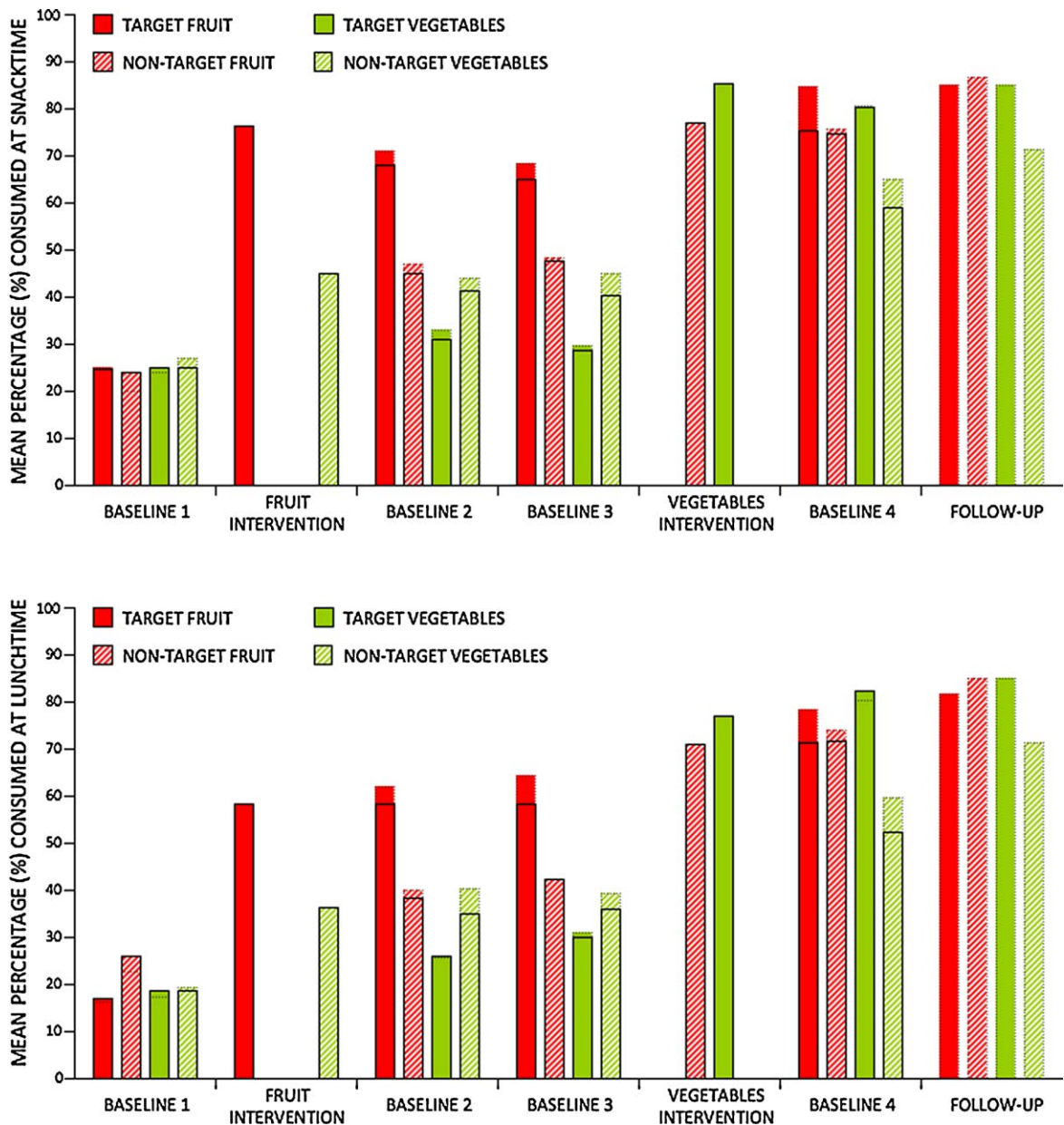


Fig. 1. Mean percentages of experimental foods consumed at snacktime (top graph) and at lunchtime (bottom graph), across seven stages of the study. Red bars show children's consumption of fruit, and green bars of vegetables; target foods are represented by bars of solid colour, and non-target foods by striped bars. The averages for all 20 participants are represented by bars outlined with unbroken lines, and the averages for the 14 participants who completed the last stage (Follow up) are outlined with dashed lines.

Food group differences at Baseline 2. ANOVA found a significant difference between food groups at Baseline 2 ($F_{(3,57)} = 8.246$, $p < .001$). With a Bonferroni correction ($p < .008$) applied, post hoc *t* tests found significant differences between target fruit and non-target fruit ($t_{(19)} = 3.20$; $p = .005$; $d = .77$); target fruit and target vegetables ($t_{(19)} = 4.75$; $p < .001$; $d = 1.21$); and target fruit and non-target vegetables ($t_{(19)} = 3.73$; $p = .001$; $d = .98$). There were no other significant differences between food groups (p ranged from .12 to .66).

Generalisation of the snacktime intervention to lunchtime

Fig. 1 (lower panel) shows consumption for each food group at lunchtime during the fruit intervention phase. ANOVA found no significant difference in lunchtime consumption between food groups at Baseline 1 ($F_{(3,57)} = .007$, $p = .936$).

Lunchtime consumption during the snacktime fruit intervention phase

Relative to Baseline 1, there was a significant increase in consumption during the fruit intervention both for target fruit (17.2–58.2%; $t_{(19)} = 6.16$; $p < .001$; $d = 1.62$), and non-target vegetables (18.9–36.6%; $t_{(19)} = 3.43$; $p = .003$; $d = .86$). The difference between target fruit and non-target vegetable consumption was significant ($t_{(19)} = 3.36$; $p = .003$; $d = .81$), and mirrors that found at snacktime.

Lunchtime consumption during Baseline 2

Relative to Baseline 1, there was a significant increase in consumption during Baseline 2 for target fruit (from 17.2% to 58.4%; $t_{(19)} = 6.30$; $p < .001$; $d = 1.63$), non-target fruit (25.0–38.4%; $t_{(19)} = 2.47$; $p = .02$; $d = .54$), target vegetables (18.8% to 26.3%; $t_{(19)} = 2.48$; $p = .02$; $d = .27$) and non-target vegetables (18.9–37.2%; $t_{(19)} = 3.63$; $p = .002$; $d = .93$).

Food group differences at Baseline 2. ANOVA found a significant difference in consumption between food groups at Baseline 2 ($F_{(3,57)} = 5.92$, $p = .001$). With a Bonferroni correction ($p < .008$) applied, post hoc t tests found significant differences between target fruit and target vegetables ($t_{(19)} = 3.92$; $p = .001$; $d = 1.06$), and target fruit and non-target vegetables ($t_{(19)} = 2.94$; $p = .008$; $d = .84$). There were no other significant differences between food groups (p ranged from .02 to .88).

Vegetable intervention

Baseline 3

Before the vegetable intervention could be administered, Baseline 3 determined whether the children's consumption of experimental foods had changed over a four-week Christmas break following Baseline 2. Fig. 1 (upper panel) shows no change in consumption either at snacktime or at lunchtime between Baseline 2 and Baseline 3. ANOVA found significant consumption differences between food groups at Baseline 3 ($F_{(3,57)} = 6.86$, $p = .001$). With a Bonferroni correction ($p < .008$) applied, post hoc t tests found significant differences between target fruit and target vegetables ($t_{(19)} = 3.93$; $p = .001$; $d = 1.07$); and target fruit and non-target vegetables ($t_{(19)} = 3.93$; $p = .001$; $d = .85$). There were no other between group differences (p ranged from .05 to .33).

Snacktime vegetable intervention effects

Relative to Baseline 3, there was a significant increase in consumption during the vegetable intervention for target vegetables (from 28.8% to 85.5%; $t_{(19)} = 7.09$; $p < .001$; $d = 1.73$), and non-target fruit (47.8–76.9%; $t_{(19)} = 5.93$; $p < .001$; $d = .97$). The difference between target vegetable consumption (85.5%) and non-target fruit consumption (76.9%) was not significant ($t_{(19)} = 1.03$; $p = .318$).

Snacktime intervention effects at Baseline 4

Relative to Baseline 3, there was a significant increase in consumption at Baseline 4 for target vegetables (from 28.8% to 80.7%; $t_{(19)} = 6.07$; $p < .001$; $d = 1.64$), non-target vegetables (40.2–58.9%; $t_{(19)} = 5.76$; $p < .001$; $d = .69$), target fruit (63.3–75.4%; $t_{(19)} = 2.76$; $p = .01$; $d = .40$), and non-target fruit (47.8–74.7%; $t_{(19)} = 5.36$; $p < .001$; $d = .88$).

Food group differences at Baseline 4. ANOVA found a significant difference between food groups ($F_{(3,57)} = 3.95$, $p = .010$) at Baseline 4. With a Bonferroni correction ($p < .008$) applied, post hoc t tests found a significant difference in consumption between target vegetables and non-target vegetables ($t_{(19)} = 3.37$; $p = .003$; $d = .70$). There were no other significant differences between food groups (p ranged from .03 to .43).

Generalisation of the snacktime intervention to lunchtime

Fig. 1 (lower panel) shows lunchtime consumption of each food group during the snacktime vegetable intervention phase. ANOVA found a significant difference in consumption between food groups ($F_{(3,57)} = 10.84$, $p = .004$) at Baseline 3. With a Bonferroni correction ($p < .008$) applied, post hoc t tests found a significant difference in consumption between target fruit and target vegetables ($t_{(19)} = 3.43$; $p = .003$; $d = .92$), and target fruit and non-target vegetables ($t_{(19)} = 3.58$; $p = .002$; $d = .85$). There were no other significant differences between food groups (p ranged from .014 to .41).

Lunchtime consumption during the snacktime vegetables intervention phase

Relative to Baseline 3, there was a significant increase in consumption at lunchtime during the snacktime intervention phase both for target vegetables (from 30.0% to 76.9%; $t_{(19)} = 5.98$;

$p < .001$; $d = 1.42$), and non-target fruit (42.5–71.3%; $t_{(19)} = 5.35$; $p < .001$; $d = .89$). There was no significant difference between target vegetable and non-target fruit consumption during the intervention ($t_{(19)} = .68$; $p = .503$).

Lunchtime consumption during Baseline 4

Relative to Baseline 3, there were significant increases in consumption during Baseline 4 for target vegetables (from 30.0% to 82.7%; $t_{(19)} = 6.74$; $p < .001$; $d = 1.73$), non-target vegetables (36.1–52.2%; $t_{(19)} = 3.33$; $p = .003$; $d = .68$), target fruit (58.1–71.3%; $t_{(19)} = 4.46$; $p < .001$; $d = .42$), and non-target fruit (42.5–71.9%; $t_{(19)} = 4.83$; $p < .001$; $d = .90$).

Food group differences at Baseline 4. ANOVA found a significant difference in consumption between food groups ($F_{(3,57)} = 5.88$, $p = .001$). With a Bonferroni correction ($p < .008$) applied, post hoc t tests found a significant difference between target vegetables and non-target vegetables ($t_{(19)} = 4.09$; $p = .001$; $d = 1.00$). There were no other differences in consumption between food groups (p ranged from .03 to .92).

Follow up

Follow up measures were taken under baseline conditions, six months after the end of Baseline 4. The long-term effects of the fruit and vegetable interventions were measured by comparing consumption at Follow up to that in Baseline 1 for the 14 remaining participants. Long-term maintenance of the intervention effects was calculated by comparing consumption at Baseline 4 with that at Follow up.

Snacktime consumption

Relative to Baseline 1, there were significant increases in consumption at Follow up for target fruit (from 25.3% to 85.1%; $t_{(13)} = 9.02$; $p < .001$; $d = 2.83$), non-target fruit (20.5–86.6%; $t_{(13)} = 10.47$; $p < .001$; $d = 3.52$), target vegetables (24.6–85.1%; $t_{(13)} = 8.09$; $p < .001$; $d = 2.59$), and non-target vegetables (27.23–71.4%; $t_{(13)} = 5.17$; $p < .001$; $d = 2.09$). Fig. 1 shows a rising trend from Baseline 4 to Follow up for the four food groups, but this did not reach significance (p ranged from .08 to .87). ANOVA found no significant differences between food groups at Follow up ($F_{(3,57)} = 2.69$, $p = .06$).

Generalisation to lunchtime

Relative to Baseline 1, there was a significant increase in consumption at Follow up for target fruit (from 16.5% to 81.7%; $t_{(13)} = 8.95$; $p < .001$; $d = 2.59$), non-target fruit (22.8–85.1%; $t_{(13)} = 9.91$; $p < .001$; $d = 2.87$), target vegetables (17.9–84.8%; $t_{(13)} = 8.12$; $p < .001$; $d = 2.68$), and non-target vegetables (19.6–71.4%; $t_{(13)} = 6.34$; $p < .001$; $d = 2.39$). The small rising trend from Baseline 4 to Follow up was not significant for any of the food groups (p ranged from .08 to .53). ANOVA found no significant differences between food groups at Follow up ($F_{(3,57)} = 1.76$, $p = .17$).

Individual foods

Fig. 2 shows snacktime (upper panel) and lunchtime (bottom panel) consumption of each target and non-target food when presented at Baseline 1, Baseline 4, and 6-month Follow up. Data for the 20 participants who completed procedures until the end of Baseline 4 are very similar to those for the 14 who completed all phases. Despite the large change in level for each food from Baseline 1 to Baseline 4, patterns of consumption within food groups are similar across these two time points. At Follow up, snacktime and lunchtime fruit consumption ranged from 70% to 100%, with star fruit (target), mango and water melon (non-target)

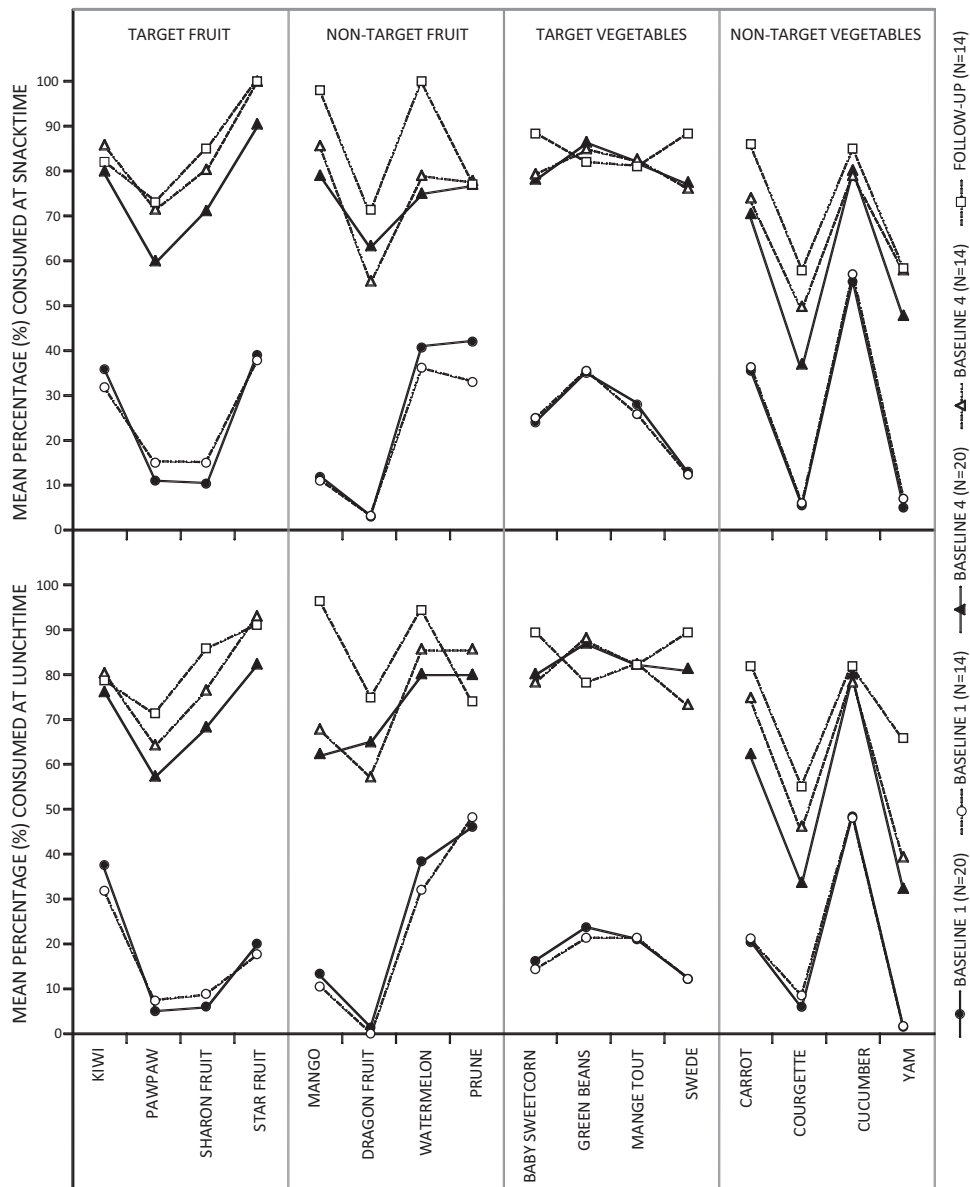


Fig. 2. Mean percentages of experimental foods consumed at snacktime (top graph) and at lunchtime (bottom graph) plotted for each named experimental fruit and vegetable, grouped across target and non-target foods. Children's consumption is plotted for Baseline 1 to Baseline 4 (black markers connected by unbroken lines) and separately averaged across (i) 20 children who participated from Baseline 1 to Baseline 4 (black markers connected by unbroken lines) and (ii) the 14 children who completed the last stage of the study (white markers connected by dashed lines).

eaten at or close to 100% and pawpaw (target), dragon fruit and prune (non-target) at the lower end of this consumption range. In both meal contexts, all target vegetables were consumed at between 80% and 90%; of the non-target vegetables, carrot and cucumber were consumed at the same level as the target vegetables, but consumption of courgette and yam was up to 20% lower.

Individual children and foods consumed

Fig. 3 shows for each child how many of the 8 fruit and 8 vegetables presented at snacktime (upper panel), and lunchtime (lower panel), were eaten (at or above 50%) by each child at Follow up. At both snacktime and lunchtime, the children ate a median of 8 fruit and 7 vegetables. There was no obvious tendency in either context for children to prefer the fruit to the vegetables. Only one child at Follow up appeared to be a fussy eater, but even she consistently ate 5 fruit and 2 vegetables at snacktime, and 3 fruit

and 2 vegetables at lunchtime. This child ate only 1 fruit and 1 vegetable in Baseline 1.

Discussion

The main aim of this study was to determine whether a modelling and rewards intervention could produce large and lasting increases in the fruit and vegetable consumption of 20 preschoolers in a day nursery setting.

Direct effects of the snacktime reward contingency

Of the 16 foods presented in the study, 4 fruit and 4 vegetables were targeted directly with the rewards intervention. In both the fruit intervention and the vegetable intervention there was a three-fold increase in consumption of these target foods and these increases were fully maintained at Follow up, more than six months after all rewards procedures were withdrawn. The

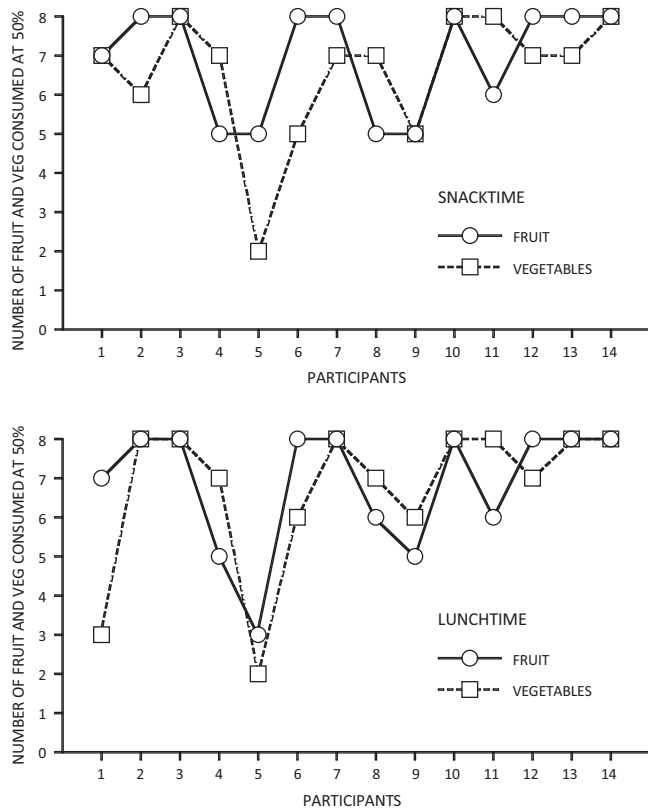


Fig. 3. The number of experimental foods that individual children consumed (at 50% or more) in Follow up, during snacktime (top graph) and at lunchtime (bottom graph), plotted for all experimental fruit (8; represented by circles) and vegetables (8; represented by squares).

modelling and rewards intervention proved to be a powerful means of producing lasting increases in young children's snacktime consumption of fruit and vegetables.

Association with the reward context

During the fruit intervention, the target fruit were presented with non-target vegetables, and in the vegetable intervention, the target vegetables were presented with non-target fruit, but consumption of the non-target foods was never rewarded. In the fruit intervention, consumption of the target fruit increased by 50% whereas the paired non-target vegetables increased by 20%. Likewise, in the vegetable intervention, consumption of the target vegetables increased by 52% whereas the paired non-target fruit increased by 30%. It appears that mere association with foods that feature in a reward contingency is sufficient to produce a moderate increase in consumption of the paired foods. However, it could also be argued that the increases in non-target food consumption resulted, at least partly, from the increased exposures they received during the intervention phases. As will be discussed below, there is good internal evidence in the study against this interpretation.

Within-category generalisation

Although non-target fruit were not presented at all during the fruit intervention, when once again presented in Baseline 2, consumption was found to be 20% higher than in Baseline 1. (There was no comparable increase, for target vegetables, which were also not presented during the fruit intervention.) Likewise, when the vegetable intervention was introduced, not only did target vegetable consumption increase, but afterwards, at Baseline 4,

consumption of non-target vegetables was found to be higher than in Baseline 3. How might this within-category generalisation have arisen? In the present procedure, the children were taught to name each food and to name the category ("fruit" or "vegetable") to which it belonged, and before the children ate their food in the intervention phases they were asked to produce these category names. Though not directly tested in the present study, it is possible that the observed within category generalisations were driven by the children's production of the category names "fruit" and "vegetables". This interpretation would be consistent with studies showing that naming is a powerful determinant of categorisation and novel behaviour in preschool children (Horne, Hughes, & Lowe, 2006; Horne & Lowe, 1996; Horne, Lowe, & Harris, 2007; Horne, Lowe, & Randle, 2004; Lowe, Horne, Harris, & Randle, 2002; Lowe, Horne, & Hughes, 2005).

By Follow up, non-target fruit consumption was close to ceiling levels and this increase was achieved in two kinds of generalisation steps: (i) a 20% increment via within-category generalisation after the intervention on target fruit, and (ii) a further 27% increase when paired with target vegetables during the vegetable intervention. Whereas the first increase in consumption did not seem to require any food exposures, the second change in level clearly derived from additional exposures in the context of rewards delivered for consumption of foods of the opposite category, namely target vegetables. A similar two-step pattern occurred in the case of non-target vegetables, except that the within-category generalisation increment occurred at Baseline 4, after the vegetable intervention.

Exposure effects

Before target vegetables were presented in the vegetable intervention, they had been presented up to 12 times at snack (four per baseline phase; see Fig. 1, upper panel), and another 12 times over the same time period at lunchtime (see Fig. 1, lower panel), making up to 24 presentations in total. Despite this large number of exposures, consumption of target vegetables increased by only 3.7% by Baseline 3. Clearly, exposure alone had little effect on consumption. However, when the reward contingency was applied to the target vegetables, consumption increased almost three-fold over a comparable number of rewarded exposures.

The absence of a pure exposure effect differs from the findings of Wardle, Cooke, et al. (2003) and Wardle, Herrera, et al. (2003) who reported that exposure alone resulted in a mean increase in primary school children's consumption of a low preference vegetable when each child, in a one-to-one context, was presented pieces of that vegetable over eight days by an experimenter. One explanation is that the results of their study are food-specific, that is, dependent on the one vegetable they presented. Certainly, it would be helpful if their study were to be repeated with a larger selection of moderately disliked vegetables before strong conclusions are drawn about the effectiveness of exposure alone on increasing consumption of previously refused vegetables.

Wardle, Cooke, et al. (2003) and Wardle, Herrera, et al. (2003) also found no significant difference between their "exposure" condition and their "rewards" condition: the effects of the latter appeared to be intermediate between those for the exposure and control conditions. However, this outcome may be the result of their extremely weak reward contingency: the children received one sticker irrespective of the number of pieces of the target food they consumed each day. It was also not established whether the stickers had any incentive value for their participants.

The findings of the present study are however consistent with studies that have employed the Food Dudes modelling and rewards intervention to target fruit and vegetable consumption in primary school children in a whole-school context. These studies found no

increase in fruit and vegetable consumption from the start to the end of the initial 12-day baselines, but rather a significant decrease over presentations. Consumption only increased when the modelling and rewards intervention was introduced, and these increases were well maintained at Follow up. The Horne, Lowe, and Randle (2004) and Horne, Tapper, et al. (2004) study included a matched control school to determine the longer-term effects of repeated presentations of fruit and vegetables alone from Baseline 1 to Follow up. Again, fruit and vegetable consumption showed a decrease at Follow up relative to Baseline.

Generalisation to lunchtime

Despite the fact that there were never any reward contingencies for consumption of any of the 16 foods presented in the lunchtime context during the present study, a comparison of the two panels of Fig. 1 shows clearly that the effects of the snacktime intervention generalised strongly to a different time of day and a different meal context consumption. As was the case for snacktime, at 6-month Follow up, there were large and significant increases in lunchtime consumption of the 16 foods relative to Baseline 1.

Non-target foods versus target foods

By the end of the vegetable intervention, the children had received an approximately equal number of presentations of all the foods. However, 8 target foods (4 fruit and 4 vegetables) participated in a direct reward contingency and the other 8 non-target foods (4 fruit and 4 vegetables) were simply presented with the target foods; reward delivery was not contingent on consumption of non-target foods. This may explain why consumption of non-target vegetables remained less than for target vegetables. At Follow up there is still a difference between target vegetable consumption at snacktime and lunchtime (85.1% and 84.9%, respectively) and non-target vegetable consumption (71.7% and 71.4%, respectively). This suggests that mere association with rewards is not sufficient to drive vegetable consumption to maximum levels. Nevertheless, the effect of association with reward-eligible foods is considerably stronger than mere exposure.

Part-timers versus full-timers

There were 12 full time and 8 part time attenders taking part from Baseline 1 to end of Baseline 4 and 6 full time and 8 part time attenders continued to Follow up. Full-time attenders received a median of 4, and part-timers received a median of 2 presentations of each food during each of the baselines. During the interventions, the full timers received a median of 12, and part-timers a median of 6 presentations of each of the target food sets. Remarkably, there was no significant difference between full timers and part timers in total mean consumption of the 4 food groups at snacktime, suggesting that as few as 6 exposures to the modelling and rewards interventions were sufficient to establish the large and lasting effects observed at Follow up.

Rising trend in consumption and reward decrement hypotheses

Inspection of Fig. 1 shows a slight rising trend in mean consumption of the foods from Baseline 4 to 6-month Follow up. This is strong evidence against any form of reward decrement hypothesis—not only does consumption show a large increase during each rewards intervention, but it also continues to rise thereafter indicating that by the end of Baseline 4, when all rewards were withdrawn, most of the children had acquired sufficient tastes of the foods to develop a lasting liking of them: extrinsic rewards were replaced entirely by the intrinsically

reinforcing properties of the foods, and it is the latter that maintained consumption after the end of the intervention. Indeed, this outcome is consistent with a recent meta-analysis of the effects of rewards given for performance of low interest tasks, which found that rewards increase free-choice intrinsic motivation on such tasks (Cameron, Bank, & Pierce, 2001; and see Reiss, 2005).

Individual foods

The discussion so far has focussed on mean consumption per food group. Fig. 2 shows how consumption of individual foods in each food group changed from Baseline 1 to Baseline 4 through to Follow up. In each food group, the pattern of preference across foods tended to persist as the level of consumption increased from Baseline 1 to Follow up, and no food proved intractable over the course of the study. There is no systematic evidence in the present study that the modelling and rewards intervention is less effective with vegetables than fruit.

Individual participants

Given that much is made in the literature on children's food preferences of a tendency to neophobia (Rozin, 1976) or fussy eating (Wardle & Cooke, 2008), we looked at how individual children responded to the modelling and rewards intervention. Specifically we measured how many of the 8 fruit and 8 vegetables each of the Follow up participants consumed at 50% or more. Fig. 3 shows that at snacktime 13 of the 14 children ate between 5 and 8 fruit and between 5 and 8 vegetables; 3 of these children reliably ate all the fruit and vegetables. Likewise, at lunchtime, 12 children ate between 5 and 8 fruit and vegetables; 6 of these ate all 16 foods. Only one child ate 5 fruit and 2 vegetables at snacktime and 3 fruit and 2 vegetables at lunchtime. Whereas this might be classified as fussy eating in comparison with the wide range of fruit and vegetables eaten by the remaining children, it can hardly be classified as an example of neophobia. At the level of individual children, there are no systematic differences in effectiveness of the intervention on fruit as opposed to vegetables.

Conclusion

The modelling and rewards intervention employed in the present study shows considerable promise as a means of building 2–4 year old pre-school children's intrinsic motivation to consume a wide range of fruit and vegetables. It is especially interesting that it was only necessary to target half the foods directly with the intervention in order for tasting and liking to develop for all 16 foods. The strong generalisation to lunchtime in the complete absence of rewards also shows that, once liking is established in one context, the behaviour of eating fruit and vegetables extends readily to other meal times. These effects, together with a continued rising trend in consumption six months after rewards were withdrawn, provide further evidence that reward decrement hypotheses do not apply to the low interest behaviour of eating fruit and vegetables. On the contrary, once liking for a wide range of fruit and vegetables is established early in life by using a strong intervention of the kind employed in the present study, this behaviour change should track into adult life and help counteract the negative health impacts of the current obesogenic environment.

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