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ARTICLE *in* OBESITY REVIEWS · MARCH 2012

Impact Factor: 8 · DOI: 10.1111/j.1467-789X.2011.00939.x · Source: PubMed

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doi: 10.1111/j.1467-789X.2011.00939.x

A narrative review of psychological and educational strategies applied to young children's eating behaviours aimed at reducing obesity risk

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Received 23 May 2011; revised 15 August 2011; accepted 1 September 2011

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Summary

Strategies to reduce risk of obesity by influencing preschool children's eating behaviour are reviewed. The studies are placed in the context of relevant psychological processes, including inherited and acquired preferences, and behavioural traits, such as food neophobia, 'enjoyment of food' and 'satiety responsiveness'. These are important influences on how children respond to feeding practices, as well as predictors of obesity risk. Nevertheless, in young children, food environment and experience are especially important for establishing eating habits and food preferences. Providing information to parents, or to children, on healthy feeding is insufficient. Acceptance of healthy foods can be encouraged by five to ten repeated tastes. Recent evidence suggests rewarding healthy eating can be successful, even for verbal praise alone, but that palatable foods should not be used as rewards for eating. Intake of healthier foods can be promoted by increasing portion size, especially in the beginning of the meal. Parental strategies of pressuring to eat and restriction do not appear to be causally linked to obesity, but are instead primarily responses to children's eating tendencies and weight. Moderate rather than frequent restriction may improve healthy eating in children. Actively positive social modelling by adults and peers can be effective in encouraging healthier eating.

Keywords: Feeding practices, modelling, obesity, preschool children.

obesity reviews (2012) **13** (Suppl. 1), 85–95

Introduction

Childhood is a critical age both for development of lifelong eating habits and behavioural risk factors for obesity (1). Nevertheless, recent reviews of interventions aimed at preventing childhood obesity have acknowledged that the majority of these interventions have taken place in school-based settings, and yet have had rather limited success, especially dietary interventions (2,3). Schools are obviously convenient and practical settings to carry out such interventions; however, there are two major weaknesses to this approach that may explain the lack of success: first, engagement of parents, and consideration of the family environment, is often too limited; second, it has been argued that by school age (e.g. older than 6), quite strong eating habits may already have formed (4). By contrast, younger preschool children are in the early stages of learning about adult foods, eating culture and environment, and just developing their own likes and dislikes. Thus, it is this transitional preschool period that may be a more effective stage for obesity prevention (2).

Eating is an outcome that can be influenced by a complex array of sensory, physiological, genetic, temperamental, social (family, parental, peer), cultural, environmental and learned inputs. Table 1 sets out the main influences and the developmental stages at which their influence can be seen

Table 1 Influences on development of young children's eating behaviour and their key stages

Developmental stage of influence				
Prenatal/*in utero*	Pre-weaning (0–6 months)	Post-weaning (6–9 months)	Post-weaning (9–18 months)	Early years
Genetic	Genetic	Genetic, innate likes/dislikes	Genetic, innate likes/dislikes	Genetic, food neophobia
Mother's diet*	Mother's diet†	Food texture exposure	Parental feeding practices	Parental feeding practices
	Extent of breast or formula feeding	Extent of breast or formula feeding	Parents' eating behaviour	Parents' eating behaviour
	Complementary feeding	Complementary feeding	Siblings' eating behaviour	Siblings' eating behaviour
			Parenting style	Parenting style
	Family food environment	Family food environment	Family food environment	Family food environment
			Carer/teacher modelling	Carer/teacher modelling

*Via both programming of fetal development and exposure to flavours and nutrients via amniotic fluid (5,7).
†Via flavours transferring to breast milk from foods eaten (5).

on young children's eating behaviour. There is increasing recognition of very early influences on childhood eating, including maternal pre-partum diet, and pre-weaning feeding practices (5–7). However, consideration of these is beyond the scope of this review. Genetic influences will be considered where relevant to particular behaviours being described.

Scope and methodology of the review

This narrative review summarizes a more detailed review (8) supporting the ToyBox obesity intervention in preschool children (Y. Manios *et al.*, unpublished data). It is primarily concerned with studies of eating behaviour, including dispositions such as likes and dislikes, in preschool children that provide evidence for the effectiveness of strategies used by parents/carers, teachers and health professionals to promote healthy eating to lower risk of obesity. The studies are examined in the context of current understanding of the psychological and behavioural processes that underlie the development of eating behaviour in young children. Both the design and success of some interventions depend on understanding innate and temperamental influences on children's acceptance of different foods and trait differences in their eating behaviour; thus, these influences are considered here first.

The bibliographic search strategy focused on articles published in peer-reviewed, English language journals, published from 1980 to April 2010 (including online). The databases used included PubMed, Web of Knowledge, Scopus and PsycINFO. Citations in reviews and citation paths within databases were also used. In addition, leading groups in the field were contacted for information on relevant in-press material. Key terms included child* with preschool, eat*, food, diet, food choice, preference, like, liking, acceptance, intake, snack*, satiety, appetite, exposure, reward, model*, parent*, feeding, strategy, fruit, vegetable, restrict*, portion, means-end, neophobia, picky/fussy eating, pressure to eat.

Innate and temperamental influences on children's eating

Post-weaning, parents and carers soon become aware of patterns of idiosyncratic behaviour towards food in their children: indeed, parents of more than one child are often struck by the marked differences between siblings in such behaviours (10). These differences may largely reflect the influence of inherited traits, and are important as they are now known to have considerable impact on parental feeding practices (11). Current understanding of these traits is summarized here.

Innate taste preferences

In common with other mammals, human neonates accept sweet taste but reject bitter and sour tastes (5). However, genetic variation in taste receptor expression (the TAS2R38 gene) confers differential sensitivity to bitter taste, which in turn can alter more complex taste preferences (12). Thus, bitter-sensitive children preferred higher levels of sucrose in foods and drinks (13) and disliked bitter vegetables compared to less-sensitive children (14,15).

Salty taste seems to be innately liked by many animals, although human neonates appear indifferent to it; nevertheless, infants start to express a preference for salty taste by 4 months of age, i.e. pre-weaning (5). Post-weaning, dietary experience, i.e. learning, will be influential on children's liking for salty taste and other taste preferences (5).

Food neophobia and picky eating

Food neophobia is defined as a reluctance to try new or unfamiliar foods (16). Most parents are familiar with children being unwilling to try new foods, especially in preschool children, the age group considered here (17). However, children clearly vary on a continuum in the extent to which they persist in this. Food neophobia is considered a form of personality trait associated with anxiety and shyness in children (18,19), and twin studies have shown strong heritability (75%) of food neophobia in children (20).

The main concern for food neophobic children is that their diet will be unhealthily limited, because of avoidance of fruits, vegetables and protein-rich sources, rather than one of over-eating (21,22). Picky eating is an overlapping concept of limited diet, but including a reluctance to try quite familiar foods (17). Both traits lead parents to adapt their feeding practices, possibly succumbing to pacification by treating with palatable, energy-dense, nutrient-poor foods (23,24).

Enjoyment of food, impulsivity, eating rate and satiety responsiveness

In adults, there is increasing evidence for an important influence of trait variation in characteristics such as reward sensitivity, impulsivity and eating rate on obesity risk (25). Similarly in children, these traits have been shown to be both highly heritable and predictors of obesity risk (26–30). These facets can be measured behaviourally (e.g. eating in the absence of hunger) or by questionnaire (e.g. 'my child gets full before his/her meal is finished' shows 'responsiveness to satiety'; 'given the choice, my child would eat most of the time' indicates 'enjoyment of food') (27).

Promoting acceptance of healthy foods by repeated exposure

Evidence in both animals and human beings demonstrates that, whereas a novel food is usually treated cautiously, familiarity through repeated exposure leads to increased acceptance of the food (31). Therefore, a simple intervention can involve repeated exposure to brief tastes of new, healthy foods.

In an early study of taste exposure, 14 2- to 3-year-old children were asked to taste new fruits or cheeses on 0, 2, 5, 10, 15 or 20 occasions (32). Between 5 and 10 taste exposures were needed to see an increased preference for the new food – in contrast to a single exposure needed for 4- to 7-month-old infants (33). A subsequent study (34) in 43 2- to 6-year-old boys emphasized that such exposure to novel foods needed to include actual tasting, not merely looking and smelling, to achieve increased liking for the taste, not just the look, of the food.

Two more recent studies capitalized on the ability of taste exposures to increase acceptance, in designing interventions to improve liking and intake for novel, moderately disliked vegetables. In a study on 49 5- to 7-year-olds (35), an exposure-only group tasted a sweet red pepper on 8 d over 2 weeks, and was assessed for liking and intake before, during and after exposure. A second group was additionally offered a sticker as a reward for trying the pepper (except on test days); a third group did not receive any exposure sessions. Both exposure groups showed increased liking, although intake only rose significantly for the exposure-only group, compared to the unexposed group. The less effective change in intake in the reward group suggests the possibility that using a reward might partially devalue the rewarded food (see next section); another possibility is that it distracted attention from the tasting.

A subsequent intervention was carried out by parents at home (36): 156 parents of 2- to 6-year-old boys and girls were randomly assigned to exposure, information-only or control (advice after the study) groups after a pre-intervention taste test at which a 'target' vegetable was selected – 143 of their children completed the protocol. Intake, liking and preference ranking was assessed before and after 14 d of intervention (tasting once per day, for the exposure group). Advice was given about modelling and encouragement, engagement in preparation, etc., so that this was not a strictly 'mere' exposure condition. Only the exposure group showed improvements in acceptance of the vegetable over all three measures.

The concept of flavour–flavour learning has been used to encourage a liking for vegetable flavours presented as purée drinks in 13 4- to 5-year-old children (37). Flavour–flavour learning is a form of associative learning that can occur during eating, whereby acceptance of a previously 'neutral' (often novel) flavour is altered by pairing its consumption with a flavour that is reinforcing, i.e. either liked (e.g. sweetness) or disliked (38). During conditioning trials, one target flavour was sweetened with 20-g d-glucose (about 12% w/v), whereas the other was unsweetened. Children were asked to sip and swallow both flavours three times on each of two consecutive days. Ranked preference increased significantly for the sweetness-paired flavour only. Despite this success, the advisability of relying on sweetness (and typically more energy) to encourage vegetable consumption is not clear.

One study revealed how sensitive attempts to encourage young children to eat novel foods can be to the information provided: 40 3- to 8-year-old children were presented with a novel cheese or a novel rice-like buckwheat side dish (39). They were asked either 'Would you like to try it?' or 'Would you like to try it? It tastes good!'. For the more popular novel cheese, emphasizing that it tasted good reduced willingness to try it, whereas the reverse was true for the cereal. The authors suggest that the cheese looked like candy to the children, so was tempting to try, but stressing its good taste may have made children suspicious, so less willing to try.

However, positive messages can be effective: a study of the impact of positive messages about a novel vegetable, kohlrabi, contained in a children's storybook, in 118 3- to 5-year-olds, showed a beneficial effect on willingness to try the vegetable, compared to a group receiving negative messages, after two reading sessions (40).

Rewarding eating: evidence for benefits and drawbacks

Using rewards is a common means to encourage a behaviour, albeit there are various theoretical accounts as to the process, some suggesting that extrinsic rewards may only encourage a behaviour transiently at best (41,42). An increasing number of interventions involve rewards, whether social or more tangible and edible, for healthy eating in children: yet some approaches can actually have a counterproductive effect (35). This could represent an 'over justification' effect, whereby the value of the food, or the intrinsic motivation to consume it, is degraded by becoming the means to an end (the reward), which may be more immediately or inherently desirable (1,43,44). Nevertheless, parents often claim success in using overt reward strategies of this sort (45). The evidence for varied effects of differing reward strategies is now considered.

In 64 3- to 5-year-old boys and girls, the effects of treating a food as a reward vs. receiving positive attention from an adult when eating the target food were compared (46). Preference for the target food increased in both conditions and was present at a 6-week follow-up. By contrast, in 12 3- to 4-year-old boys and girls, when consumption of fruit drinks was instrumentally rewarded with a play activity of each child's choice on six occasions, liking for the rewarded drink was reduced (47).

In a complex, and somewhat underpowered study, Stark *et al.* (48) reported using a combination of techniques to encourage healthier snacking in preschool children (17 2- to 5-year-olds) in a nursery setting, i.e. teaching healthy/unhealthy colour coding of snacks (red = bad, green = good), teaching children to 'cue' their choice with self-declarations as to the healthiness of the snack and rewarding both healthy choice and cueing with stickers. The study also involved monitoring of snacking behaviour at home. Despite training lasting from 10 d to 6 weeks, increased healthy snack choice was only transient.

Three experiments compared the impact of 'if-then' (means–end) contingencies on children's eating (44). In the first experiment (42 4- to 7-year-olds), children in the if-then conditions were told that, if they ate food X, they could have some of food Y, with foods counterbalanced for X and Y. Control children were merely offered X then Y, matching sequence with the other conditions. The foods were chosen for each child to be of middle preference. Both liking and choice increased for the 'then' (second) food, whereas liking for the 'if' food decreased immediately, but returned to baseline at 6 weeks. These results were only partial support for devaluing of foods seen as means to an end, given that liking had returned to baseline by 6 weeks. Moreover, a second experiment showed that the devaluing did not occur if the reward food was initially less liked than the 'if' food. Even so, a third experiment using novel and familiar fruits did support a means–end effect, suggesting that rewarding eating familiar foods with novel ones may be a beneficial strategy.

A similar study in 86 4- to 7-year-old children, using snack foods of moderate appeal, found reduced preference for the 'if' food, although preference did not increase for the 'reward' snack (one trial only) (49). Control groups showed that the effect depended on explicit awareness of the contingency, not the sequence of eating the snacks.

Hendy (50) applied these principles, as well as a modelling strategy, via teachers in a nursery setting, in 64 3- to 5-year-olds. Four new fruits and vegetables were placed on children's group tables at lunchtime on 3 d, with the following five contexts: (i) mere exposure – just placing the fruit and vegetables; (ii) 'modelling' – teachers ate each of the new foods and said 'I like to try new [fruit]'; (iii) 'reward' – teachers said twice, 'If you try two of these new foods with at least one bite, you can have a special dessert. If you try all of these new foods, you can also have candy to take home for later'; (iv) 'insist/try one bite' – each child was given a piece of each new food and told 'Please try one bite of each new food?', but was not forced to eat it; and (v) 'choice' – teachers said twice during the meal to each child, for each food, 'Do you want any of this?'; a small amount was offered if they said yes. For both the number of new foods sampled and the number of meals during which at least one new food was sampled, 'reward', 'insist' and 'choice' strategies all had higher scores than the exposure control, but 'modelling' was not significantly greater. This was also true for total number of bites across all meals, but 'choice' was most effective, followed by 'reward' then 'insist'. Modelling (albeit rather neutral in execution) did not perform better than exposure: this seems quite surprising, and is discussed further below when other modelling strategies are examined. It may be encouraging that the means–end reward strategy increased acceptance of the new foods, but it should be remembered that this was while the contingency was operating – there was no assessment of liking at a later stage. In fact, there was evidence that sampling was highest for the first lunch, which might suggest deterioration in acceptance over trials.

Despite the concerns about using rewards to encourage healthy eating, using delayed reward proved successful in increasing fruit and vegetable acceptance in 188 6- to 9-year-old children ('Kids Choice Program') (51). The authors were sensitive to the possibility of the 'over justification' effects of using reward, but argued that this risk could be reduced by using small and delayed reinforcement, avoidance of (sensory-specific) satiation effects by offering food choice and requiring that only a small amount of food be eaten to receive reinforcement, and including conditions that encourage peer participation and modelling. Children were rewarded for either fruit or vegetable intake over 18 meals: each day they ate fruit (or vegetable) during school lunch the research team would punch one hole in their plastic nametag necklace. They could trade in three holes in their nametags for a small prize of their choice. To gain a hole, they had to eat at least 1/8 cup of the target food. The intervention was successful in increasing trying of fruits or vegetables, specifically for the rewarded food type. Reported preferences 2 weeks later also increased for the rewarded food, but at 7 months these preferences did not differ from baseline. This loss of effect might be due to an insufficient number of reinforced exposures to the target foods, and/or continued competition with more intrinsically rewarding foods experienced over that time, but probably not due to a negative effect of reward, given the positive results at 2 weeks. In addition, secondary analyses of the Kids Choice Program data have also shown that both normal-weight and overweight children benefit equally from the programme (52).

In an earlier but influential study of rewards in 45 3- to 5-year-old children, both tickets to view a film and verbal praise resulted in reduced liking for flavoured milk drinks (43). By contrast, liking increased slightly in non-rewarded exposure groups. These findings are rather disturbing, as they show that even the social reward of verbal praise, while being able to increase consumption at the time, nevertheless resulted in reduced liking when the contingency was absent.

This question over the effectiveness of verbal praise has recently been addressed in a large study of 450 4- to 6-year-old children in South London, examining the impact of rewards on their vegetable liking and intake (53). There were four conditions lasting 12 d: no treatment control; exposure plus tangible reward (stickers for tasting), exposure plus verbal praise for tasting and mere exposure, i.e. repeated tasting without reward. Liking and intake were measured at baseline and at 1, 30 and 90 d after the intervention. At 1 and 30 d post-intervention, the sticker reward group showed the biggest improvement in intake, followed by the praise reward group, and both were superior to exposure only or control. These two reward groups produced equal improvements in liking, although the exposure-only group also successfully increased liking. Ninety days later, ranked preferences remained higher for these treatment groups compared to control, and increased intake was maintained best for the sticker reward group. These results are encouraging, and refute previous findings showing negative effects of reward, both tangible and verbal, usually on liking.

Parenting, the family food environment and young children's eating behaviour

Parental feeding practices arise out of challenges to parents' goals as to how their child should eat, or the rate at which they are growing or putting on weight. Essentially, these are strategies designed to control how much of what foods, and when, a child will eat, and may apply to any carer responsible for feeding the child. The practices are usually measured using validated questionnaires such as the child feeding questionnaire (54) or the parental control index (55). Typical practices include using food as a reward, using food to pacify, pressuring a child to eat, restricting certain types of food, monitoring or closely controlling children's eating and modelling. A distinction has also been made between these generally overt strategies and more covert ones (not detectable by the child), such as not buying unhealthy food, keeping it out of a child's sight and reach or serving smaller portions (56); however, it is not yet clear which is more effective for reducing risks of childhood obesity (57).

Greater pressure to eat from parents is associated with children of lower weight (58) and, experimentally, with reduced intake (of less liked foods) (59) as well as with picky eating (60,61). Although it is possible (from largely cross-sectional data) that children eat less and lose weight as a reaction to parental pressure to eat, it now seems clear from mediational and longitudinal studies tracking child weight or eating over time that parents are reacting to underweight and/or picky eaters by encouraging greater consumption and healthier eating (62,63).

Nevertheless, some parental practices may influence child eating in other ways: an observational study of mealtime interactions for 77 3-year-old children and their mothers found that mothers who frequently prompted children to eat had children who ate more and faster, and this was related to a more controlling maternal style (64). In a cross-sectional study of 564 parents of preschool children (55), there was a slight negative effect of parental control on fruit and vegetable intake, which became non-significant once neophobia (small negative association) was included in the regression model: the main predictor was parents' own fruit and vegetable consumption.

Hendy *et al.* (65) studied parental practice predictors of child weight and diet, in 6- to 10-year-olds, in competition with genetic, exercise and television watching contributions, using the self-report parent meal-time action scale. Children's healthy weight and diet was predicted by seven practices: positively with daily fruit and vegetable availability, fat reduction, positive persuasion and insistence on eating (fathers only); negatively with snack modelling, allowing many food choices and preparing special meals (differently from the family meal).

In contrast to pressure to eat, parents' use of food restriction – typically of perceived unhealthy but often highly palatable foods – is associated with higher weight status and gain in longitudinal studies (66). Restrictive eating may in part be a response to a child with an inherited strong appetite or 'enjoyment of food' disposition, who would be at risk of excess weight gain (11). Even so, it is clear that the strategy can be counterproductive: experimental studies have shown that restricting access to food draws children's attention to it and enhances their desire for it, particularly if the food is palatable (67,68). Such practices are also associated with risk of obesity and eating in the absence of hunger in young children (66,69,70). Direct experimental evidence relating to these concerns is considered here.

In a total of 68 3- to 6-year-olds, two experiments used 8–10 sessions involving restricted access to a palatable snack vs. longer access to a bland snack (67). Desire for and intake of the restricted food increased substantially. However, in the first study, appetite for both had declined 3 weeks later: moreover, these restriction effects were positively related to the mothers' restriction of the palatable foods at home, leaving interpretation of the findings unclear.

A more recent study investigated whether restriction could bias desire for a food if it was no more palatable than the unrestricted food in 74 5- to 6-year-old children (68). Red or yellow M&M chocolates (sweet) and crisps (salty) were used. Restricting access to the 'red' foods increased desire and subsequent intake of those foods (otherwise identical to the unrestricted yellow foods). In addition, the children least affected by restriction were those whose parents normally applied moderate restriction at home, whereas children experiencing either high or low restriction at home both ate more energy overall.

Interestingly, it appears that careful use of restriction of a healthy (but less palatable) food such as fruit might help to encourage its consumption (71). Two groups among 70 5- to 7-year-old children were forbidden to eat fruits and sweets, respectively, whereas a control group was allowed to eat everything. Although restriction only increased expressed desire for sweets and not for fruit, for intake, children in both the fruit- and the sweet-prohibition conditions consumed relatively more of the formerly forbidden food during a taste session. This is an interesting result; however, it is not easy to see how parents might reliably put it into practice, and there must be a concern about creating mixed messages on eating healthy foods.

Perhaps a more positive message can be taken from another recent attempt to examine the impact of restriction on fruit intake in 4- to 7-year-old children (72). Here, there were two fruit conditions: a normal presentation condition and a visually appealing or entertaining condition, where the fruit appeared in a boat-like sculpture. Restriction made no difference, but children ate much more of the entertaining fruit presentation. The message is 'make food fun to eat'.

Balancing internal and external influences – satiety responsiveness and portion size

Adaptive eating requires knowing about the consequences of eating a particular food in the current state, and how that state will change on eating: thus, healthy regulation of eating requires a learned integration of internal and external cues, so that amount eaten matches need (73). Children are normally able to learn to discriminate after-effects of quite small energy differences in food, such that, when hungry, they learn to prefer higher energy foods (74–76). Even so, increasing age seems to be associated with a weakening of this sensitivity (77), perhaps due to increasing dominance of cognitive strategies (78). There has long been concern that overemphasis on or attention to external influences can promote over-eating and obesity (79,80). Experimental meal size conditioning in contexts that emphasized either internal or external control supports the importance of this issue: Birch *et al.* (81) gave 22 3- to 4-year-old children experience of eating differently flavoured high- and low-energy yoghurt pre-loads (60 vs. 145 kcal), followed by *ad libitum* eating of liked snacks (three pairs of trials). Half of the children ate the food in a context emphasizing internal control (discussing internal appetite feelings with adults), whereas the other half ate in a context stressing external control (signalling the meal start, discussing meal times, amount of food on the plate, rewards for finishing the yoghurt). Those children trained in the internal context ate less after the high-energy paired flavour than after the low-energy paired flavour, whereas for the externally trained children there was no difference in snack intake after the different yoghurt flavours. Thus, emphasizing external control of eating may inhibit the children's ability to learn to regulate intake-based energy need.

Habitually, both adults and children eat a consistent volume or weight of food (82): therefore, diluting the energy density by substituting foods lower in fat and sugar, and increasing fruit and vegetable servings, should help to lower energy intake. This was shown to be the case in 2- to 5-year-olds, both for a single meal (83) and for multiple meals over a week (84).

An important external influence on amount eaten is portion size (82). Increasing main course portion size proportionately increased lunch intake in 4- to 6-year-old children, but not in 2- to 3-year-olds, suggesting that this external influence may increase quickly with age (85). Also in line with a susceptibility to such external control, a subsequent study found not only that doubling main course portion size increased overall lunch intake in 3- to 5-year-olds, but that those children who were more responsive to portion size also ate more in a test of eating without hunger (86). However, there was no clear relationship with this over-eating risk and age-adjusted body mass index for this age group.

Young children's responsiveness to portion size can be used to advantage to promote greater fruit or vegetable consumption. Children (3–5 years old) were served a first course of raw carrots at lunch (87). Doubling the portion size of the carrots led to a 47% increase in carrot intake, but not overall energy intake. Another study doubled the portion size of side dishes, rather than first courses, of carrots, broccoli or apple sauce, eaten with a pasta meal, in 43 5- to 6-year-old children (88). This resulted in 43% more of the apple sauce being eaten, and less of the pasta meal; however, there was no increase in the amount eaten of the vegetables, perhaps because of lower palatability. Considering both studies together, for vegetables it is possible that serving large portions as a first course rather than as a side dish may be more effective.

Social cognitive theory: observational learning and modelling in eating

Not all learning requires direct reinforcement to alter behaviour: a child's innate predisposition to imitate allows parental modelling to do so. The impact of this sort of modelling, or observational learning, led to the development of Bandura's social cognitive theory (89). Modelling by respected peers, parents or teachers is one potentially useful way to encourage healthy eating (90–92), and may contribute to the strong correlations between parental and child diets and food preferences, especially for easily categorized foods such as fruits and vegetables (93–95). However, surveys of effects of the family food environment necessarily confound modelling with availability and exposure (96).

Moreover, effects of modelling need not necessarily be beneficial: a child may model unhealthy eating from observing its parents or siblings. Peer pressure (social conformity) can reverse a 'target' child's preferred food to align with the opposite preference expressed by the majority (97).

Modelling may also be weaker than other strategies, depending on the relationship between model and observer, and the emotional response of the model (50,98). Indeed, modelling is the basis of success for television advertising to children, and the large amount of advertising of relatively unhealthy energy-dense foods and drinks to children could be contributing to childhood obesity (99).

In a series of studies with 3- to 5-year-old children, teachers' modelling of eating new or familiar foods was only successful in improving acceptance by the children if the teacher expressed obvious and audible delight at trying the food – silent modelling was ineffective (91). However, when the enthusiastic teacher model competed with a similar peer model, results were less consistent, with girls especially being influenced more by the peer than the teacher.

When peer models were trained to demonstrate eating of new foods by rewarding the models with small toys (100), girls were more effective models than boys, but the benefit of modelling was no longer present 1 month later. The trained models reported preferring the food they had been rewarded for eating, but actually ate as much of the unrewarded foods, suggesting at least no detrimental effect of rewarding on intake.

The use of video film of peers modelling healthy eating – specifically enthusiastic eating of fruits and vegetables – was effective in improving fruit and vegetable consumption in primary school children ('Food Dudes' intervention) (101). However, it is not clear from those studies whether the use of rewards was also critical.

The benefit of modelling eating a food may be quite specific to aspects of the food being modelled. Adults either modelled eating uncoloured semolina ('different' condition) or the same colours (including novel flavours) as 27 2- to 5-year-old children were asked to eat ('same' condition), or did not eat any ('presence' condition) (102). The results showed that only the 'same' condition reliably enhanced children's intake and acceptance of the novel food.

A recent study examined whether positive and negative modelling could respectively increase or decrease consumption of a novel 'blue' food, relative to a mere exposure control, in 3- to 7-year-old children (103). The design also tested whether positive modelling would counteract any adverse effect from negative modelling, and whether the effects would generalize to another blue food. Positive modelling enhanced intake, which generalized to a similarly coloured food, whereas negative modelling suppressed intake. Furthermore, this negative effect was diminished following a positive modelling session, at least in slightly older children.

One study investigated the possible synergistic reinforcing effects of either energy in a yoghurt drink or teacher modelling or both, on yoghurt flavour preferences in 4- to 7-year-old children (104). The energy condition involved either a low-energy aspartame-sweetened yoghurt drink, or an energy-rich yoghurt drink. Modelling involved teachers enthusiastically eating the yoghurt before, and mothers doing so during, the time the child ate the yoghurt, as well as relating a story about a cartoon hero branded with the yoghurt's name. Children were allocated to one of four groups: low energy without modelling; low energy with modelling; high energy without modelling; high energy with modelling (nine trials). Only the high energy with modelling group reliably increased preference after training, suggesting that modelling works better with energy-rich palatable foods, although either caloric or sensory reinforcement may have been involved. Modelling may draw attention to the sensory experience, and any contrast with expectations could have a detrimental effect, particularly where finishing of the yoghurt was demanded.

Conclusions

Interventions in preschool children may be more effective than those in older children in a school setting, although evidence from such interventions is scarce. The younger the children, the less established and externalized are their eating habits. In addition, there should be more opportunity for involvement, and training, of parents. In order to increase their effectiveness, interventions should train parents and carers in awareness of inherited variations in children's eating behaviour.

Children can be encouraged to eat moderately disliked and/or unfamiliar foods by repeated brief tasting of the target food in a positive social context. At least five, and perhaps 10 such taste exposures may be necessary for a reliable improvement in liking or intake. Using rewards may be an effective strategy to encourage healthier food choice, provided the reward is not a more highly liked food. Using tokens or other representations of reward, for later exchange, may be a safer approach to rewarding eating. However, verbal praise has obvious intrinsic appeal, as well as convenience, and can produce a quite long-lasting increase in liking for vegetables. Moreover, foods such as fruits and vegetables should be made as intrinsically appealing as possible, including enhancing the visual appearance, to entertain the child, and perhaps sweetening the taste.

Carers should avoid excessive coercion or pressure to eat, or conversely restriction, that could distract a child from learning to regulate their eating based on physiological cues associated with the food eaten. Such approaches are also likely to engender a negative social and emotional experience that could impede acceptance of the food. Instead, parents or carers can exert positive control by avoiding availability of, or exposure to, unhealthy foods, and by manipulating portion sizes in favour of healthy foods, especially early in the meal.

Finally, young children can be encouraged to eat healthily by positive and active social modelling, especially by parents and peers. This could also be achieved via several media, including films and books, and should include as wide a variety of healthy foods as practicable.

Conflict of Interest Statement

None of the authors has any conflicts of interests to declare.

Acknowledgements

The ToyBox-study is funded by the Seventh Framework Programme (CORDIS FP7) of the European Commission under Grant agreement No. 245200. The content of this article reflects only the authors' views and the European Community is not liable for any use that may be made of the information contained therein.

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