Development of food acceptance patterns in the first years of life

Leann L. Birch

Department of Human Development and Family Studies, Graduate Program in Nutrition, 211 Henderson Building South, The Pennsylvania State University, University Park, PA 16802, USA

The early transition to the omnivorous diet

As omnivores, human subjects need to consume a variety of foods to maintain growth and health. However, as mammals, during the first months of life we consume only a single food: milk. By about half way through the first year of life, an exclusive milk diet is no longer adequate to maintain growth and health, and current recommendations are that infants should begin solid foods at about this time (Hendricks & Badruddin, 1992). Our understanding of the individual and contextual factors that can facilitate or impede the child's transition from exclusive milk feeding to consuming the omnivore's varied diet is limited, but we do have a more complete understanding of this early transition in another omnivore, the laboratory rat, based on research by Galef and colleagues (Galef & Beck, 1991). For example, rat pups learn to prefer the adult diet consumed by the mother over other diets, and the pups' experience with the flavour cues in their mothers' milk are central in this learning process. By implication, the breast-fed infant may experience, via its mother's milk, flavours in the diet of the mother. Research confirms that the flavours present in human mothers' diets are also present in their milk, and that they affect the infant's sucking response and intake during feeding (Mennella & Beauchamp, 1991). However, to date, there is only very limited evidence regarding whether early experience with flavours in milk during the suckling period facilitates the infants' acceptance of solid foods later on, during the transition to the adult diet.

The transformation of the young child's diet occurs during a period when positive energy balance and rapid growth must be sustained, and the majority of children negotiate the transition without major difficulty. This success can be attributed largely to the fact that, as a young omnivore, the infant 'comes equipped' with a set of predispositions and abilities that facilitate this dietary transition, promote the acceptance of solid foods, and shape subsequent dietary patterns (Birch & Fisher, 1995). In research designed to investigate the developing controls of food intake during the first years of life, our approach has been to examine what children are learning during this transition. This entails examination of the environmental contexts in which children's experience with food occurs, and investigation of the processes by which this learning occurs. During the first 5 years of life, children learn an enormous amount about food and eating, including which substances are considered food within their culture. Children are also learning likes and dislikes, as well as when to eat, and how much to eat. Children also begin learning simple cuisine rules regarding what foods are consumed at particular mealtimes, which foods are eaten in combination (in the USA, peanut butter and jelly (jam) but not peanut butter and mustard), and whether it is appropriate to add flavours to foods (put salt, not sugar on french fries). Children acquire most of the previously mentioned abilities without benefit of explicit tutelage, via processes of associative learning and imitation. Associative learning is particularly important in the learning of evaluative and emotional responses, such as food preferences (Martin & Levey, 1978). In the case of food preferences, associations are formed between foods and other more potent cues present in the contexts in which eating occurs, or arising as a consequence of eating.

Information available from a variety of sources can provide direct and indirect evidence regarding what children are learning about food and eating during the first years of life. Before presenting what is known about the developmental processes affecting food acceptance patterns in children, descriptive data from national surveys of children's food intake patterns, as well as surveys of children's growth patterns, will be presented briefly to provide a picture of current trends. This information can provide a basis for assessing the current climate and context in which children develop controls of food intake and food acceptance patterns.

Children's diets, childhood obesity, and problems of energy balance

With respect to the quality of children's diets, Muñoz *et al.* (1997) examined the food intakes of 3300 children and adolescents, 2–19 years of age, who participated in the US Department of Agriculture's 1989–91 Continuing Surveys of Food Intakes by Individuals. The children's food intake patterns were compared with the recommendations based on the US Department of Agriculture's (1996) food guide pyramid. These recommendations can be viewed as providing guidelines for what the omnivore's diet should look like, and suggest the number of servings per d that should be consumed from each food group for optimal health (US Department of Agriculture, 1996). The question addressed by Muñoz *et al.* (1997) was, 'How do children's food intake patterns compare with the guidelines?'

These findings reveal major discrepancies between US children's food intake patterns and the US Department of

Corresponding author: Dr Leann L. Birch, fax +1 814 863 7963, email llb15@psu.edu

https://doi.org/10.1079/PNS19980090 Published online by Cambridge University Press

Agriculture's (1996) recommendations. The mean number of servings was below recommendations for all food groups except dairy. About 30 % of children met individual recommendations for fruit, grain, meat, vegetables and dairy. Only 1 % of children met all recommendations, and 16 % met none of them. Those who met the recommendations had nutrient intakes above recommended dietary allowances, but their diets were also too high in fat. In fact, among this sample, total discretionary fat and sugar accounted for approximately 50 % of children's total energy intake. In summary, children's diets are too low in fruits, vegetables and grains, and too high in sugar and fat. This pattern prevails despite guidelines and nutrition education campaigns designed to alter intake in directions consistent with guidelines. The goal of many nutrition education campaigns is to increase consumption of fruits, vegetables and grains, and reduce the proportion of energy obtained from fat and sugar. Why is altering dietary patterns in this direction so difficult, and how can we accomplish this? The evidence regarding children's predispositions and the acquisition of children's food preferences will reveal some very good reasons why foods high in sugar and fat are highly preferred and resistant to change. This analysis also suggests that the straightforward approaches adopted by parents to bring children's diets into line with the recommendations, such as restricting children's access to palatable high-fat high-energy foods and encouraging intake of 'healthy' foods, such as fruits and vegetables, are ineffective and may have negative effects on attempts to promote healthy diets for children. Fortunately, this analysis also suggests some child-feeding strategies that might be more successful in promoting healthy diets for children.

With respect to children's growth patterns, the prevalence of overweight among children in the USA has doubled since the mid 1970s, and these increases are greatest among girls, as shown in Fig. 1. Although these increased prevalence rates in overweight are a consequence of changes in both energy intake and expenditure, they are also consistent with the observation that children's food intake patterns are far from the current recommendations.

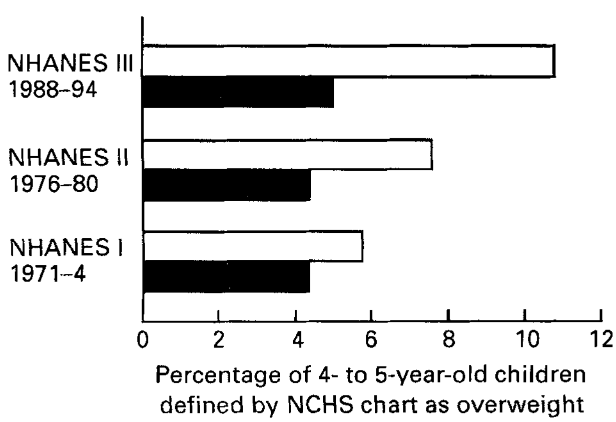

Fig. 1. Prevalence of overweight based on percentage of National Health and Nutrition Examination Survey (NHANES) pre-schoolers above 95th percentile on National Center for Health Statistics (NCHS) growth chart (Hamill *et al.* 1979). (▭), Girls; (▬), boys. (From National Institute of Diabetes and Digestive and Kidney Diseases, 1997.)

Weight concerns, diets, and health: a context for learning about eating

Although the data reveal that children and adults in the USA are getting heavier, the standards of beauty for women include being slim. The pressures to be slim promote pervasive weight concerns and dieting among women and girls, beginning at least as early as middle childhood. At any given time, about half US women report that they are dieting (National Institutes of Health Technology Assessment Conference Panel, 1992), and many of those who are dieting are not overweight, while many who are overweight are not trying to lose weight. We have also seen an increase in dieting attempts among children and adolescents, even among those who are not overweight (Goodrick *et al.* 1996). Children are also reporting dieting and weight concerns at younger and younger ages (Maloney *et al.* 1989; Killen *et al.* 1993; Thelen & Cormier, 1995), and are showing evidence of 'fat phobia'. There is also evidence that children are learning to lie about intake (Muñoz *et al.* 1997) in the same way that adults do (Prentice, 1996). In addition, despite the efforts of nutrition educators to promote concepts of 'moderation' and 'variety' in dietary recommendations, we tend to dichotomize foods as 'good' or 'bad' (Rozin *et al.* 1996). Further, 'bad' foods are typically highly-palatable foods, often high in sugar and fat, that 'taste great' but are forbidden by chronic dieters and those pursuing good health. In contrast, 'good' foods, such as fruits and vegetables, may be perceived as healthy, but not very tasty, and may be eaten only as a means to attain health or weight goals. It is in the context of these attitudes regarding food, eating, health and beauty that young children are making the transition to the adult diet of their culture.

Children's predispositions, context and early experience

As a result of our omnivore status, children are genetically predisposed to learn to associate foods with the contexts and consequences of ingestion, to accept some substances and to reject others. This includes the predisposition to accept substances that taste sweet and salty and to reject sour and bitter tastes. The predispositions to accept sweet and reject sour and bitter tastes are present at birth, although these responses are subsequently modified by learning. In the newborn infant, the facial expression elicited by a sweet taste is dramatically different from the expression in response to sour or bitter tastes (Steiner, 1979). The infant's facial expressions that occur in response to food flavours serve as important signals to parents and care givers. While the former response is interpreted as 'he likes it', the latter response is 'he doesn't like it'. These predispositions have been viewed as adaptive and could serve a protective function; sweet tastes in nature signal a source of energy and micronutrients (as in ripe fruit), while sour and bitter tastes may indicate the presence of toxins. There also appears to be a predisposition to consume foods with the salty taste, which is not present at birth, but appears at about 4 months (Beauchamp *et al.* 1986). Predispositions to accept sweet and salty tastes and reject sour and bitter imply that some foods (sweet and salty foods) will be more readily accepted than others, and that foods with bitter or sour flavour components will likely meet with rejection.

https://doi.org/10.1079/PNS19980090 Published online by Cambridge University Press

These predispositions bias young children to prefer and accept sweet and salty foods, and suggest that one challenge in fostering healthy diets is to facilitate children's acceptance of foods that are not predominately sweet or salty.

Infants are also predisposed to be neophobic about food. Neophobia, or fear of the new, describes the omnivore's typical rejection response to a new food. This response may seem maladaptive, because omnivores need variety in the diet and the young child must learn to accept at least some of the new foods offered. However, this need for variety must be weighed against the fact that putting something new into the gastrointestinal tract is a risky business; the new substance may be toxic. Kalat & Rozin (1973), based on a series of experiments with another omnivore, the rat, demonstrated that the reduction of neophobia that occurs with repeated opportunities to consume a new food is attributable to 'learned safety'. Neophobia and its reduction play an important role in shaping the food acceptance patterns of young children, because as the transition to the adult diet begins, all foods are new. We have seen some suggestion that flavours in the mother's milk might moderate the neophobic response, but this neophobic predisposition implies that we should not expect new foods to be immediately accepted. However, neophobia does not reflect a fixed dislike for a new food, but a transitory one that may be altered via subsequent food experience. The view that the neophobic response is normal and adaptive also implies that when children reject new foods, they are behaving normally, and should not be labelled as 'finicky' or 'fussy eaters'.

We have conducted a series of experiments with infants and young children to examine their neophobic reaction to foods, and to explore ways to reduce that response. This research reveals that the initial rejection of new foods can often be transformed to acceptance by providing repeated opportunities to eat the food. These findings are consistent with the 'learned safety' view of neophobia; when the consumption of a new food is not followed by negative gastrointestinal consequences, the neophobic response is reduced, resulting in increased acceptance. However, experiments with children reveal that these changes don't occur as rapidly as we might like, and that multiple opportunities to sample a new food are necessary (Birch & Marlin, 1982). In addition, consumption of the food seems necessary to reduce neophobia; simply looking at or smelling a new food is not effective in reducing food neophobia. For example, infants show dramatic changes in their responses to new foods as their familiarity with the food increases with repeated exposure (Sullivan & Birch, 1994; Birch *et al.* 1998). When 4- to 6-month-old infants were repeatedly given a new vegetable over a series of ten daily feedings, infants' reaction to the food and their intake of the food increased dramatically. Pre-school children show a similar pattern (Sullivan & Birch, 1990).

The latter finding suggests the importance of early experience on children's developing food acceptance patterns, and data confirm that the quantity and quality of children's experiences with food have powerful effects on food preferences and food intake patterns (for reviews of the evidence, see Birch, 1992; Birch & Fisher, 1996). In the development of children's food acceptance patterns, genetic predispositions (neophobia, acceptance of sweet, salty, and rejection of sour and bitter) interact with their early experience, shaped by the environment, to produce each child's unique food acceptance patterns. The challenge in the research we have done is to reveal how these predispositions and environmental contexts interact to produce children's food acceptance patterns.

Effects of experience: learning to associate foods with contexts and consequences of eating

Children are predisposed to learn to associate sensory cues of foods with the contexts and consequences of eating those foods, and this predisposition can also serve to facilitate the transition to the omnivore's diet. Again, it is essential for maintaining growth and health that children learn to accept and like at least a subset of the foods in the adult diet of their culture. While children do not need to learn to like sweet or salty foods, and will readily accept even novel sweets, there is substantial evidence that children's preferences for the majority of other foods are strongly influenced by learning and experience, especially via the impact of associative learning. Associative learning is central to the learning of evaluative responses (Martin & Levey, 1978) and, as indicated previously, this learning involves learning associations between sensory cues of foods and other stimuli that (1) elicit strong affective reactions, either positive or negative and (2) occur in spatial or temporal contiguity.

Children can learn to associate foods with aspects of positive or negative social contexts; repeatedly presenting a food in a positive context results in increased liking for that food (Birch *et al.* 1980). In contrast, presenting foods in a social context that generates more negative emotions, for example coercing a child to consume a food by offering a reward, leads to decreased liking (Birch *et al.* 1984). These observations are important because such feeding tactics are commonly used by parents, who are attempting to encourage children's intake of 'healthy' foods, or restrict children's intake of unhealthy foods (usually those high in sugar and fat). These specific practices may be reflective of child-feeding strategies intended to control children's intake, involving restriction of palatable foods or encouraging consumption of 'healthy' foods. Unfortunately, there is evidence that the imposition of these parental controls impede the development of children's self-control of food intake, and may foster the development of unhealthy diets and overweight in childhood.

In addition to learning associations between foods and the social contexts of eating, children are also learning to associate foods with the post-ingestive effects that follow eating those foods. The most widely-known example of this form of learning is the conditioned aversion (Garcia *et al.* 1974). However, in addition to developing learned aversions to foods associated with gastrointestinal illness, there is evidence that the preferences can also be learned via the association of food cues with the positive consequences of ingestion (Capaldi, 1996). Evidence from research with another omnivore, the rat, reveals that energy-dense foods come to be preferred over energy-dilute ones following repeated opportunities to ingest the foods and to learn to associate flavour cues with the post-ingestive consequences of foods differing in energy density (Booth *et al.* 1982; Sclafani, 1990). A predisposition to learn food preferences based on energy density could also serve an adaptive function, at least in contexts where food is scarce. It would be advantageous to prefer foods that provide a more concentrated source of energy.

To investigate whether children might also learn to prefer energy-dense foods, we conducted a series of experiments in which children had repeated opportunities to consume two different versions of the same food (a pudding or a yogurt, for example) that differ in energy density (for a review of these findings, see Birch, 1996). In these experiments, we have produced differences in energy density by manipulating either the fat or carbohydrate content of foods, and results are similar for both macronutrients, suggesting that energy density may be the relevant factor. The foods used in these experiments had distinct flavour cues added, but were otherwise very similar in sensory characteristics. For example, a child might consume an almond-flavoured, low-energy-density yogurt on some days, and a high-energy cherry yogurt on other days. Flavour–energy density pairing is counterbalanced across children, and serving sizes are constant across conditions. In one of these experiments (Kern *et al.* 1993) we added a 'mere exposure' contrast group, in which we compared the effects of eating foods differing in energy density with the effects of merely tasting small amounts of those foods. We also assessed the children's preferences when they were hungry, after an overnight fast, and after a meal, in the absence of hunger. This contrast was included because we hypothesized that if these preferences were attributable to a learned preference based on energy density, then preferences should be most strongly expressed during hunger.

The results are shown in Fig. 2, and provide support for associative conditioning based on the post-ingestive consequences of energy density; children learned to prefer energy-dense foods over energy-dilute foods. We have proposed elsewhere (Birch, 1992) that children's preferences for energy-dense foods, especially for high-fat foods, may be in part a result of these learned preferences, acquired via associative conditioning as a result of repeated opportunities to consume these foods and experience the consequences of ingestion. In this line of research, we focused on children's learned preferences for energy-dense foods. A related practical question is whether children's preferences for energy-dense foods are good predictors of their intake of those foods. We have obtained data on children's preferences as predictors of intake, and, in general, children's preferences are good predictors of their self-selected intake, with correlations between preferences and intake between 0·60 and 0·80 on average (Birch, 1979).

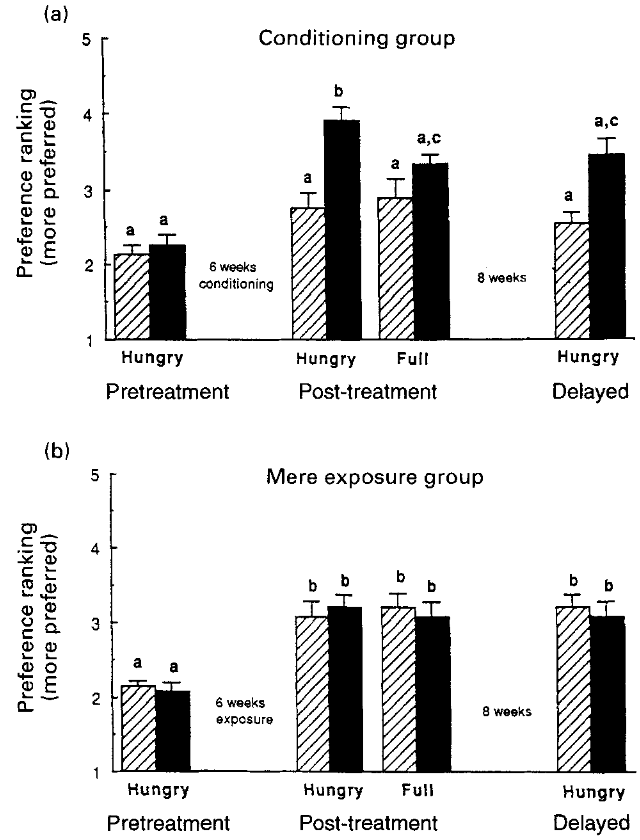

Fig. 2. Effects of (a) conditioning (n 12) or (b) mere exposure (n 15) treatment on 3- and 4-year-olds' preferences for high-fat (■) and fat-free (▨) paired flavours. After treatment, children's preferences were assessed both hungry and full. Values are means with their standard errors represented by vertical bars. [a,b,c] Mean values with unlike superscript letters were significantly different ($P < 0·05$). (From Kern *et al.* 1993.)

Children's responsiveness to energy density as a control of food intake

More recently (Fisher & Birch, 1995), we investigated whether children's preferences for high-fat foods predicted the percentage of energy from fat in their diets. In this research, all children were offered the same menus, in which 33 % of energy was derived from fat, and they self-selected their diets from the standard menus over six periods of 30 h each (intake from breakfast on day 1 through to lunch on day 2). Preference data for foods were obtained using a rank order preference procedure (Birch, 1979). Food and nutrient intakes were calculated based on weighed intake data. Although they were offered the same diets, the children's fat intakes ranged from 25 to 42 %. As shown in Table 1, children's preferences for high-fat foods predicted the percentage of energy from fat in their self-selected intake (r 0·54, $P < 0·05$). Furthermore, the children's preferences for high-fat foods were also predictive of their skinfold thicknesses, an index of children's adiposity. These findings are consistent with those from other laboratories, showing links between fat intake and adiposity in children (Gazzaniga & Burns, 1993; Nguyen *et al.* 1996). Children's fat preferences were also significantly related to their parents' BMI. We know that among adults high-fat diets are associated with greater adiposity. One hypothesis is that heavier parents were consuming diets that included many high-fat foods, and those high-fat foods were readily available to children in the home where children would have had many opportunities to learn to prefer them. Additional research is needed to investigate this possibility, but these findings suggest a possible environmental mediator of familial patterns of adiposity. These findings demonstrate that children's food preferences are important determinants of their food intake, and that these preferences can be learned via repeated exposure to

Table 1. Pearson product-moment correlations among children's fat preferences, fat intake, anthropometric measurements, and parent's BMI, dietary restraint, and dietary disinhibition scores

Variable	*n*	Children's fat preference	Children's % fat intake	Parental BMI†
Children's energy intake (%)	18	0·37	0·25	0·51
Children's fat intake (%)	18	0·54*	1·00	0·67**
Children's fat preference	18	1·00	0·54*	0·75**
Children's weight-for-stature (%)	18	0·35	0·17	0·23
Children's triceps skinfold (%)	16	0·61**	0·41	0·48
Children's subscapular skinfold (%)	16	0·30	0·34	0·45
Parental dietary restraint†	14	0·47	0·70**	0·82**
Parental dietary disinhibition†‡	14	0·24	0·39	0·70**

* $P < 0{\cdot}05$, ** $P < 0{\cdot}01$.

† Represents mean score for each pair of parents.

‡ Factor from the three-factor eating questionnaire, where high scores indicate high levels of the eating behaviour (Stunkard & Messick, 1985).

energy-dense foods. Furthermore, these learned preferences can affect the macronutrient composition and the total energy of their diets.

In addition to shaping preferences for energy-dense foods, other findings reveal that the energy density of foods can also have more direct effects on children's food intake. In particular, there is evidence that infants as young as 6 weeks can adjust their formula intake in response to changes in the energy density of formula, with infants fed on more-dilute formulas consuming greater volumes that those consuming more-energy-dense formulas (for a discussion of these findings, see Fomon, 1993). Initial research conducted in our laboratory on the food intake of 2–5-year-olds revealed similar findings. In single-meal protocols, children consumed fixed volumes of first course 'preloads' (drinks or yogurts) varying in energy density, which were high energy density on some days, low energy density on other days, followed by a self-selected second course. In a series of experiments we noted that following an energy-dilute first course children consumed significantly more in a self-selected meal than following an energy-dense first course (Birch & Fisher, 1997). Since what occurs within an eating occasion may or may not be reflective of the regulation of energy intake over longer time periods, we have also conducted research designed to determine whether children regulate energy intake over 24 h periods (Birch *et al.* 1991, 1993).

In this research we measured pre-school children's food intake over 24 h periods, at all six meals and snacks each day for at least 6 d, one session per week (Birch *et al.* 1991, 1993). Children were attending a day-care programme, and they were offered the same menus at each meal across the experimental periods. The results shown in Fig. 3 were expressed as CV for individual meals, and for 24 h intake. While there were large individual differences among children in their CV for energy intake, the general pattern that emerged across all children was one in which large CV for individual meals occurred in conjunction with small CV for total energy intake. While CV for individual eating occasions averaged 34 %, those for 24 h total energy intake averaged about 10 %. When we examined individual children's patterns of intake across successive meals, energy intake was negatively correlated, with large meals followed by small ones and *vice versa*. This pattern of findings suggests that despite highly variable intake at individual meals, children's total energy intake is relatively constant because they regulate energy intake across successive meals.

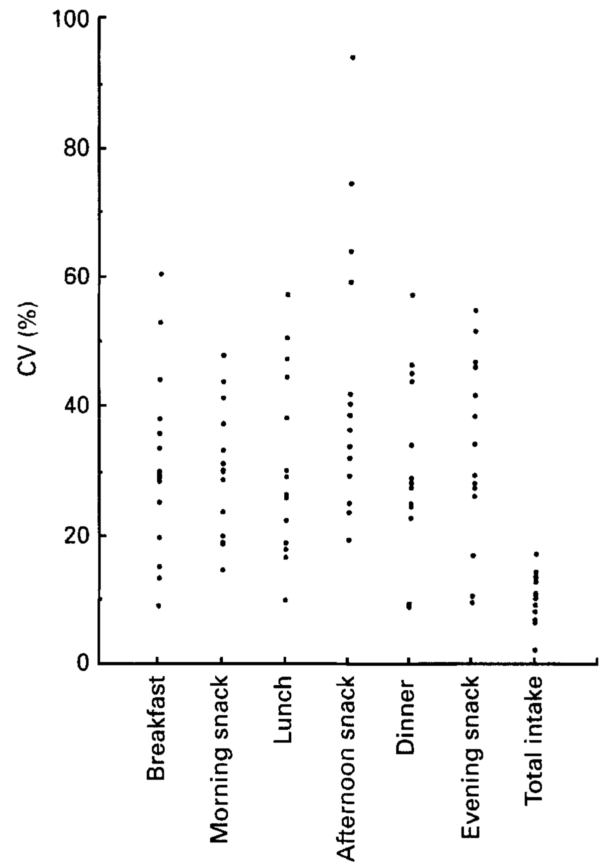

Fig. 3. CV for total energy intake and for intake at the six meals and snacks for individual children (within-subject variation). Each point represents the mean value for a single child for 6 d, except where the values for two children coincide and one data point is shown. (From Birch *et al.* 1991.)

Individual differences in the controls of energy intake: effects of child feeding practices on children's intake and adiposity

As shown in Fig. 3, there are large individual differences in how tightly energy intake was regulated over 24 h periods. In subsequent research we have identified predictors of individual differences in the extent to which children are responsive to energy density as a control of food intake (Johnson & Birch, 1994). We have consistently noted clear sex differences in responsiveness to energy density, with boys adjusting energy intake more precisely in single-meal protocols than girls. Furthermore, patterns of interactions involving child gender suggests that boys and girls are being parented differently with respect to food and eating, and that boys and girls may have also been responding differently to maternal control attempts. Mothers' child-feeding practices, especially the extent to which they reported restricting and encouraging children's intake, proved to be significant predictors of children's responsiveness to energy density as a control of food intake; mothers who reported greater attempts to control what and how much children consumed had children who were less responsive to energy density in regulating their intake. Furthermore, mothers who reported assuming greater control over their children's intake also reported using higher levels of dietary restraint in controlling their own intake. Dietary restraint is a measure of the extent to which intake is restricted by conscious strategies, such as 'counting calories', and was measured using the restraint subscale of the eating inventory (Stunkard & Messick, 1985). These findings revealed that high levels of dietary restraint in mothers as well as greater adiposity in daughters was predictive of lower responsiveness to energy density among daughters. We interpret these findings as evidence that when mothers exert higher levels of external control over children's eating, children show reduced responsiveness to hunger and satiety cues in controlling intake and increased responsiveness to the presence of palatable foods (Birch *et al.* 1987; Fisher, 1997; Fisher & Birch, 1998; JO Fisher and LL Birch, unpublished results).

Currently, we have been conducting a series of studies to investigate the links between parents' child-feeding practices and children's food intake. In this work, rather than measuring children's responsiveness to energy density, we are investigating the 'flip side' of responsiveness to energy density as a control of intake. In this case, we are focusing on individual differences in the extent to which children's eating is elicited by the presence of palatable food in the absence of hunger when children are given access to palatable foods. We explored the relationship between maternal restriction of children's intake of palatable snack foods on children's subsequent response to and intake of those foods, using a free access protocol designed to assess children's responsiveness to palatable foods in the absence of hunger (Fisher & Birch, 1996). We also explored maternal and child characteristics that could serve as predictors of maternal control. Participants were seventy-one 3- to 5-year-olds and their mothers. We obtained anthropometric measures on mothers as well as on children, and also measured mothers' dietary restraint and disinhibition. Children ate their standard preschool lunch, and were invited individually to come to our laboratory immediately following lunch, where their hunger levels were first assessed. Since we wanted to see children when hunger cues were minimal, any child who indicated that she was still hungry was thanked and returned to the classroom, to be seen another day when they reported being full after lunch. After assessing the child's preferences for the set of ten snack foods (including cashews, potato chips, pretzels, chocolate bars, popcorn, Skittles, ice cream, frozen yogurt, chocolate chip cookies and fig bars) using our standard procedure, the adult excused herself and explained that she would be back in a few minutes, and that the child could eat or play with the toys available until she returned. Measures of interest were derived from the child's intake during this 10 min free access period. Results indicated that on average children consumed about 928 kJ, corresponding to about 15 % of the total recommended energy intake for children of this age, despite the fact that they had just consumed a lunch, and had indicated that they were not hungry. The results differed dramatically for girls and boys, as shown in Fig 4. Overall, the child's weight-for-height was a good predictor of intake, as has been reported previously in the literature (Birch *et al.* 1991). After adjusting for weight-for-height, maternal restriction remained a significant predictor for girls, with mothers who reported greater restriction having daughters who ate more in the free access setting. The sex × restriction interaction indicates that no such relationship was noted for boys. While this work does not provide evidence regarding causality, subsequent experimental research (Fisher & Birch, 1998) revealed that restricting access to palatable snack foods can increase selection and intake of those foods when they are made freely available. Mothers' own dietary restraint, the extent to which she consciously restricted her own intake, predicted her attempts to restrict her daughter's intake.

These findings are especially provocative in light of the previously cited data indicating that dieting and chronic dietary restraint have become normative among women in the USA today. The results of a recent update of a National Institutes of Health Technology Assessment Conference statement on methods for voluntary weight loss and control (National Institutes of Health Technology Assessment Conference Panel, 1992) indicate that chronic or repeated dieting is typically ineffective and may be harmful to women. Many of these women are mothers, and our findings suggest that the negative effects of chronic dieting may extend to their daughters. Chronic dietary restraint may be harmful to women's physical or psychological health, and our findings suggest the possibility that chronic dieting by mothers may also contribute to the aetiology of problems of energy balance in their young daughters.

We have reported that maternal dietary restraint is associated with maternal restriction of daughters' intake. Our findings suggest that even at this very early age child-feeding practices differ by child gender. These restrictive

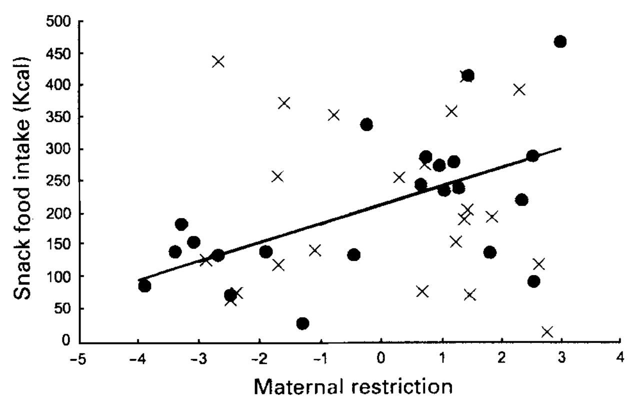

Fig. 4. Predicted and actual values of children's snack food intake for different levels of maternal restriction expressed in standardized Z scores. Regression equation for children's predicted snack intake = 215·0 + 29·3 (gender × maternal restriction). (●), Girls; (×), boys. (From Fisher, 1997.)

practices, apparently used more extensively by mothers with girls than with boys, have the effect of shifting the focus of the child's controls of food intake from hunger and satiety to responsiveness to environmental cues, such as the presence of palatable foods. We have also seen that restriction can contribute to unhealthy dietary practices by fostering preferences for, and intake of, energy-dense foods high in sugar and fat. These early gender differences in child-feeding practices used with girls and boys, especially the greater use of restriction with girls, may be developmental precursors of later gender differences in the prevalence of dieting and weight concerns.

Summary and conclusions

As young omnivores, children make the transition from the exclusive milk diet of infancy to consuming a variety of foods. They must learn to accept a set of the foods available in their environmental niche, and they 'come equipped' with a set of predispositions that facilitate the development of food acceptance patterns, constrained by predisposition and limited by what is offered to them. While children are predisposed to like sweet or salty foods and to avoid sour or bitter foods, their preferences for the majority of foods are shaped by repeated experience. The predispositions that shape food acceptance patterns also include neophobia and the predisposition to learn to prefer and accept new foods when they are offered repeatedly. In addition, the predisposition for associative conditioning affects children's developing food acceptance patterns, resulting in preferences for foods offered in positive contexts, while foods presented in negative contexts will become more disliked via the learning of associations with the social and environmental contexts. Children also learn to prefer energy-dense foods when consumption of those foods is followed by positive post-ingestive consequences, such as those produced when high-energy-density foods are eaten when hungry. Although children are predisposed to be responsive to the energy content of foods in controlling their intake, they are also responsive to parents' control attempts. We have seen that these parental control attempts can refocus the child away from responsiveness to internal cues of hunger and satiety and towards external factors such as the presence of palatable foods. This analysis suggests that taking a closer look at what children are learning about food and eating may provide clues regarding the formation of children's food acceptance patterns, and that this approach also suggests potential causative factors implicated in the aetiology of obesity and the emergence of weight concerns. Current data, although limited, suggest that child-feeding practices play a causal role in the development of individual difference in the controls of food intake, and perhaps in the aetiology of problems of energy balance, especially childhood obesity. These relationships should be pursued in future research.

References

Beauchamp GK, Cowart BJ & Moran M (1986) Developmental changes in salt acceptability in human infants. *Developmental Psychobiology* **19**, 17–25.

Birch LL (1979) Preschool children's food preferences and consumption patterns. *Journal of Nutrition Education* **11**, 189–192.

Birch LL (1992) Children's preferences for high-fat foods. *Nutrition Reviews* **50**, 249–255.

Birch LL & Fisher JA (1995) Appetite and eating behavior in children. *Pediatric Clinics of North America* **42**, 931–953.

Birch LL & Fisher JA (1996) The role of experience in the development of children's eating behavior. In *Why We Eat What We Eat: The Psychology of Eating*, pp. 113–141 [ED Capaldi, editor]. Washington, DC: American Psychological Association.

Birch LL & Fisher JO (1997) Food intake regulation in children: Fat and sugar substitutes and intake. *Annals of the New York Academy of Sciences* **819**, 194–220.

Birch LL, Fisher JO & Grimm-Thomas K (1996) The development of children's eating habits. In *Food Choice, Acceptance and Consumption*, pp. 161–206 [HL Meiselman and HJH MacFie, editors]. London: Blackie Academic & Professional.

Birch LL, Gunder L, Grimm-Thomas K & Laing DG (1998) Infant's consumption of a new food. *Appetite* **30** 283–295.

Birch LL, Johnson SL, Andresen G, Peters JC & Schulte MC (1991) The variability of young children's energy intake. *New England Journal of Medicine* **324**, 232–235.

Birch LL, Johnson SL, Jones MB & Peters JC (1993) Effects of a non-energy fat substitute on children's energy and macronutrient intake. *American Journal of Clinical Nutrition* **58**, 326–333.

Birch LL, McPhee L, Shoba BC, Steinberg L & Krehbiel R (1987) 'Clean up your plate': Effects of child feeding practices on the conditioning of meal size. *Learning and Motivation* **18**, 301–317.

Birch LL & Marlin DW (1982) I don't like it; I never tried it: Effects of exposure to food on two-year-old children's food preferences. *Appetite* **4**, 353–360.

Birch LL, Marlin DW & Rotter J (1984) Eating as the 'means' activity in a contingency: Effects on young children's food preference. *Child Development* **55**, 432–439.

Birch LL, Zimmerman S & Hind H (1980) The influence of social-affective content on preschool children's food preferences. *Child Development* **51**, 856–861.

Booth DA, Mather P & Fuller J (1982) Starch content of ordinary foods associatively conditions human appetite and satiation indexed by intake and eating pleasantness of starch-paired flavors. *Appetite* **3**, 163–184.

Capaldi ED (editor) (1996) Conditioned food preferences. In *Why We Eat What We Eat: The Psychology of Eating*, pp. 53–80. Washington, DC: American Psychological Association.

Fisher JA (1997) Forbidden fruit: does restricting access to food influence children's eating? PhD Dissertation, The Pennsylvania State University.

Fisher JA & Birch LL (1995) Fat preferences and fat consumption of 3- to 5-year-old children are related to parental adiposity. *Journal of the American Dietetic Association* **95**, 759–764.

Fisher JO & Birch LL (1996) Maternal restriction of young girls' food access is related to intake of those foods in an unrestricted setting. *FASEB Journal* **10**, A225.

Fisher JO & Birch LL (1998) Restricting access to a freely available snack food impacts pre-school children's subsequent selection and consumption patterns. *FASEB Journal* **12**, A530.

Fomon SJ (1993) *Nutrition of Normal Infants*. St Louis, MO: Mosby-Yearbook.

Galef BG Jr & Beck M (1991) Diet selection and poison avoidance by mammals individually and in social groups. In *Handbook of Behavioral Neurobiology*, vol. 10, pp. 329–346 [E Stricker, editor]. New York: Plenum Press.

Garcia J, Hankins WG & Rusinak KW (1974) Behavioral regulation of the milieu interne in man and rat. *Science* **185**, 824–831.

Gazzaniga JM & Burns TL (1993) Relationship between diet composition and body fatness, with adjustment for resting expenditure and physical activity, in preadolescent children. *American Journal of Clinical Nutrition* **58**, 21–28.

Goodrick GK, Poston WSC II & Foreyt JP (1996) Methods for voluntary weight loss and control: Update 1996. *Nutrition* **12**, 672–676.

Hamill PVV, Drizel TA, Johnson CL, Reed RB, Roche AF & Moore WM (1979) Physical growth: National Center for Health Statistics Growth Chart. *American Journal of Clinical Nutrition* **32**, 607–629.

Hendricks KM & Badruddin SH (1992) Weaning recommendations: The scientific basis. *Nutrition Reviews* **50**, 125–133.

Johnson SL & Birch LL (1994) Parents' and children's adiposity and eating style. *Pediatrics* **94**, 653–661.

Kalat JW & Rozin P (1973) 'Learned safety' as a mechanism in long-delay taste-aversion learning in rats. *Journal of Comparative and Physiological Psychology* **83**, 198–207.

Kern DL, McPhee L, Fisher J, Johnson S & Birch LL (1993) The postingestive consequences of fat condition preferences for flavors associated with high dietary fat. *Physiology and Behavior* **54**, 71–76.

Killen JD, Taylor CB, Hammer LD, Litt I, Wilson DM, Rich T, Hayward C, Simmonds B, Kraemer H & Varady A (1993) An attempt to modify unhealthful eating attitudes and weight regulation practices of young adolescent girls. *International Journal of Eating Disorders* **13**, 369–384.

Maloney MJ, McGuire J, Daniels SR & Specker B (1989) Dieting behavior and eating attitudes in children. *Pediatrics* **84**, 482–487.

Martin I & Levey AB (1978) Evaluative conditioning. *Advances in Behavior Research and Therapy* **1**, 57–102.

Mennella JA & Beauchamp GK (1991) Maternal diet alters the sensory qualities of human milk and the nursling's behavior. *Pediatrics* **88**, 737–744.

Muñoz KA, Krebs-Smith SM, Ballard-Barbash R & Cleveland LE (1997) Food intakes of US children and adolescents compared with recommendations. *Pediatrics* **100**, 323–329.

National Institute of Diabetes and Digestive and Kidney Diseases (1997) Increased prevalence of overweight in preschoolers shows need for early intervention. *WIN Notes*. Bethesda, MD: National Institutes of Health.

National Institutes of Health Technology Assessment Conference Panel (1992) Methods for voluntary weight loss and control. *Nutrition Reviews* **50**, 340–345.

Nguyen VT, Larson DE, Johnson RK & Goran MI (1996) Fat intake and adiposity in children of lean and obese parents. *American Journal of Clinical Nutrition* **63**, 507–513.

Prentice AM (1996) Food and nutrient intake and obesity. In *Progress in Obesity Research*, vol. 7, pp. 451–457 [A Angel, H Anderson, C Bouchard, D Lau, L Leiter and R Mendelson, editors]. London: John Libbey.

Rozin P, Ashmore M & Markwith M (1996) Lay American conceptions of nutrition: Dose insensitivity, categorical thinking, contagion, and the monotonic mind. *Health Psychology* **15**, 438–477.

Sclafani A (1990) Nutritionally based learned flavor preferences in rats. In *Taste, Experience, and Feeding*, pp. 139–156 [E Capaldi and T Powley, editors]. Washington, DC: American Psychological Association.

Steiner JE (1979) Facial expressions of the neonate infant indicating the hedonics of food-related stimuli. In *Taste and Development: The Genesis of Sweet Preference. NIH Publication* no. 77–1068, pp. 173–189 [JM Weiffenbach, editor]. Washington, DC: US Department of Health and Human Services.

Stunkard AJ & Messick S (1985) The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. *Journal of Psychosomatic Research* **29**, 71–83.

Sullivan S & Birch L (1990) Pass the sugar; pass the salt: Experience dictates preference. *Developmental Psychology* **26**, 546–551.

Sullivan SA & Birch LL (1994) Infant dietary experience and acceptance of solid foods. *Pediatrics* **93**, 271–277.

Thelen MH & Cormier JF (1995) Desire to be thinner and weight control among children and their parents. *Behavior Therapy* **26**, 85–99.

US Department of Agriculture (1996) *Nutrition and Your Health: Dietary Guidelines for Americans. DHHS Home and Garden Bulletin* no. 232, *4th ed.* Washington, DC: US Government Printing Office.