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Editorial

Persuading children to eat enough fruit and vegetables is a universal problem in developed countries. The articles in this edition of the newsletter focus on the early years with good reason. Food preferences are influenced by experiences during the very earliest stages of life, as Catherine Forestell's contribution, 'Prenatal and post-natal influences on fruit and vegetable acceptance throughout childhood', describes. Innate predispositions to prefer sweet or energy-dense foods and to dislike those that are sour and bitter, act as barriers to children's vegetable intake, but experience also plays a role. Mothers who consume plenty of vegetables during pregnancy and while breastfeeding provide their infants with experience of flavours through amniotic fluid and breast milk. This taste exposure appears to enhance acceptance and increase preference for novel foods at weaning.

The importance of early experience is further demonstrated in the work of Sophie Nicklaus and her colleagues. The second article in the newsletter, 'Vegetables: choices at the age of 2-3 years and link with preferences until adulthood', describes longitudinal research study in a French day-care centre. Two to three year old children's food choices during buffet lunches were recorded and examined in relation to their food preferences from 4 to 22 years later. Preferences for vegetables, and variety of vegetables consumed at follow-up, were predicted by intake at baseline, suggesting that lifelong eating patterns may already be established in early childhood.

The third article 'Healthy eating in childhood: the importance of exposure' (Lucy Cooke from University College London) rounds off the issue by suggesting ways in which exposure (or experience) can be manipulated to increase children's acceptance of vegetables. Children's tendency to avoid unfamiliar food (neophobia) is known to be a barrier to fruit and vegetable intake, but can be overcome with repeated tasting of small quantities. In a series of semi-naturalistic studies using socio-economically diverse samples of parents of children from 2-7 years of age, the efficacy of this approach has been demonstrated. These studies offer hope to despondent parents who have all but given up trying to cajole their young children into eating up their greens!

A growing body of research points to the early childhood years as a critical period for the development of eating habits and evidence of the most effective techniques for improving children's dietary patterns is beginning to emerge. Dissemination of these findings to parents and all concerned with the feeding of young children must be a priority.

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Prenatal and Postnatal Influences on Fruit and Vegetable Acceptance throughout Childhood

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The establishment of a balanced diet early in life that includes adequate intake of fruits and vegetables lays an important foundation for long-term physical, cognitive and emotional health. Because fruit and vegetable intake is associated with prevention of several noncommunicable diseases such as obesity[1] and cancer,[2] various health authorities recommend consumption of five to ten servings daily.[3], [4] However, adults' intake of fruits and vegetables remains substantially below recommended levels.[5,6] Moreover, recent evidence indicates that these poor eating habits begin early in life. By two years of age, many children are eating too many sweet and salty snacks, which are displacing healthy alternatives like fruits and vegetables.[7, 8]

As most parents and caregivers will testify, increasing young children's fruit and vegetable consumption can pose a considerable challenge, since their food intake is controlled by a myriad of innate predispositions and individual preferences. For example, because children are innately predisposed to dislike bitter tastes,[9,10] they typically avoid cruciferous and leafy vegetables. Children also have an innate preference for sweet tastes that persists throughout infancy and childhood.[11, 12] Although fruits are predominantly sweet, they are also avoided likely because of the widespread availability of a variety of highly palatable, energy-dense alternatives such as sweetened beverages and desserts. Another significant predictor of low fruit and vegetable intake is neophobia,[13, 14] or the innate tendency to reject new foods,[15] which is especially prevalent between two and three years of age.[16] While these innate predispositions likely evolved, in part, to attract children to familiar sources of calories and avoid bitter-tasting toxins, in our current environment they can lead to maladaptive feeding patterns that result in reduced dietary variety and inadequate nutrition. However, as will be discussed in this article, early flavor experiences which occur during gestation and lactation may interact with these innate predispositions to enhance children's flavor preferences and improve long-term eating habits.

Early Flavor Learning

Psychophysical studies have shown that children's first exposure to flavors occurs before birth in the intrauterine environment. Flavors of foods within mothers' diets, such as garlic,[17] alter the odor of amniotic fluid, which is swallowed and inhaled by the fetus by the last trimester of pregnancy. After birth, exposure to these flavors continues, since the flavor of breast milk also reflects the mothers' dietary choices.[18] These flavor changes in amniotic fluid and breast milk are not only perceived by the fetus and infant respectively, but they bias preferences after birth as well.[19, 20] This has been demonstrated experimentally in a study in which infants, whose mothers consumed carrot juice either during pregnancy or the first two months of lactation, displayed fewer negative responses while eating carrot-flavored cereal when compared to plain cereal at six months of age.[21] These early exposures to flavors within the mothers' diet may serve to heighten children's hedonic responses to these flavors when they are later experienced in foods at weaning.

Exposure to dietary flavors in amniotic fluid and breast milk may be one way that infants learn which foods are "safe", thereby reducing food neophobia and increasing infants' readiness to accept new flavors. In one study, when infants were fed a green vegetable daily over a 10-day exposure period, breastfed infants increased their acceptance of the green vegetable more dramatically than formula-fed infants.[22] Further research has shown that these early feeding experiences may have long-term consequences. For example, girls who were breastfed for at least six months were less likely to be picky eaters at 7 years of age.[23] One explanation for these findings is that unlike formula feeding, which exposes infants to a monotony of flavors, breastfeeding provides varied sensory experiences, which may facilitate diet diversity throughout development.

Conclusions

Although more research is needed to understand how early experiences affect later consumption of foods such as fruits and vegetables, it appears that repeated exposure to a variety of flavors within amniotic fluid and breast milk enhances children's acceptance and preference for novel foods at weaning. Because the development of preferences for healthy food choices begins during gestation and breastfeeding, it is the first, but not the only way in which children learn about the foods that are accepted and preferred by their mothers. As children grow and mature, the effects of these early experiences interact with a host of other factors, many of which are determined by children's parents. Factors, such as genetic make-up (i.e., sensitivity to bitter tastes),[24] child-feeding strategies,[16, 25] food availability[26] and social modeling of healthy eating habits[27] are just a few of the variables that interact and contribute to the development of life-long preferences for fruits and vegetables and healthy eating patterns in general.

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Vegetables:
choices at the age of 2-3 years and link with preferences until adulthood

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Children are known for avoiding consumption of vegetables. However, in (some!) adults, vegetables naturally belong to the food repertoire. How does vegetable consumption evolve between childhood and adulthood?

Early childhood: not a good time for vegetables!

From 1982 to 1999, in a day care in Dijon, France, children aged 2 to 3 years were offered a "buffet" for lunch (Nicklaus et al., 2005a; b). In this relatively unusual setting, they could choose freely what to eat among an offer of two appetizers (often at least one vegetable salad), one protein-based dish (meat, fish or egg), two side dishes (most often one starchy food and one vegetable), two cheeses and bread. Desserts were not offered at lunch but during an afternoon snack. Children could take as much food as they wanted, provided they had cleaned their plate before taking more food. If they were not hungry, they were not forced to eat. Trained day care assistants recorded their food choices. Each of the 418 children in this study took part in 109 (± 48) lunches on average during which 117 (±19) different foods were offered.

The most often chosen foods were animal products except cold fish (top 4: sausage, breaded fish, ham, cured sausage), starchy foods (top 4: French fries, pasta, rice, couscous) and dishes made of starchy and animal products such as salty cake, cheese puff and quiche. The ten foods that were least often chosen were all vegetables: braised lettuce, steamed chicory, chicory salad, cauliflower salad, leek with vinaigrette, red cabbage salad, ratatouille, green cabbage, Brussels sprouts and baked tomatoes.

Proposing reasons why vegetables were not chosen in this setting is speculative. In young children, the nutrient composition might be a strong determinant of choice. Energy-dense foods were often chosen, as well as protein-rich foods. Sensory properties might also explain choices: foods with strong flavours (developed aromas, acidity, and bitterness) or with fibrous texture were often avoided. In the case of vegetables, both a low energy-density and unpleasant sensory properties (bitterness, texture) might account for their avoidance by toddlers.

Evolution of liking of vegetables until adulthood: reason for hoping...

In 2001 and 2002, the children whose food choices were recorded at 2-3 years old were surveyed to assess their current food preferences, the variety of their food repertoire and their food neophobia (Nicklaus et al, 2004; 2005c). Their age varied then between 4 and 22 years old. We studied whether their current food preferences were related to their food choices when they were 2-3 years old, and to their current age, taking into account possible gender differences.

Whatever food group was considered (animal food, vegetables, starchy foods, cheeses and mixed dishes), food choice at 2-3 years old significantly predicted current preference for foods from the same group. In the case of vegetables however, this relation was true for girls but not for boys. In both genders, preference for vegetables increased regularly with age. This was observed for beetroot, carrot, cucumber, chicory, tomato, ratatouille, sauerkraut, cauliflower, Brussels sprouts, spinach, turnip, leek and peas. Furthermore, we observed that in both genders, the variety of vegetables chosen in the day care buffet at 2-3 years old significantly predicted the variety of vegetables currently consumed.

This underlines that early consumption of vegetables is beneficial for future preference; and that preference for vegetables is partly determined already at 2-3 years old and increases with age, likely due to mechanisms that were not investigated in this survey. The vegetables for which preference increased with age are relatively common in the French repertoire, so they might have been repeatedly offered throughout childhood becoming more accepted as a result of repeated exposures (see paper from L. Cooke for insight on the role of exposure on preference for vegetables).

Perspective

We showed that there is a link between consumption, degree of choice of vegetables in early childhood and preference for vegetables during later stages of life. However the most bitter or fibrous vegetables were not an easy choice for toddlers and were avoided most of the time. Acceptance at this age might depend on earlier exposure to vegetables, for instance at the age when infants start to consume food other than milk (see paper from A. Forestell for insight on the role of very early exposure to vegetables of vegetable flavour). In all instances, the role of parents is central in providing a varied and healthy diet consistently throughout infancy and childhood and in modelling consumption of healthy food.

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Healthy Eating in Childhood:
The Importance of Exposure

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Children's food preferences are strongly associated with their consumption patterns[1]. Identifying factors that determine preferences is therefore crucial to the development of effective interventions to improve children's diets. One of the most important determinants of a child's liking for a particular food is the extent to which the food is familiar[2]. In other words, children like what they know and they eat what they like.

The problem of neophobia

In theory, all a parent need do to ensure a healthy diet for their child is to provide a wide variety of nutritious foods and feed them often enough for those foods to become familiar. Unfortunately, a major barrier to increasing the familiarity of foods is a trait termed food neophobia (literally, 'fear of the new') that typically emerges during the second year of life[3]. This manifests as an avoidance of, and reluctance to taste new foods and has been associated with poorer dietary quality and lower fruit and vegetable intake[4,5].

The effect of exposure

An extensive literature, both epidemiological and experimental, indicates that with experience of repeated tasting or "exposure", neophobia can be reduced and dislikes transformed into likes. Surveys of food consumption and preferences have identified a link between early experience of tastes and subsequent food acceptance. For example, a cross-sectional survey of mothers of preschool children found that early introduction to fruits and vegetables during weaning was associated with increased intake in 2-6 year-olds [4]. Likewise a longitudinal study in the US found that exposure to a wide variety of fruits in the first two years of life predicted variety of fruits consumed by school-aged children[6].

Experimental studies have also provided evidence of the efficacy of exposure in increasing food preferences in animals as well as in human infants[7], preschoolers[8], and adults[9]. The strength of the neophobic response changes during development as does the number of exposures required to effect change. In infants, a single exposure may be sufficient to dramatically increase intake and liking[7] and effects may generalise to similar foods. Older children and adults on the other hand, may need as many as 10-15 taste exposures before benefits are observed[8]. Laboratory-based research has also shown that there are circumstances in which exposure is less effective; for example, when the target food is intrinsically unpalatable or when exposure is in a different modality to that in which changes in preferences are being attempted, e.g. offering repeated visual exposure to food. Overall, however, the evidence clearly supports the use of taste exposure in healthy eating interventions.

Naturalistic studies

In order to investigate whether the results of these studies can be replicated in real-world eating situations, we have carried out a series of more naturalistic studies aimed at increasing children's acceptance of vegetables. Vegetables are an important target for intervention because children's consumption is known to be inadequate and neophobia is specifically associated with lower intake. The first of these, a randomised, controlled trial in a school setting evaluated two interventions, one reward-based and one exposure-based[10]. Children aged 5-7 were randomised to one of the intervention groups or to a no-treatment control after a pre-intervention session during which they tasted and rated pieces of red pepper (uncooked). Eight days of either simple tasting or tasting rewarded with a sticker followed for the two experimental groups, with no further intervention for the control group. Children in the exposure group's liking and intake of the pepper increased significantly from pre- to post-intervention, as did that of the reward group, but to a smaller extent, suggesting that giving rewards may limit the impact of exposure.

In a second study of 2-6 year-olds, mothers randomised to an exposure condition were taught exposure feeding techniques and asked to offer their child a taste of an individually-selected, target vegetable every day for 14 days. Greater increases in liking, ranking and intake were observed in the exposure group when compared both with an information group given healthy eating leaflets or a no-treatment control group. Increases were significant only in the exposure group[11].

There is a need to test the effectiveness of this approach in more socio-economically disadvantaged populations among whom vegetable intake is known to be particularly low. We therefore undertook a pilot study to evaluate a similar exposure-based intervention delivered in a group setting to low income mothers and their two year old children (Cooke & Wardle, manuscript submitted). Significant increases in liking of and intake of a target vegetable were observed after two weeks of daily tasting. Mothers were very positive about the content and format of the intervention and about the value of the exposure techniques that they had been taught. A randomised controlled trial is now needed to replicate these findings in a larger sample with a longer term follow-up.

Summary

The power of "mere exposure" to alter children's food preferences is well-established and experimental findings have begun to inform the content of interventions. If future large-scale interventions prove to be successful, simple advice could be offered to health professionals or to parents themselves.

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