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Early Influences on Taste Preferences

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Introduction

In this review, the 'early influences' considered include genetic, prenatal, early postnatal and childhood influences on perception and taste preferences. 'Taste' is used in its broad sense, including taste, flavor, and texture. 'Preferences' include responses to tastes and flavors, as well as to foods and beverages.

People differ in taste and smell sensitivity [1, 2], and in behavioral traits important in food choice [2]. At least some of these differences are of genetic origin. Intrauterine influences include experiences early in pregnancy, such as the effects of the mother's morning sickness on the salt preference of her offspring [3] and, later in pregnancy, where flavors experienced in the mother's amniotic fluid may influence subsequent preferences [4, 5]. Flavors experienced during the first 2–3 months of life can influence food preferences later in childhood [6] and perhaps into adulthood [7]. Experience with a variety of foods during weaning can ease acceptance of new food flavors [8]. Lastly, longitudinal studies suggest that food preferences and choices at 2–3 years old have a predictive value for preferences later in childhood [9] and, for some foods, into adolescence [10, 11].

We first describe some of the findings mentioned above and then explore their theoretical and practical implications, suggesting ways to help mothers successfully introduce new foods during weaning and beyond.

Development of the Senses

Anatomically complete taste buds can be identified in the human fetus by the 15th week of gestation, and olfactory neurons, apparently functional, are present by about the 25th week. Although it is difficult to establish at what

stage in gestation the fetus actually begins to experience tastes and flavors, it has been known for more than 100 years that infants born 1 or 2 months prematurely respond to some tastes. In 1859, Kussmaul [12] reported that premature infants sucked with apparent satisfaction on sweet substances and rejected bitter solutions. This was confirmed by later studies [for review see 13, 14]. In the last months of gestation the fetus 'inhales' amniotic fluid and so may be exposed to any aromas present therein [14]. In addition, newborn infants respond to aromas that could only have been experienced prenatally [5] (see 'Effects of prenatal sensory experience on later reactions to foods', below) so it is reasonable to conclude that during the last weeks of a normal pregnancy the fetus is able to detect food aromas reaching the mother's amniotic fluid.

Kussmaul [12] was also the first to report that newborn infants clearly detect and respond to different tastes. His observations that they lick and smack their lips when offered a sweet solution, purse their lips when tasting strong acids and spit out strong bitter tastes have since been confirmed by many others. Lipsett [13] provides a good historical review of this work, also noting, as do Beauchamp and Mennella [14], that neonates show no distinctive response to weak salt solutions and do not refuse weak acid or bitter tastes. Many different cultures provide infants with sweetened 'pre-lacteal' feeds [14, 15], often consisting of honey or sugared water, sometimes supplemented with oils or herbs. Although the rationales for pre-lacteal feeding vary, they are certainly considered pleasing for the infant [14], thus confirming that a 'liking for sweet tastes' by newborn infants is easily detected.

Similarly, newborn infants detect and respond to some odors. Steiner [16] reported that about 50% of newborn infants responded positively to butter, banana and vanilla aromas, and speculated that these reactions may be innate. More recently, Schaal et al. [4] provided an alternative explanation, showing that responses to food aromas can be learned in utero.

Genetic Influences on Perception and Food Preference

The earliest influences on development of perception are (a) genetic predispositions to like some tastes and dislike others, and (b) differences in sensitivity to some tastes and flavors inherited from parents. Genetic predispositions are not fixed and can change according to experience. This was nicely demonstrated by Moskowitz et al. [17] who reported that an Indian community, used to eating tamarind, liked strong acid and bitter tastes. Inherited differences in sensitivity to particular tastes and flavors can influence preferences and food choices [18, 19], but so far the effects observed are not large. The most completely studied are the inherited differences in sensitivity to 6-*n*-propyl thiouracil (PROP). Some people perceive 0.001*M* PROP as

extremely bitter, while for others it is not bitter at all [18]. These differences can be linked (although usually with poor predictive power) to differences in food preferences. Thus, Turnbull and Matisoo-Smith [20] showed that 3- to 6-year-old children who were PROP tasters disliked raw spinach (but not cooked spinach or raw or cooked broccoli) more than did non-tasters.

Children who are PROP tasters also seem to like less intense sweet tastes than do non-tasters [21]. Following up on this, Lin [22] recently reported an inverse correlation ($r = -0.51$, $p < 0.0001$) between sensitivity to PROP and the frequency of dental caries in 6- to 12-year-old children. This possible health consequence of a genetic difference in taste sensitivity merits further study.

Behavioral traits can also be genetically influenced, so it is probable that neophobia and variety-seeking are to some extent inherited. At present it is not possible to evaluate the relative contributions of genetics and environment to these behaviors but they need more exploration.

Effects of Prenatal Sensory Experience on Later Reactions to Foods

Aromas of at least some of the foods eaten by the pregnant woman find their way into her amniotic fluid, so if she eats garlic then her amniotic fluid smells of garlic [23], if she eats curry it smells of curry [24], etc. Two recent studies [4, 5] show that aromas experienced in utero appear to influence the infant's responses to aromas and foods. Schaal et al. [4] gave women an anise-flavored drink daily during the last weeks of pregnancy. In the first hours after birth, the infants showed positive facial responses to anise aroma if the mother had consumed anise during the last weeks of pregnancy. This observation offers a possible explanation for the results of Steiner [16]. As noted above, he found that about half the newborn infants he tested appeared to like banana aroma. It is possible that their mothers ate bananas in the last weeks of pregnancy whereas the mothers of non-responding infants did not.

Mennella et al. [25] found that, if mothers consumed carrot juice for several days during the last weeks of pregnancy, at weaning the infant showed more enthusiasm for a carrot-flavored cereal than an unflavored one. An evident limitation of this study was that the mother could not be 'blind' to the treatment, so may have influenced the behavior of her infant by pathways other than flavor experience.

For the moment, we can conclude that these first results are fascinating and promising, but that much more needs to be done before we fully understand prenatal influences on subsequent food choice.

Crystal and Bernstein [3] identified another prenatal influence, specifically on salt taste preference. They showed that the offspring of mothers who had

experienced moderate or severe morning sickness during pregnancy had greater salt preference and greater salt use. As women with different levels of morning sickness did not differ in reported salt use prior to pregnancy or as a function of their pregnancy symptoms, this effect seems to be specifically linked to vomiting early in pregnancy. The mechanism could involve a change in expression of (or response to) angiotensin II. Whatever the mechanism, the long-term increases in salt use could have long-term health consequences in salt-sensitive hypertensive people.

Effects of Early Postnatal Flavor Experiences on Subsequent Food Preferences

Flavors experienced in the first 2–3 months of life can influence subsequent food preferences.

The flavors of at least some foods eaten by lactating mothers quickly find their way into her milk. If the mother eats garlic, her milk smells of garlic [26] and the baby responds, often by taking more milk (at least, during the first garlic-flavored feed). Similarly, if the mother consumes vanilla, her milk tastes of vanilla [27]. Thus, in contrast to infant formula, mother's milk provides a potentially rich and complex sensory experience for the infant, reflecting in part the mother's eating habits and food culture [28].

Sullivan and Birch [29] showed that, at weaning, breastfed infants adapted more rapidly to new foods than did bottle-fed infants, suggesting perhaps that their richer sensory experience facilitated acceptance (or that they had already come across aspects of the new flavors in their mother's milk).

For evident ethical and practical reasons it is not easy to study the long-term effects of flavors in the mother's milk or bottle formula. However, in a series of studies using hydrolyzed infant formula, Mennella et al. [6, 30–32] cleverly used a 'natural experiment' to show that flavor experiences in the first few weeks of life can indeed influence later preferences. Hydrolyzed formula is appropriate for children with severe allergies to milk proteins and has a distinctive (and to adults, very unpleasant) acid, bitter, 'burnt' taste due to the free amino acids and small peptides it contains. As some children are obliged to consume them from a very early age, their use provides useful information on taste acceptance in the first months of life, and about the influence of early sensory experiences on later food selection. The key findings from this work were as follows:

(1) Infants up to 2–3 months old readily accepted hydrolyzed formula [31, 32].
(2) At 7.5 months, when presented with hydrolyzed formula for the first time, they strongly rejected it [31].
(3) If they regularly consumed hydrolyzed formula during the first 7 months, they readily accepted it at 7.5 months. If a different brand of hydrolysate

was offered to these infants, it was less well accepted [32]. (Note: for adults, the two hydrolyzed formulae had different tastes and flavors but were equally unpleasant).

(4) If hydrolyzed formula was given during 4 of the first 7 months, it was accepted at 7.5 months, but with less enthusiasm than if it had been experienced for the full 7 months [31].

(5) Children who had experienced (the bitter and acid) hydrolyzed formula for several months early in life more readily accepted acid tasting (but not bitter tasting) drinks at 4–5 years of age. This effect on acceptance of acid taste was no longer evident at 7 years. Children who had been fed soya formula, which is bitter and astringent, more readily accepted bitter tasting foods at 4–5 years old [6, 30]. In contrast, children's preferred levels of sweetness at 4–5 years old correlated best with the sugar content of their current breakfast cereal, and whether or not the mother routinely added sugar to their foods [30].

Mennella et al. [5] also demonstrated that if lactating mothers consumed carrot juice for several days shortly after giving birth, the flavor was transferred to their milk and, at weaning, the infants showed more enthusiasm for cereal prepared in carrot juice than for an unflavored cereal, although they did not eat significantly more. Once again, as the mother could not be 'blind' to the treatment, pathways other than flavor experience may have influenced the infant's behavior.

A very different study, carried out by Haller et al. [7], illustrates how flavor experiences in the first months of life may well have an impact on preference lasting well into adulthood. In Germany, for many years, infant formula has been flavored with vanilla. Haller et al. [7] asked over 130 German adults if they had been breast- or bottle-fed, and then asked them to taste two samples of tomato ketchup and note, which one they preferred. One ketchup was flavored with vanilla, the other not. The result was striking. Two thirds of the respondents who had been breast-fed liked the normal ketchup best. In contrast, two thirds of those who had been bottle-fed preferred the vanilla-flavored ketchup.

Effects of Early Post-Weaning Experiences on Development of Food Preferences in Young Children

Sullivan and Birch [29] asked mothers to offer the same vegetable (pea purée) for 10 days to their infants at weaning. All the infants (4–6 months old) showed significant increases in acceptance and intake, suggesting that simply being exposed to a new food increases its acceptability. However, as Birch [33] pointed out, it sometimes requires 8–10 exposures to achieve clear increases in acceptance, so caregivers should be encouraged to be persistent and continue to offer (without pressure) new foods that are initially rejected [33].

Brown and Grunfeld [34] gave infants sweetened or non-sweetened baby foods during the first 3 months after weaning and then measured acceptance and intake of (new) sweetened or non-sweetened fruits. They found no differences between the groups in acceptance or intake of sweet fruits, suggesting that, while exposure does facilitate acceptance of a food, the effect of sweetness does not necessarily generalize from one food to another.

Gerrish and Mennella [8] showed that experiencing a variety of foods at weaning facilitates subsequent acceptance of new foods. For 10 days, groups of mothers fed their infants the following weaning foods: either carrot purée, potato purée, or a variety of purées (pea, potato and squash). On the 1st and 11th days all infants were offered carrot purée, and on the 12th day, chicken purée. The chicken was an entirely new flavor to these infants. In addition, at the beginning of the study, mothers were asked how often her child had consumed fruit purées (never, occasionally, or daily). The results were as follows:

(1) Infants who experienced a variety of purées more readily accepted the carrot purée than did infants who had received only potato (108 ± 11 vs. 64 ± 12 g). This result is open to several interpretations, including: (a) experience with variety facilitated acceptance of carrots (favored by the authors); (b) infants who had eaten potato purée for 9 days ate less of the carrot purée perhaps in the expectation it would have a similar caloric density to potatoes (the potato purée had a higher caloric density), or (c) the flavors and textures that became familiar during the variety condition generalized to carrot purée.

(2) The infants who had experienced a variety of flavors more readily accepted the completely novel chicken purée than those who had not (31 ± 7 vs. 13 ± 2 g). This result clearly suggests that experience with variety *did* facilitate acceptance of this new food.

(3) Regular consumption of fruit did not diminish later acceptance of vegetables. In fact, earlier regular exposure to fruit was linked to a significantly enhanced acceptance of carrots on day 1 of the study (74 ± 10 vs. 43 ± 5 g).

In a recent cross-cultural study on weaning practices, Maier et al. [35] showed that exposure rates during weaning similar to the 'control' and 'variety' conditions used by Gerrish and Mennella [8] can actually be found in different regions of Europe, confirming the practical significance of the above findings.

In a longitudinal study specifically addressing the development of preference for sweetness, Beauchamp and Moran [36] measured the relative intake of water, 0.2 and 0.6 *M* sucrose at birth, 6 months and 2 years in 63 infants. Newborn infants consumed more 0.6 *M* sucrose than 0.2 *M* and more 0.2 *M* sucrose than water. At 6 months, the infants were divided into 2 groups: those who had regularly been fed sugar water and those who had not.

Although the 2 groups did not differ in their intake at birth, those regularly fed sugar water consumed, in an intake test, more sugar water (but not more water) than those who had not. At 2 years old, children who had been fed sugar water consumed more sucrose (with no difference if exposure was <6 or >6 months). Thus early exposure to sugar water had long-lasting effects on acceptance of sucrose in water. There were no differences in consumption frequency of other sweet foods nor did the effect generalize to other sweet drinks. (The same infants were tested with 0.6*M* sucrose in Kool-Aid. All of them drank more of the sweetened than the non-sweetened Kool-Aid.) Lastly, intake of 0.6*M* sucrose at 2 years was correlated with intake at 6 months (but not at birth) suggesting that innate acceptance of sweet tastes can be modified early in life. Beauchamp and Cowart [37] proposed that a sense of what should or should not be sweet rather than a general hedonic responsiveness to sweetness itself is what may be influenced by dietary experience. Thus a familiar food, only experienced without added sugar may not be enhanced by making it sweeter, while for an unfamiliar food, a sweetened version would be more acceptable. This study is one of the few covering the period from birth to 2 years old and has important implications for the studies described below, linking tastes at 2–3 years old with later preferences.

Preferences at 2–3 Years Old and Other Factors as Predictors of Liking Later in Childhood

Skinner et al. [9] examined the evolution of 97 children's food preferences, taking measures at 2–3, 5 and 8 years old. They found that patterns of preference over this period were remarkably stable. Children who liked the most foods at 2–3 years old liked the most at 8 (correlation, $r = 0.79$). They also liked the same foods at each time, so that consistency (percent agreement for specific foods) was 84%. In addition, there was no significant increase in the number of foods liked. The best-liked foods were carbonated soda, popcorn, white bread rolls, salted crackers, raw apples, French fries, potato chips and chocolate chip cookies. Disliked foods were preponderantly vegetables. Mothers tended not to offer foods they themselves disliked and if mothers liked many foods, the children were less likely to be neophobic.

Nicklaus et al. [10, 11] longitudinally followed the evolution of food preferences in over 300 children beginning at 2–3 years old (in which actual food choices were measured in about 100 meals for each child); these subjects were followed up from between 4 and 22 years of age. Pre-adolescent preferences were rather well explained by choices at 2–3 years old, but evolved with age and gender thereafter, particularly for meats and vegetables, so that in adolescence preferences were only modestly related to

early choices. In contrast, current preference for cheeses was well explained by choice at 2–3 years old across all age groups.

Cashdan [38] and Fischler and Chiva [39] explored the evolution of children's food choices, reporting that at 2–4 years old children became noticeably more conservative with respect to the foods they would accept. This was sometimes interpreted by parents as becoming more 'particular' eaters.

Very recently Liem et al. [40, 41] examined later determinants of sweet preferences of children in Holland. In children aged 4–5 years whose parents restricted access to sweet foods and drinks, they showed that consumption of sugars in beverages was lower than in 'control' children whose parents did not restrict (40 ± 23 and 63 ± 37 g/day, respectively; $p < 0.01$). The restricted children also tended to eat less sweet sugars at breakfast ($p < 0.09$). They did not, however, consume significantly less sweet sugars over the whole day (110 ± 54 vs. 122 ± 54 g/day, respectively; $p = 0.41$). In addition, restricted children preferred significantly higher concentrations of sucrose in orangeade than did non-restricted children. Unfortunately with the study design used, it was not possible to identify the direction of causality, so it was not clear if restricting access to sweet foods and drinks increased sweet preferences or if restrictions tended to be imposed because children showed more marked sweet preferences [40].

In a second study with slightly older children, Liem and de Graaf [41] showed that 8 days of exposure to orangeade containing added sucrose was enough to increase preference for sweeter orangeades ($p < 0.05$), once again suggesting that children habituate to sweeter versions of foods. In contrast, exposure to an equally liked, but more acid orangeade did not increase preference for more acidic orangeades. They also checked if the increased sweet preference in orangeade (above) generalized to another food (yoghurt). The children showed a non-significant trend towards an increased preference for sweet yoghurt ($p = 0.09$).

Discussion and Conclusions

From an evolutionary psychobiology perspective, these results provide a reasonably coherent picture suggesting that early influences on later food preferences are well adapted to a hunter-gatherer existence but perhaps less so to the modern economy.

Genetics provide sensitivity to and preference for sweet tastes (useful for identifying ripe fruits) and a dislike for strong bitter tastes (useful for identifying bitter poisons). These are not fixed likes and dislikes and can change according to experience (thus acceptance for non-poisonous bitter foods can easily be learned). Inherited differences in sensitivity (particularly

to bitter tastes) can influence food preferences and choices. So far, the effects observed are not large, although the observations that PROP-insensitive infants tend to like sweeter foods [21] and are more likely to have caries [22], certainly merit further examination.

There is an evident adaptive advantage for infants to develop a mild but not overwhelming preference for food flavors experienced in their mother's milk. These flavors reflect her food choices and the food choices of her culture. The simple fact that she survived long enough and was fit enough to reproduce and suckle her child shows that her food choices must have at least have been adequate, if not positively good.

As the infant grows up, other influences on food preference and choice come into play, so these early effects cannot be expected to lead to exclusive preferences. Cashdan [38] has argued that, for early humans living out their lives in the same food environment, there would be a survival advantage for the child to be open to accept new foods during the first 2 years (i.e., early exposure to food flavors in mother's milk plus a full seasonal cycle of exposure to adult foods) followed thereafter by a gradual decrease in willingness to experiment (where the costs of experimentation would be higher as the child becomes more mobile and is less protected by parents). Taken together, the early influences on food preferences described in the earlier sections of this review fit closely to this pattern. In the first few months of life, infants do accept unusual flavors more easily and they do tend to like them years later. Similarly, foods liked at 2–3 years old are liked 6–8 years later, and few new foods are added to or subtracted from the list of liked foods. Few studies have examined the evolution of preferences in the age range 8–24 months, so influences on food acceptance during this phase are still poorly understood. It seems, however, that once a particular food becomes accepted and familiar at this stage of development, the preference can be long lasting. Thus preferred levels of sweetness or saltiness in particular foods may be established in the first 2 years. We do not know the extent to which these preferences generalize to similar foods or to other foods. This is an important unanswered question.

This reading of early influences leads to several practical conclusions (some of which certainly need to be studied further before being unequivocally recommended).

(1) Mother's milk reflects the flavors of foods she eats and these can influence her child's food preferences later in life. This suggests that the lactating mother should regularly eat the range of healthy foods that she wants her child to accept later on.

(2) Infants more readily accept new foods and flavors during the period from weaning to about 2 years of age, and surprisingly few new foods are easily accepted in the remaining years of childhood, so it seems worthwhile to make sure that the child experiences a wide range of healthy foods during this period.

(3) 'Repeated exposure' can increase acceptance of new foods. If the infant dislikes a new food on the first 2–3 occasions it is offered, many mothers give up. As Birch [33] suggests, it may be better to offer it without coercion and not give up until 8–10 tries.
(4) Preferred levels of sweetness (and saltiness) in particular foods seem to be influenced by early and current experiences, so perhaps it is better to begin with the levels of sugar and salt one considers healthy. It may be difficult to reduce preferred levels later on.
(5) For parents wishing to reduce their child's sugar intake, setting restriction rules for access to sweet foods and drinks does not seem to work very well.
(6) Lastly, even short-term exposure to a sweeter version of a food or drink may increase the preference for sweetness; so once again, it really does seem important to begin and persist with the levels one considers healthy.

As Benton [42] has pointed out, educational strategies typically involve attempts to impart basic nutritional information. An alternative strategy, worth exploring, is to teach parents more about child development in the hope that an understanding of innate tendencies, effects of early experiences and child psychology will be more successful in teaching healthy food preferences.

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Discussion

Mrs. Maier: With respect to the influence of exposure to new foods and flavours on their acceptance, I would like give an example from the work we are presently doing in Dijon. The first time babies were given puréed peas, some obviously didn't like them, but after 8–10 exposures most readily accepted them.

Dr. Leathwood: Yes, even though mothers tend to give up on an initially rejected food after 2–3 tries, it is easy to demonstrate increasing acceptance for some foods after more exposure than that, suggesting that, if an infant does not accept a new food, it is worth persisting in a relaxed, non-coercive manner on up to 8–10 occasions [1].

Dr. Verloove: I have exactly the same pictures of my own son eating his first apple sauce which was sterile, so many of us will recognize this kind of behavior.

Dr. de Nef: Is it not better to advise the parents to give natural products, fruits and vegetables, instead of industrially prepared bottles of vegetables?

Dr. Leathwood: It seems that the important point is to give a wide variety of vegetables. Parents can cook the vegetables themselves or they can use prepared jars. It is interesting to note that in some countries (France, for example), mothers tend to give one vegetable at the time apparently because they want their child to experience the tastes and flavours of a wide range of individual vegetables. In some other countries, mothers tend to offer mixed vegetables and a limited range [2]. It would be very interesting to know more about the longer term consequences, if any, of these different approaches.

Dr. Hernell: Yesterday when we discussed dietary fiber we agreed on that we would like children to eat more fruit and vegetable. From what you said it seems that to start complementary feeding with fruit and vegetable would be the right thing to do. But in reality, is it not true that fruit and vegetable are not what most children prefer when they grow older? So what is the reason, are we doing something wrong when we introduce complementary foods?

Dr. Leathwood: We have shown that experiencing a variety of vegetables increases acceptance of new foods, but we only have good evidence for relatively short term effects. Others have shown that preferences at 2–3 years old predict quite well preferences later in childhood so we do know that if children like and eat a wide variety of foods at 2–3, they are more likely to be eating a wide variety when they reach 8–10 years of age [3]. Unfortunately, there is very little information

available about predictors of fruit and vegetable preferences in 2–3 year olds. One study, on sugar water preference, showed that liking for sugar water at 6 months was a reasonably good predictor for liking for sugar water at 2 years, but the effect did not seem to generalize to an increased liking for sweetness in other beverages [4].

Since many children like and eat fruit and vegetables, perhaps we should be doing retrospective studies to check if their parents gave a greater variety of vegetables early on.

Dr. Hernell: I think we have quite large observational studies because this is a typical way to wean infants; to start with fruits and vegetables. This seems natural and I think is a rather strict weaning mode in many countries. Still you have the problem that when the children grow older they don't prefer fruits and vegetables.

Mrs. Gailing: Yes, they are different. The recipes for baby foods in jars are different in different countries; they are adapted to local tastes.

Dr. Verloove: Perhaps that explains some of the differences.

Dr. Salminen: It was really fascinating to listen to you. I was thinking along the lines of Dr. Hernell. If one considers the Nordic countries, there is still great seasonal variation in the availability of fruit and vegetables. Is there any information about how that may have influenced the eating habits of old generations?

Dr. Leathwood: I am not aware of any systematic studies on this point but it is certainly worth exploring further.

Dr. Verloove: There could be an additional advantage in that you are forced to eat different things in different months of the year, so maybe one week you would eat the same thing but the week after it would be something different.

Dr. Steenhout: I like the data showing that we should not abandon the introduction of a new food before having tried 8–10 times. If a child doesn't like something today, should we repeat it tomorrow or in a very short time? Is there a timing in the introduction or can we just give more space in between, and in terms of development, repetition is very often important or not?

Dr. Leathwood: Repeatedly offering an initially rejected food is certainly a good way to increase the probability it will be accepted. As for the frequency at which the food should be offered, we are currently studying this.

Dr. Verloove: Have there been any studies connecting the food habits of the mother during pregnancy to these kinds of things?

Dr. Leathwood: The best-known studies in this domain are the two I briefly mentioned in my presentation. Schaal et al [5] showed that, if mothers regularly consumed an aniseed flavoured drink during the last weeks of pregnancy, the newborn infants showed a significant preference for aniseed aroma. Mennella et al [6] found that, if the mother consumed carrot juice for several days during the last weeks of pregnancy, at weaning the infant tended to show more enthusiasm for a carrot-flavoured cereal than an unflavored one. As I pointed out, an evident limitation of this study was that the mother could not be 'blind' to the treatment, so may have influenced the behavior of her infant by pathways other than flavour experience.

Dr. Verloove: If the mother's habit was to eat different foods every day, this could be different situation for the child as compared to a child whose mother ate, say, pizza practically every day throughout pregnancy.

Dr. Waterland: Given that flavors found in the mother's diet are transported to breast milk, are there any good data indicating that breastfed infants are more accepting of a broad range of foods later on after weaning compared to formula-fed infants?

Dr. Leathwood: Yes there is at least one study. Sophie Nicklaus [7] recorded the number and types of food chosen from a selection of 8 different foods (and, on

average, for 110 meals per child) by 418 children aged 2–3. She reported that length of breastfeeding was significantly and positively correlated with the variety of foods selected.

Dr. Kleinman: Young children, even during infancy, are increasingly being exposed to longer durations of television viewing. There is evidence linking that to attention deficit disorder. Do you think that there is an influence on food preference at that age from television viewing?

Dr. Leathwood: Older children certainly see and hear about foods on television. This can influence the foods they want to try, but as those of us who are parents well know, it up to us to decide what they get, and to give our children robust guidance.

Dr. Kleinman: I was thinking more of 1–2 year-olds. The mother is perhaps offering a wide variety of so-called healthy foods and yet that 1-year-old is sitting in a chair watching television for 3 or 4 h/day perhaps. I wonder if that has been studied.

Dr. Leathwood: I don't know of any research on effects of television viewing on food preferences in 1-year-olds.

Dr. Hardiono Djoened: If exposure to a variety of foods is better for taste preference why do mothers always stick to one infant formula instead of changing the formula for example every week or every month? You told us that exposure to a variety of foods facilitates acceptance of new foods by the infant. Why don't we recommend that the mothers change the infant formulas, for example change to another brand every week, and then next week to another brand.

Dr. Leathwood: You raise a very interesting point. I think mothers stay with a particular formula for reasons other than the taste. With respect to providing formulas with a variety of aromas, there are in fact strict constraints and producers are not allowed to provide formula with a range of aromas. This is perhaps because people haven't fully considered the potential advantages.

Dr. Exl-Preysch: I think this question needs to be considered in its broader health context. I remember very well when, for example, it was permitted to add vegetables to infant formula. Misuse of such mixes could lead to health problems such as allergies and diarrhea. I think we are glad that putting vegetables into formulas is no longer allowed. However, I wanted to ask if are there any data or knowledge on the taste preferences of infants from vegetarian parents or even macrobiotic parents? If they are eating nothing but vegetables then the infants should prefer that when they are older as well.

Dr. Leathwood: With appropriate planning and (sometimes) supplementation, infants of vegetarian parents grow adequately and have adequate nutritional status [8]. For families eating macrobiotic diets, there is evidence for growth stagnation at the time of weaning followed by (partial?) catch up between 2 and 4 years old [9]. This study did not identify any long-term consequences of macrobiotic diets for mental status [9]. However, I am not sure if the children all preferred vegetables when they were older.

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