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Research report

Feeding infants and young children. From guidelines to practice☆

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ABSTRACT

Following a workshop on infant feeding held at the Rowett Institute of Nutrition and Health, University of Aberdeen on March 17, 2010 experts were invited to exchange ideas and to review evidence on both pre and post natal dietary environments in shaping children's eating habits. A central theme during the workshop was the idea of "sensitive periods" during infancy for learning about foods and a particular focus was developed around acceptance and intake of fruits and vegetables. Presentations covered the guidelines provided by various governments on how to feed infants during weaning; the importance of the *in utero* experience; the impact of varying the sensory experience at weaning; the effect of parenting styles and practices on children's eating habits; the use of visual experience in promoting intake of vegetables; and reports from mothers regarding their decisions about weaning and the introduction of vegetables. This collection of papers seeks to review guidance from governments on feeding infants and to consider current evidence on parental feeding practices with the aim of enhancing insight into best practice in establishing healthy eating in children.

The first years of life are a critical period in the development of a child; it is a period of rapid growth, with major changes in motor and cognitive function. This early period is punctuated by specific milestones in which infants acquire gross motor skills such as sitting without help to fine motor skills, including those related to feeding from reaching for foods to self-feeding (Carruth & Skinner, 2002). The subject of infant feeding is emotive as it is complex. In contrast to the consensus that "breast is best", there has been much debate around the "what, when and how" of solid food introduction and how best to feed infants beyond the weaning period. Governments produce guidelines to facilitate infant feeding (Schwartz, Scholtens, Lalanne, Weenen, & Nicklaus, 2011) but whether or not these are heeded appears variable (Caton, Ahern, & Hetherington, 2011).

The experience which can shape this early period occurs before birth (Cooke & Fildes, 2011). Gestation is a time when the developing foetus is exposed to components of the maternal diet and this is then followed by a milk feeding period which can complement and expand the infant's sensory experience through breastfeeding (Cooke & Fildes, 2011). The period of weaning when complementary foods are introduced is a crucial time of transition from milk to culturally appropriate family foods. This period using specially prepared foods is unique to humans (Sellen, 2007); other mammals tend to experience suckling then independent foraging with little reliance on transitional feeding. Unlike other mammals, the human infant is persuaded, cajoled and rewarded for trying new foods and so uniquely parenting styles impact on this early feeding experience (Blissett, 2011). Parents can use a variety of ways to encourage children to eat well through taste and repeated exposure, but as infants become more neophobic they may accept or refuse to taste foods on the basis of visual recognition (Heath, Kennedy, & Houston-Price, 2011). The journey made by the developing foetus to the self-feeding child is the focus of this Special Issue of Appetite. This period determines the pattern of acquiring eating habits throughout life (Nicklaus, Boggio, Chabanet, & Issanchou, 2004, 2005) and is crucial for establishing the foundation of a healthy diet.

A start before birth

The Barker hypothesis has transformed the ways in which foetal origins and later health risks are understood (Barker, 1992). In much the same way, early infant nutrition is identified as crucial for both the immediate growth and well-being of the infant and for later "programming" of health status (Lucas, 2005). Early food experience has therefore been studied to identify critical stages in the acquisition of food habits (Cooke & Fildes, 2011; Nicklaus, 2011). It has been proposed that these early stages in feeding will have long lasting and profound effects on appetite

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regulation, food preferences and food intake. Even before birth, the developing foetus experiences the food environment through volatile compounds passed from the mother to the amniotic fluid (Schaal, Marlier, & Soussignan, 1998, 2000; Mennella, Johnson, & Beauchamp, 1995). Thus, although babies are adapted to accept breast milk which is the perfect fit for their needs and provides a complex taste environment, they have already had exposure to features of the maternal diet. Mothers who choose to breastfeed their babies continue to expose them to features of their diet (good and bad) and this link between the *in utero* and postnatal periods constitutes a form of chemosensory learning or chemical continuity (Schaal & Orgeur, 1992).

Breast is best

Breastfeeding for at least 4 months confers many benefits to the developing infant (such as improved immunological function; Oddy et al., 2011), and to the mother (including lower retention of weight gain postpartum (Østbye, Krause, Swamy, & Lovelady, 2010) compared to formula feeding. Breastfeeding has the potential to protect against obesity for the child (Arenz & von Kries, 2009); and it may also encourage and enhance infants' ability to express nutritional wisdom, or the self-regulation of energy intake (e.g. Heinig, Nommsen, Peerson, Lonnerdal, & Dewey, 1993; Li, Fein, & Grummer-Strawn, 2010). Breastfed babies are more willing to try and to accept novel foods than formula fed babies perhaps as a function of early exposure to such flavours via breast milk (Sullivan & Birch, 1994). This phenomenon described as a "flavour bridge" may make later transitions in feeding smoother especially during weaning (Mennella & Beauchamp, 2005; Mennella, Jagnow, & Beauchamp, 2001). This kind of early flavour learning could even last until adulthood as illustrated by the impact of consuming a vanillin flavoured formula in infancy on the preference for a ketchup flavoured with vanillin in adults (Haller, Rummel, Henneberg, Pollmer, & Köster, 1999).

The extent to which maternal dietary cues are transmitted seem to be variable across individuals and highly dependent on the type of compound (Hausner, Bredie, Mølgaard, Petersen, & Møller, 2008). Due to variations in the composition of volatiles in mother's milk, breastfed infants are more familiar with novel flavours and changing flavours than formula fed infants partly explaining the facilitative effect of breastfeeding on food acceptance (Hausner, Nicklaus, Issanchou, Mølgaard, & Møller, 2010). Breastfeeding encourages acceptance of novel foods as a result of exposure to specific flavour compounds. Given the sensory advantage of breastfeeding and the potential long lasting effects of some milk feeding experiences on later dietary outcomes, promoting a varied and healthy diet during pregnancy and lactation will benefit the baby. Early flavour learning through breastfeeding may confer an advantage to the infant by early exposure to healthy foods provided that the mother has a healthy diet (Forestell & Mennella, 2007; also Cooke & Fildes, 2011).

The World Health Organisation (WHO) has over the past decade advocated that infants should be breastfed exclusively for 6 months (WHO, 2001). The first of its guiding principles for the introduction of complementary feeding for breastfed infants states that one should "Start at six months of age with small amounts of food and increase the quantity as the child gets older, while maintaining frequent breastfeeding" (page 5, WHO, 2003). Exclusive breastfeeding for at least 4 months provides the best start in life, however the duration of exclusive breastfeeding which provides the greatest benefits against potential risks, has been the subject of debate specifically within the developed world (Fewtrell, Wilson, Booth, & Lucas, 2010; Renfrew, McGuire, & McCormick, 2011; Wright, 2011). There appears to be a mismatch between the advice to breastfeed exclusively for 6 months and the reality of less than 1% of mothers who manage this (Bolling, Grant, Hamlyn, & Thornton, 2007); suggesting that the advice should be reappraised (Fewtrell et al., 2010).

The European Food Safety Authority (EFSA, 2009) states that for healthy term infants across the European Union the introduction of complementary foods between 4 and 6 months is safe and poses little risk either in the short term (risk of infection) or long term (development of allergies or obesity). An emerging literature supports this assertion by EFSA (see Fewtrell et al., 2010; for a full discussion). Whilst it is safe to introduce solid foods between 4 and 6 months there is convincing evidence that providing solid foods *before* 4 months can increase the risk of obesity in later life (Ong et al., 2006; Huh, Rifas-Shiman, Taveras, Oken, & Gillman, 2011). The transition to solid foods is a crucial period for the child preparing the ground for a varied and omnivorous diet to optimise growth, but the advice on the process of weaning (what, how, when) varies between countries and cultures (Schwartz, Scholtens et al., 2011). Experts disagree about the optimal duration of exclusive breastfeeding and the lack of consensus across government agencies regarding weaning practices may serve to confuse parents. For example, UK mothers are guided by the needs of their infants rather than agency guidelines (Caton et al., 2011). Nevertheless, there appear to be optimal periods to introduce specific tastes, textures and forms of food in order to promote healthy eating.

Sensitive periods

It has been suggested that infants accept with more ease certain tastes and textures at specific times during early life (e.g. Harris, 1993) so called "sensitive periods" (Cashdan, 1994). These correspond to a time frame during which experience will impact strongly with long lasting effects, and may influence the development of later food preferences. These sensitive periods are not well described in the literature, but emerging evidence is beginning to shed light on these periods. For example, the timing and introduction of textured foods by 6 months affects later dietary choices and food fussiness (Coulthard, Harris, & Emmett, 2009, 2010). Infants offered lumpy foods after 9 months consumed fewer fruits and vegetables and had more feeding problems at age 7 years than those offered these foods between 6 and 9 months (Coulthard et al., 2009). Also, babies appear to accept novel flavours early on in life, thus exposure to a protein hydrolysate formula (characterised by a relatively bitter taste) improves acceptance if offered before 3.5 months when there appears to be a "window" after which this taste is rejected (Mennella, Lukasewycz, Castor, & Beauchamp, 2011). Notions of "sensitive periods" in the introduction of solid foods are discussed in more detail by Nicklaus (2011).

Weaning and complementary feeding

Weaning or complementary feeding (although not synonymous these two words are often used as if they were), constitutes the next major feeding transition. It corresponds to two particular changes: the cessation of lactation and suckling and the progressive introduction of foods other than milk in the infant diet (Humphrey, 2010). The WHO emphasizes that complementary feeding should be timely, safe, adequate in terms of variety of foods, frequency, amounts and consistency and complementary foods should be given in an appropriate way (Weaver & Michaelsen, 2001). Interestingly from an evolutionary perspective, humans show a unique pattern: a prolonged period of post weaning dependency because infants lack sufficient motor and cognitive skills necessary to sustain themselves by locating and procuring an appropriate food supply to match their immature