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Research report

A step-by-step introduction to vegetables at the beginning of complementary feeding. The effects of early and repeated exposure ☆

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ABSTRACT

Infancy is considered a critical period for establishing food preferences which then track into later life. Breastfeeding (BF) experience is associated with eating a larger variety of foods such as vegetables later, possibly due to the variety of flavours delivered to the baby via breast milk. Some mothers add vegetables to milk just before introducing solid foods to facilitate acceptance of vegetables during complementary feeding (CF). Therefore the present study was conducted to test a step-by-step exposure to vegetables first in milk then in rice at the start of CF, on intake and liking of vegetables in the first year of life. *Method:* Just before the start of CF, enrolled mothers were randomised to either the intervention group (IG, n = 18 of which 6 were breastfed) or control group (CG, n = 18 of which 6 were breastfed). IG infants received 12 daily exposures to vegetable puree added to milk (days 1–12), then 12 × 2 daily exposures to vegetable puree added to baby rice at home (days 13–24). Plain milk and cereal were given to the control group. Then both groups received 11 daily exposures to vegetable puree. To compare intake and liking, amount consumed was weighed and liking rated during days 25–26 and 33–35 after the start of CF in the laboratory, supplemented by the same data recorded at home between laboratory visits. Vegetables were provided in daily rotation (carrots, green beans, spinach and broccoli) and a new vegetable (parsnip) given on day 35. *Results:* IG infants liked and ate the target vegetable purees more than CG infants. Pace of eating was higher for vegetables in the IG than CG infants. Carrots were consumed and liked more than green beans. However, at 6 months then 18 months follow up measurements, group differences were no longer observed, but the differences in intake between vegetables remained the same (carrot > green beans). Mothers reported that they appreciated the structure and guidance provided by this systematic approach. Early exposure to vegetables in a step-by-step process enhanced intake and liking of vegetables during CF. This step-by-step early exposure to vegetable tastes could be included in CF guidelines. This approach could be replicated and extended in order to investigate any long term benefits of this way of exposing infants to vegetables at the start of the CF period.

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Introduction

Despite the known health benefits of consuming diets which are rich in plant sources, fruit and vegetable intakes are generally lower than recommended across Europe (Yngve et al., 2005). In the UK, children are encouraged to eat vegetables as part of their five-a-day fruit and vegetables, but only around 20% manage to meet this

recommendation. Most children aged 5–15 years eat just one portion of vegetables each day and 7% of children eat no fruit or vegetable (National Obesity Observatory, 2012). A meta-analysis of school based interventions to promote intake of fruit and vegetables revealed a low success rate with an average of only 0.07 g of additional vegetable eaten (Anderson et al., 2005; Evans, Christian, Cleghorn, Greenwood, & Cade, 2012; Ransley et al., 2007). This suggests that it is challenging to persuade school-aged children to eat more vegetables through interventions. In any case, it seems particularly difficult to increase the intake of vegetables in children (Zeinstra, Koelen, Kok, & de Graaf, 2009). Vegetables may be rejected for a number of different reasons, from their bitter taste, unfamiliar texture, their relatively low energy content to simple lack of access in many families (Krolner et al., 2011; Mennella & Ventura, 2011). Food learning starts very early; especially the first two years of life

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seem important for the development of healthy eating habits (Cashdan, 1994) as this is a period in which new foods are relatively easily accepted (Lange et al., 2013; Schwartz, Chabanet, Lange, Issanchou, & Nicklaus, 2011). Once food habits are established they tend to be stable. Various studies (see Nicklaus & Remy, 2013) for review) have shown that food preferences which are developed at an early age, have a long-lasting influence.

Methods which mothers use to promote the intake of vegetables in their children are numerous, since it is recognised that these foods are less appealing than others (see Schwartz et al., 2013). Strategies include adding ketchup or seasoning and even hiding vegetables (Caton, Ahern, & Hetherington, 2011). Providing vegetables by “stealth” delivers the benefits of consuming vegetables but with a non-recognisable form and the taste of vegetables is masked by other more familiar and liked flavours. However, this strategy probably does not allow for familiarisation with the visual, olfactory, gustatory or textural properties of vegetables to increase familiarity and willingness to eat (Aldridge, Dovey, & Halford, 2009; Dazeley, Houston-Price, & Hill, 2012), visual cues being particularly important for children in sensory-decision making in deciding to eat a novel fruit (Dovey et al., 2012). In other words, this approach leads to vegetable intake but not to learning to like, eat and recognise vegetables.

Adding flavours which are already liked promotes intake of vegetables through flavour-flavour learning (FFL). Systematic studies of FFL reveal that this improves the likelihood of trying a vegetable but does not increase liking or intake of the unmodified vegetable relative to mere exposure in pre-school children (Anzman-Frasca, Savage, Marini, Fisher, & Birch, 2012; De Wild, De Graaf, & Jager, 2013). The most successful strategy to promote vegetable intake is mere or repeated exposure (Ahern, Caton, Blundell, & Hetherington, 2013; Hausner, Olsen, & Møller, 2012; Remy, Issanchou, Chabanet, & Nicklaus, 2013). Mere exposure (Zajonc, 1968) produces a favourable response to a novel stimulus if experience with that stimulus produces no negative consequence, through the mechanisms of ‘familiarity’ (Zajonc, 1968) and ‘learned safety’ (Kalat & Rozin, 1973). Successful vegetable introduction includes not only repeated exposure but also applying daily variety in 3–5 day rotation schemes (Nicklaus, 2011).

Given that vegetables are typically eaten within a composite meal and that they are generally disliked by children, it is important to understand whether pairing vegetables with other flavours can enhance their acceptance or whether children learn to prefer the composite rather than the pure vegetable flavour. In particular, during CF there is a sudden transition from milk feeding to the strong taste of pure vegetables, but would liking and intake be facilitated by a more gradual approach? In France, as recommended in specific national CF guidelines (Comité National de l'enfance, 2014; INPES, 2004, 2005), some mothers add water from cooking vegetables or vegetable puree to milk as a means of developing their child's taste for vegetables (Schwartz et al., 2013). The amount added is increased gradually over time. Thus French mothers recognise that special strategies may be needed to develop acceptance of foods such as vegetables which are generally disliked (Schwartz et al., 2013). If infants learn to like the flavour of a new vegetable by its association with milk or another familiar food, then this practice could limit acceptance of vegetables given in a pure form since acceptance might be context-dependent, namely, liked only in combination with the familiar, liked flavour. On the other hand, vegetables offered systematically and gradually with the aim to replace the composite with only the pure vegetable may assist in promoting acceptance. The practice adopted by French mothers has not been tested systematically to our knowledge and in any case it is not known whether this practice can be generalised beyond the French context.

Flavouring milk, either breast or formula milks, by adding vegetable cooking water or puree might seem unusual in some cultures.

However, breastfed infants are naturally exposed to flavour variations in breast milk because mother's exposure to dietary flavour cues is transmitted through breast milk (Hausner, Bredie, Mølgaard, Petersen, & Møller, 2008). This phenomenon, called a ‘flavour bridge’, transmits to the weanlings the flavours of the mother's diet before starting the CF process and it increases compliance and acceptance of new foods (Hausner, Nicklaus, Issanchou, Mølgaard, & Møller, 2010; Mennella, Jagnow, & Beauchamp, 2001).

Therefore, the aims of the current intervention were to test the effects of providing vegetables step-by-step in milk and then in cereal during CF on intake and liking of pure vegetables, and to investigate the acceptability of this strategy among mothers. The hypotheses were that: (a) the gradual introduction to vegetables will increase intake and liking of those vegetables (carrot, green bean, broccoli and spinach); (b) this exposure effect would generalise to another, unfamiliar vegetable (parsnip); and (c) that any differences found between the two groups would endure until 6 months and 18 months after the intervention.

Method

Participants

Mothers were recruited from the local community using widespread advertising within mother and baby groups and a recruitment agency between September 2011 and May 2012. Infants under the age of 12 weeks were not able to participate but could be part of the study after this time. Infants suffering from a chronic health condition requiring medication, born prematurely before 37 weeks of gestation (Migraine et al., 2013), fed hydrolysed-protein formula (Mennella & Beauchamp, 2002; Mennella, Forestell, Morgan, & Beauchamp, 2009; Mennella, Kennedy, & Beauchamp, 2006) or with a known food allergy were not eligible to participate. In total, the research team made contact with 48 mothers and from this initial contact 40 mothers were screened and accepted into the study. Mothers were randomised to either the intervention ($n = 20$) or control group ($n = 20$) after they had consented to the study and before they had completed any questionnaires. Written informed consent was obtained from all mothers of the participating infants. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects/patients were approved by the Institute of Psychological Sciences (University of Leeds) ethics committee who adheres to the principles set down by the British Psychological Society (Ethics Ref No: #11-0031). Of the original 40 mother–infant dyads who agreed to take part in the study, complete data were obtained from 36 mothers (18 in each group). Reasons for non-completion included missed appointments ($n = 2$), relocation ($n = 1$) and return to work ($n = 1$).

Procedure

Each group followed a 35 day CF intervention (see Fig. 1). IG infants received 12 daily exposures to vegetable puree added to milk (days 1–12), then 12×2 daily exposures to vegetable puree added to baby rice at home (days 13–24). Plain milk and cereal were given to the control group. Then both groups received 11 daily exposures to vegetable puree. The rationale for exposing the infants to vegetables added to milk then to cereal then as a puree was to mimic the progression that mothers use in building up gradually to a stronger, distinctive taste. Also the reason for choosing puree rather than cooking water from vegetables was to standardise the amount and intensity of vegetable flavour.

Mothers were invited to the Human Appetite Research Unit (HARU) Infant Laboratory and given a full explanation of all study procedures. They were each given a pack containing a 35 day diary

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