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## **Reading appetite cues in infancy: a role for nutrition education**

**Marion M Hetherington and Janet McNally**

**School of Psychology**

**University of Leeds, Leeds, LS2 9JT, England**

**Short Title: Nutrition Education and Appetite Cues**

**Correspondence: Marion Hetherington, School of Psychology, University of Leeds, Leeds, LS2 9JT, England. [M.hetherington@leeds.ac.uk](mailto:M.hetherington@leeds.ac.uk)**

### **Abstract**

Infants communicate complex aspects of appetite through a variety of behaviours. In newborn babies mouthing and orientation towards odours from breastmilk signal preference, whereas for older infants likes and dislikes are signalled via facial expressions. Infants communicate readiness to eat by sucking their hands and eliciting the hunger cry, and indicate satiation through a wide repertoire of behaviours ranging from subtle facial expressions, shifts in gaze through to changes in gesture and bodily movements including turning their head away. Filming mealtime interactions reveals the dynamic nature of infant communication and caregiver response. Optimal responsiveness to infant cues may be influenced by individual characteristics of the mother as well as mode of feeding [breastfed or formula]. A series of studies has used video capture to characterise the ways in which infants communicate appetite. We have then translated this into an educational resource for healthcare professionals and caregivers on how to identify, interpret and respond to these cues. There is a potentially important role for nutrition education in promoting both the principles of good nutrition as well as ways to read then respond sensitively to infant appetite cues.

One of the most obvious and attention grabbing ways that infants signal their need for energy is through the hunger cry [1]. It is no accident that the human neonate is capable of emitting such a powerful distress call since there is a strong biological imperative to secure a source of nourishment for survival. Newborn babies also use more subtle communication cues to indicate interest in food-related stimuli. In a series of elegant studies Marlier and colleagues measured preferences for odours in neonates by recording head orientation and mouthing in a paired choice odour test [2,3]. They found that even if 2 and 4 day old babies had been formula fed they oriented towards and mouthed more in response to breastmilk odours than formula, perhaps due to the complexity and appeal of human milk [2]. As the infant develops, so too does their ability to communicate hunger, appetite and satiation through a repertoire of facial expressions and overt behaviours [4]. Clearly it is hard for us to know exactly what the infant is communicating, but observational studies reveal some consensus on basic hunger, appetite, satiation and liking cues.

According to McNally et al [5], who reviewed a series of studies on infant communication cues during the first 2 years of life, hunger is more easily recognised by mothers than satiation cues, and feeding cues are easier to interpret as children grow older. Infants communicate appetite in diverse ways and this is influenced by characteristics of the infant such as developmental stage, and temperament, whereas perception of appetite cues depend on characteristics of the mother including prior experience of breastfeeding and maternal weight status.

When mothers were asked to identify what signals they used to begin complementary feeding, Anderson et al. [6] reported that they responded to characteristics of their baby [e.g. age, weight], to their overt behaviours [e.g. rapid rate of milk consumption, agitation, "chewing" their hands] as well as external factors such as time of day and time since last feed. Mothers tended to discern the hunger cry more by time of day than by the characteristics of the cry itself. In this same study satiation signals were described by mothers in relation to expressions of contentment, and their baby appearing to be more settled.

In an observational study by Gross et al. [7], mothers' perceptions of infant hunger and satiation were influenced by breastfeeding status and maternal body weight. Mothers with obesity were more likely to identify sucking on hands as a hunger cue and less likely to believe that babies know when they are full. One interpretation of this observation is that mothers with obesity are more alert and responsive to cues for hunger and less sensitive to signs of fullness, which may result in overfeeding. They also found that breastfeeding mothers were more "tuned in" or sensitive to infant hunger than those who formula fed. The observation that breastfeeding promotes more responsive feeding has been supported by a number of studies by Shloim et al [8-10] and could

relate to a greater level of closeness, contact and trust that their baby is capable of communicating satiety. It has also been shown that infants born to mothers at high risk of obesity were less likely to breastfeed exclusively, and less likely to believe that infants know their own hunger and satiety than mothers at low risk [11].

Through semi-structured interviews with mothers, Hodges and his colleagues [12] investigated which cues mothers were using to initiate and which to end feeding. Typical hunger cues in this study were crying, fussing and licking the lips and these were reported across several age groups [3, 6 and 12 months]. Common satiation cues included pulling away, spitting food out and terminating the feed. The prominence, intensity and specificity of infant cues guided maternal decisions about beginning or ending a feed and mothers reported greater ease in interpreting cues with increasing infant age.

Following on from this research with mothers, Hodges et al. [13] developed the Responsiveness to Child Feeding Cues Scale [RCFCS] which has 20 types of hunger cue and 28 types of satiation cue. Hunger and satiation cues were further categorised as 'early' [e.g. increased alertness], 'active' [e.g. excitatory movements] and 'late' [e.g. fussing and crying] in order to reflect changes in cue intensity with time. They found that mothers were typically more responsive to hunger than satiation cues. The authors interpreted this in the context of the greater urgency and biological imperative of hunger compared to satiation. Maternal responsiveness to satiation was predicted by characteristics such as lower body mass index, longer breastfeeding duration, and higher educational level. Breastfeeding may facilitate responsiveness to infants and this may later serve to protect infants against excess weight gain, but long term protective effects of breastfeeding for weight status remain contested [14].

In their study of the changes in feeding cues expressed over time, Hodges et al [15] filmed mother–infant pairs during mealtimes in the home when infants were aged 3, 6, 9, 12, and 18 months. They used the RCFCS at each time point and noticed that fullness cues became more diverse and less subtle over time. In the first 2 observations [3m and 6m] disinterest, falling asleep, decreased muscle tone and activity level signalled fullness but during the later observations pushing or pulling away and communicating “no” verbally became more apparent. For appetite cues, postural attention and reaching for food increased after 6 months. Over the course of development, motor and language skills improve to enable infants to assert themselves more clearly in relation to readiness to begin or end eating.

In a longitudinal study of infants Skinner et al [16] provided mothers with pictures of hunger cues and asked at what age these were displayed by their own baby. Infants were aged 2 to 24m and mothers were interviewed at least 6 times out of a possible 10 times. They found that hunger-related behaviours [e.g. opening the mouth as the spoon approached] appeared at a younger age than satiation behaviours [e.g. closing the mouth to reject food] [4.4 to 5.7 months versus 5.8 to 7.5 respectively]. Also mothers reported that infants signalled interest in eating by opening the mouth in readiness as food approached, eating steadily, and/or eating a large amount of food. Food dislikes were communicated via facial expressions, and by body movements, such as turning the head or body away from food or throwing food away. Cues of food dislike appeared by 8m of age, and strong indications of food likes and dislikes increased in frequency with age. Overall, mothers reported that their infant's ability to communicate improved in scale and scope over time in tandem with the mother's improved skill in interpreting these cues [16].

Overall, infants begin to communicate hunger during the milk feeding phase via hand sucking, hand to mouth, agitation, orienting towards the breast/bottle, culminating in the "hunger" cry. Satiation is initially signalled through disinterest and sleep and later signalled through avoidance cues such as stopping or slowing down acceptance, turning the head and pulling the body away. The greater urgency and survival value of communicating hunger takes precedence over other needs. Cues to signal fullness appear later than hunger cues and responsiveness to these may depend on characteristics of the mother including breastfeeding duration, maternal body mass index and education. As infants progress to solid foods, approach and avoidance behaviours become more complex including the use of language to signal appetite, food likes and dislikes. For some parents, interpretation of infant communication cues is challenging and among mothers at high risk of obesity is a belief that they know better than the infant when to feed and when to stop feeding [11]. However, the nature of responsive feeding is that it is reciprocal, prompt and appropriate [17]. What then can be done to facilitate this?

### **Responding to infant feeding cues**

Responsive feeding facilitates positive feeding interactions and supports the development of healthy eating habits [17]. However, mothers may have difficulty in interpreting their infants' feeding signals. In particular, ease in interpreting cues may vary according to mothers' own body mass index [BMI], breastfeeding history, educational level and depressive symptomatology [5]. There is also evidence that mothers may have difficulty in responding to cues appropriately. A survey of 361 mothers of

toddlers [aged 12-36 months] found 75% using coaxing or coercion when feeding their child while 44% of mothers also reported that they did not interpret food refusal as indicating satiation [18]. Such findings suggest that while responsive feeding is desirable, it may be difficult for some mothers to achieve. Mothers may therefore, benefit from educational support in recognising and responding to their infants' cues.

### **Investigating and understanding infant interest in food**

The development of educational resources to promote responsive feeding depends first on the availability of accurate information concerning indicators of infant interest in food. Despite this, few tools have been developed for the systematic observation of infant behaviour during feeding [5], beyond the Nursing Child Assessment Satellite Training [NCAST] Feeding Scale [19] and the Responsiveness to Child Feeding Cues Scale [RCFCS; 13]. However, while the NCAST scale and the RCFCS are validated scales, they serve primarily as measures of parental feeding responsiveness and they do not quantify the relative frequencies or rates of different feeding signals, neither do they capture the relative timing of hunger and fullness cues within feeding episodes. This is important as the relative proportions and timing of different behaviours has implications for mothers in determining when to terminate meals. Evidence suggests that infants may display a mixture of hunger and fullness cues even in the later stages of feeding, thereby contributing to maternal uncertainty about ending feeds [20].

There is therefore the need to develop a more detailed understanding of markers of infant interest in food as a first step in promoting responsive feeding. In view of this McNally et al. [21] conducted detailed video observations of 20 infants with eight males and twelve females between six and eighteen months of age at the time of entry into the study [mean age 11.7 months  $\pm$  3.40]. Seven infants had been fed using Baby Led Weaning [as defined by their mothers]. Three novel coding schemes were developed with an explicit focus on infant gaze, gesture and vocalisation as key behaviours providing information from which infant state, interest and motivation may be inferred [22]. Within this it was assumed that behaviours occurring early in feeding would be indicative of hunger and those occurring later would indicate fullness. All coding schemes were subjected to intra or inter-reliability testing and were found to achieve good levels of reliability. Video clips of the first, middle and last 20% of each course of each meal were coded in random order to examine changes in infant behaviour as feeding progressed.

Analyses of the three coding schemes showed significant increases between the first 20% of main courses and the last 20% of desserts in the use of exploratory behaviours by infants such as the visual examination and physical manipulation of objects and food and the use of vocal play. In frequencies of exploratory gaze behaviour showed significant increases over time in both main and dessert courses. In contrast frequencies of gazing at food [not accompanied by physical manipulation] decreased significantly between the start of main courses and the end of desserts and over time within each course.

Other significant findings were that rates of social gesture and socially orientated vocalisations increased significantly from the first to the last sections of meals. Rates of social gesture use also increased significantly within main and dessert courses. Rates of social vocalisation also increased from the start to the end of main and dessert courses, though significant increases were only observed during the main course.

Together, findings suggest that infant gaze, gesture and vocalisation behaviour changed over time from feeding related activities [gazing at food] towards non-feeding related activities such as exploration and social interaction. This is consistent with descriptions of post-ingestive behaviour change in animals from feeding related to non-feeding related activities post-ingestion, i.e. the behavioural satiety sequence [23] and suggests that shifts towards exploratory and social activity over the course of feeding may indicate diminished interest in feeding. Attention to such broad behavioural patterns may therefore assist mothers in recognising declining interest in food in their infants.

### **The development and feasibility testing of an online, self-directed responsive feeding resource**

Several studies have shown individual and group-based feeding interventions to be effective in increasing parental feeding knowledge and promoting responsive feeding [24-26]. However, face to face interventions are costly, have limited accessibility [27] and there is evidence that online, self-directed programmes may achieve similar outcomes in the field of parenting interventions. McNally [28] therefore developed a prototype, online, self-directed educational resource [Mealtime Mindreading] to examine its acceptability and perceived usefulness to parents and childcare professionals. The resource was developed using findings from the observational work described above and the wider infant feeding literature. It comprised 64 slides including tabulated descriptions of feeding cues in infants from 6 to 14 months with links to 45 video illustrations of behaviours associated with infant interest and disinterest in food. Video illustrations involved clips of the same female infant filmed at monthly intervals from 6 months to 14 months of age in the home

environment. These were captioned to describe the behaviours they illustrated and the age ranges to which they applied [Figure 1].

The online responsive feeding resource was designed using Articulate Presenter version 13 and hosted by Articulate Online for an eight-week period. Satisfaction with the resource was assessed via an adapted version of the User Satisfaction Questionnaire [USQ] [29] a measure which is used to assess content of Web-based programmes. Participants were also asked to provide qualitative feedback regarding the resource's most and least useful aspects. Metrics regarding resource use (percentage of slides viewed and the duration of viewings) were compiled via the data capture features of Articulate Online. Correlations were conducted to explore satisfaction with the resource for parents with different duration and types of feeding experience according to: number of children, infant age, perceived ease in judging infant hunger and satiation and the degree to which parents experienced concerns about their infant's feeding behaviour.

Thirty-four participants viewed the resource (thirty parents and four childcare or nutrition professionals. Twenty-three of whom completed the evaluation questionnaire (mean age of participants was  $33.8 \pm 4.5$  years). Around one third of parents taking part (31.6%) reported some difficulty in identifying when their infant was either hungry or full and more than a quarter (26.3%) reported concerns about their infant's eating.

The resource was well received by participants with high overall satisfaction ratings and mean ratings across all questionnaire items (4.48 and 4.31 out of a maximum score of five respectively, Figure 2).

In relation to the qualitative feedback, more than half of participants [ $n = 13$ ] identified the resource videos as its most useful feature [Table 1]. Importantly, there were indications that the videos helped parents to understand their infants' behaviour better: *"I didn't know if my baby was disliking her food or being naughty throwing spoons. It's nice to see this is normal"*; *"The [...] videos were useful. I have noticed a few times recently that my son has been rubbing his eyes during meals [...] now I know why!"*. This is consistent with evidence that video-based resources can facilitate learning [30] and the use of video to increase maternal sensitivity to infant cues in non-feeding related interventions [31,32]. As such, observational learning may be a particularly helpful tool for developing awareness of infant feeding cues and promoting attunement to these.



Interestingly overall satisfaction with the resource was inversely correlated with parents' level of concern about their infants' eating, suggesting that parents with higher levels of feeding concerns may need more specific resources to support them. Three parents commented that more information on fussy eating, under or over eating would have been useful: *"I worry a lot about a limited diet and how she only likes runny food [...] These types of preferences weren't explored"*; *"My daughter eats a bit more than she should [...] it would have been good to have more information about knowing how much is an ok amount for a baby"*. This foregrounds the need for responsive feeding programmes to tailor guidance around specific issues and needs, i.e. individual infants' eating traits and appropriate responses to these.

### **Conclusions**

In order to promote responsive feeding, parents must be able to recognise different appetite cues from their infants then respond promptly and appropriately. Infants are capable of signalling hunger and satiation but sensitivity to interpreting these cues may depend on features of the mother as well as characteristics of the child. Evidence suggests that mothers who have breastfed their baby and those who are a healthy weight may be more willing to trust that babies are capable of signalling appetite cues. Interviews with mothers of preschool children suggest that confidence in the child's ability to communicate appetite and to self-regulate develops with experience (33). Nutrition education has a role in assisting with recognising and responding to appetite signalling by infants. Resources may be particularly important for mothers at high risk of obesity or for mothers whose children are fussy eaters. It is clear from our preliminary research that mothers value resources with video content to illustrate different aspects of hunger, appetite and satiation. Future research could usefully evaluate the efficacy of online, video-based resources for improving responsive feeding. A trial to test whether nutrition education illustrated with filmed mealtime examples can increase confidence as well as accuracy in perceiving infant communication of appetite is warranted. Initially a feasibility trial could be developed and then a full scale randomised control trial could be developed. It is especially important to evaluate resources which are tailored to the needs of mothers and their infants.

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**Table 1: Most and least useful aspects of the resource reported by participants**

<b>Most useful</b>	<b>Least useful</b>
Video content [n = 13]	Download/longer viewing would be helpful [n= 3]
Information about feeding cues [n = 8]	More information needed [n = 5] re: Cues in self-feeding/BLW babies [n = 2] Feeding problems eating [n = 3]
Helped with understanding infant behaviour [n = 2]	Presentation/design [voiceover, video quality, visual appeal [n = 3]:
Helped with knowing when to stop feeding [n = 2]	Problems viewing videos on phone [n = 1]
Age specific information [n = 2]	Reading cues is harder than resource suggests [n = 1]
Good for first time parents [n = 2]	Not useful for older babies [n = 1]
Made me think about what I am seeing when feeding [n = 2]	Too much overlap between age groups in videos and tables of cues [n = 3]
Easy to use/clear [n = 1]	

Figure 1 – Screenshot of the responsive feeding resource [Mealttime Mindreading].

Menu

1. Welcome to the Mealttime Mind ...
2. About this resource
3. Responsive feeding - the whats ...
4. Responsive feeding - things to b...
5. Responsive Feeding Tips
6. What might influence how your L...
7. Individual Differences - 'Feeding...
8. Type of food/likes and dislikes
9. Day to day factors which affect L...
10. Spotting Hunger and Fullness ...
11. Hunger signs at 6,7 & 8 months
12. Full or filling up at 6,7 & 8 months
13. Hunger at 9,10 & 11 months
14. Full or filling up at 9,10 & 11 m...
15. Hunger at 12,13 & 14 months
16. Full or filling up at 12,13 & 14 ...
17. Your turn at mealttime mindrea...
18. Other sources of information
19. QUESTIONNAIRE LINK AND T...

FINAL Mealttime Mind Reading illustration (14:33 / 16:30) Resources

### 12,13 & 14 months - Full or filling up

(Click on the video to start or to replay)

When Evie has had enough to eat, her attention turns to playing with the bowl



Back to fullness at 12, 13 and 14 months

30

⏪ || ⏩ ⏲ < PREV NEXT >

Figure 2– Overall satisfaction ratings, mean ratings across all USQ items and standard errors

