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# Looking for cues – infant communication of hunger and satiation during milk feeding.

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Abstract

It is known that duration of breastfeeding and responsive feeding are associated with decreased risk of obesity. It is however, not clear whether breastfed infants signal more to mothers to facilitate responsive feeding, compared to formula fed, nor what communication cues are important during the feeding interaction. The present study aimed to explore feeding cues in milk-fed infants and to examine if such cues vary by mode of feeding. Twenty-seven mothers and infants were filmed while breastfeeding or formula feeding. Infants' age ranged from 3-22 weeks. Feeding cues were identified using a validated list of communication cues (NCAST). The frequency of each cue during the beginning, middle, and end of the meal was recorded. There were 22 feeding cues identified during the feeds, with significantly more frequent disengagement cues expressed than engagement cues. Significantly more frequent feeding cues were observed at the beginning than at the end of the meal showing that cue frequency changes with satiation. Breastfeeding infants exhibited more engagement and disengagement cues than formula fed infants. Supporting mothers to identify engagement and disengagement cues during a milk feed may promote more responsive feeding- strategies that can be acquired by mothers using different modes of feeding.

Introduction:

The World Health Organization (WHO) suggests that mothers should breastfeed exclusively for the first six months of life, to continue to breastfeed beyond this time and to introduce appropriate complementary feeding (WHO. 2006). Breastfeeding confers many benefits to mother and baby, from improved gut microbiota and immune function in infants (Fisk et al., 2011; Chong. 2015) to protection from development of overweight and obesity in baby and mothers (Weng et al., 2012; Grube et al., 2015). Explanations for the beneficial effects of breastfeeding against developing overweight can be grouped into biological or behavioural accounts. Among biological account, metabolic differences attributed to the different protein content of milks (Horta et al. 2013) indicates that insulin response and adipose tissue deposition could be lower in breastfed relative to formula-fed infants. Similarly, the hormone content of breastmilk may facilitate energy regulation and reduce fat deposition in breastfed babies (Savino et al., 2011). Behavioural explanations focus on the ability of breastfed babies to recognise satiety (Dietz. 2001) and to self-regulate on the basis of greater satiety responsiveness (Ong et al., 2006; Li et al 2010). These behavioural explanations are partly related to the control of the feed resting with the infant rather than the mother. Since breastfed babies can determine when, how long and how much is consumed during a feed they may be better placed to communicate satiety cues to their mothers, who may in turn be receptive to these cues.

Thus, Singhal et al., (2010) suggest that appetite entrainment differs between breastfed and formula-fed babies because of differences in the locus of control in the feed. That is, breastfed babies have more control over the feed than formula-fed babies. It is suggested that self-regulation may be facilitated more by breastfeeding compared to formula feeding. Brown et al (2011) explored maternal control in a sample of ~500 mothers who either breastfed or formula-fed their babies using a modified version of the Child Feeding Questionnaire (CFQ; Birch et al., 2001). Mothers who breastfed for at least 6 months reported less controlling feeding behaviours, as measured by “lower levels of feeding according to a schedule” compared to mothers who formula-fed. In a later study, breastfeeding was associated with a less controlling feeding style in a sample of 390 mothers and infants aged 0–6 months (Brown and Lee. 2013). Similarly, Blissett and Farrow,

(2007) found that duration of breastfeeding during the first year of life was related to controlling feeding practices, with lower duration predicting higher control. Furthermore, parental control recorded at 1 year was stable at 2 years suggesting the durability of parental control. In summary, mode of feeding might direct children's eating more towards external factors (likely controlled by the mother e.g. time of feeding, volume of feed) or more towards internal factors (experienced by the child such as internal cues of hunger and satiety).Thus, breastfed babies, who are assumed to have more control of the meal, are predicted to eat more in response to internal signals such as hunger and less to external factors such as time or volume offered.

Caregivers who recognise and respond to their babies' behavioural cues are said to be responsive feeders (Hurley et al., 2011) and this is seen in both breast and formula feeding. Responsive feeding reflects communication between an infant and its mother. The infant communicates hunger, appetite and satiation and in turn the mother makes an appropriate response. Responsive feeding has the following elements: (1) Identification of the feeding cue; (2) Interpretation of the cue e.g. deciding what the cue means such as hunger or satiety and (3) Responding to this by either continuing to offer food or pausing/stopping (Black and Aboud. 2011; Engle et al., 2000). To feed responsively the caregiver must first identify the feeding cues which are communicated by the infant and decide if these indicate hunger or satiation. In early life, when infants are only milk fed, such feeding cues are addressed as drinking cues. . Research by McNally et al (2016) noted that parents struggle to interpret drinking cues. This is especially the case when the baby is very young. Thus, in order for parents to feed in a responsive way it is necessary to identify and respond to these cues from a very young age.

Assuming that infants are able to self-regulate and communicate hunger, appetite and satiation during a feed (Oddy. 2012; Li et al.,2014), then unresponsive feeding at any one of these three stages could result in under- or over-feeding, and hence in the long term, underweight or overweight infants.

In support of this contention, Worobey et al (2009) noted that mothers' lower sensitivity to infant's feeding cues at 6 months was positively associated with infants' higher weight gain at 12 months. Brown and Lee (2011) demonstrated that lower

levels of responsiveness to a child's needs were positively associated with higher child weight gain at the age of 2 years. In older children, such behaviours were also positively associated with higher body weight (Ventura and Birch. 2008; Hurley et al., 2011). Finally, a recent systematic review suggested that less responsive and more uninvolved parenting styles are linked to a higher child weight between 4 and 12 years (Shloim et al., 2015).

Responsive feeding is influenced by both maternal and infant characteristics (McNally et al 2015). Gross et al (2010) observed that obese mothers who breastfed for longer than other obese mothers, perceived hand sucking as a hunger cue and were therefore more aware of their infant's engagement cues. Overfeeding possibly results from missed cues, using feeding to soothe and/or responding to difficult temperaments (Stifter et al (2011). Whatever the underlying reason for this, unresponsive feeding is associated with heavier infants (Disantis et al., 2013). As caregiver and child are mutually influencing each other over time during a feed, through the consistency, meaning and appropriate interpretation of each other's behaviours, the study of responsive feeding might benefit from investigating different influences (e.g. infant's gender, maternal socio-economic status), longitudinally, and systematically (e.g. filmed observations) so that communication dynamics can be recorded and then coded.

Disantis et al (2011) noted that research exploring responsive feeding has tended to focus on pre-school children (Hurley et al., 2011; Birch et al., 2001; Hughes et al., 2005) and less on infancy. However, it is in infancy that these important meal interactions begin and therefore should be observed and understood.

Therefore, the present study examined infant communication cues during milk feeding. A feed was filmed, and the cues that were displayed by infants were systematically recorded. In particular, cues which indicated interest in eating, approach behaviours and hunger were clustered within a category "engagement". Cues which indicated disinterest in eating, avoidance behaviours and fullness were clustered within a category "disengagement". The assumption was made that engagement during a meal reflects the underlying state of hunger, and that disengagement cues reflect the onset of satiation and satiety. Since self-regulation

of milk intake by infants varies by mode of feeding (Li et al., 2010), it was hypothesized that frequency of engagement and disengagement feeding cues would vary with mode of feeding. It was also hypothesized that engagement cues would be observed more frequently early in the meal and disengagement cues would be seen more frequently at the end of a meal.

## Methods:

### Participants:

156 women in Israel (N=67) and the United Kingdom (N=89) took part in a study examining eating behaviours during pregnancy (Shloim et al., 2013). Of this number, 73 women participated in the follow-up study [N=42; from Israel (59%); N=31; from the UK (41%)] exploring eating behaviours and infant feeding choices until two years postpartum (Shloim et al., 2014). From those who agreed to the follow-up study, 41 women agreed to take part in an in-depth study characterising mother-infant mealtime interactions (Shloim et al., 2015). Thus, the present study was a secondary analysis of existing data.

### Procedure:

The researcher (NS) contacted the participants and agreed on a time to arrive at the mothers' homes to film a meal interaction. Mothers were asked to feed their infants "as normal" as possible and to ignore the presence of the researcher (see Shloim et al., 2015 for more detail). In the first follow-up (2-6 months postpartum), a total of 41 films were recorded in which mothers breastfed (N=13; 32%), formula fed (N=14; 34%) or provided solids (e.g. purees N=14; 34%). As the purpose of the current study was to explore communication cues during milk feeding only, films where mothers offered solids were not included in the present analysis. Breastfeeding was defined as feeding directly from the breast compared to formula feeding which was defined as feeding from a bottle. None of the mothers bottle-fed breast milk for this meal. Starting time of a feed was defined for breastfeeding as the time the nipple

reached the mouth. For formula feeding, the time the bottle entered the mouth was defined as the beginning of the feed.

The Nursing Child Assessment Teaching Scale (NCAST):

According to Hodges et al (2013) there are several observational tools to measure feeding interactions in early infancy but these have most often been used to identify eating pathology and were therefore not suitable for the present study. This study is based on the work of Dr. Kathryn Barnard and her colleagues who developed the child health assessment model to determine predictors that could identify children at risk for later developmental problems (Barnard and Eyres. 1979). The team suggested that a child's physical, emotional, intellectual and social domains interact and impact on the child's overall health. Barnard and her colleagues suggested that very young children depend on adults to mediate experiences and create learning experiences for them. The Nursing Child Assessment Project (NCAP) team created a framework for the child's health assessment. The original model is depicted as three overlapping circles: 1. The child-relates to child's physical appearance, temperament, feeding and sleeping patterns and self regulation; 2. The caregiver-the parent's physical health, mental health, coping ability and level of education and 3. The environment – addresses both the child and caregiver. According to Barnard and her colleagues (Barnard and Eyres. 1979; Bee et al., 1982), the most important part of the model is the interaction between the parent, the child and the environment. The infant produces clear communication cues and the mother responds to these cues. This process resonates with responsive feeding and provides a useful framework for coding infant communication during the meal. We applied the list of feeding cues, provided within the Nursing Child Assessment Teaching Scale (NCAST; Barnard. 1994), and caregiver/ parent-child feeding manual (Givens, 1978; Sumner and Spietz, 1994). The list contains 83 feeding cues and is divided into engagement (hunger; N=19) and disengagement cues (satiety; N=64). Each list is divided into potent (strong and clear) feeding cues and subtle cues, with many more disengagement feeding cues than engagement cues. Examples of engagement cues are babbling or smiling, whereas examples of disengagement cues are pushing away or vomiting. In this analysis we identified

22/83 feeding cues which are divided into engagement (N=6) and disengagement (N=16) cues. Films were viewed by the lead researcher (NS), a qualified psychotherapist with training in NCAST and the Simple Feeding Elements scale (SFES; Shloim et al., 2014, 2015). The researcher initially applied all communication cues identified by the NCAST team recording the appearance of each cue. For each film the time (in seconds) when the cue appeared was coded. Frequencies of the appearance of each cue were calculated for the total duration of the feed and then for each part of the feed (beginning, middle and end).

These sections of the meal were simply determined by sampling each third of the meal duration, so first, second and final third of the recorded meal episode. A second researcher (HH) was trained by the lead researcher to recognise engagement/disengagement cues and then viewed the films to code them independently. Quality ratings were subjected to inter-rater reliability analysis using a fully crossed design; the main author and the second researcher coded all the films and a random selection of 7 films were re-coded by both researchers independently to check reliability. The process was conducted separately for the engagement and then for the disengagement feeding cues. A high level of inter-rater agreement was found (single measures interclass correlations by use of a two way random effects model) r= 0・79 (p<0. 001) for the disengagement cues and higher for the engagement cues r= 0・90 (p<0.001). Cronbach's alpha indicated that the disengagement and the engagement feeding cues had acceptable internal consistency (α=0.794; α=0.922 respectively). It is possible that as several of the communication cues require verbal and mobile ability, they were not identified at such early age and in feeds associated with milk feeding. This is further addressed in the limitations of this study.

BMI and weight measurement:

Infants' weight, length/height and age at measurement were recorded from the Child Health Parent Held Records ('red book' in the United Kingdom and equivalent in Israel). Standardized Z-scores for weight (WHO, 2010) were calculated for all infants and are presented as mean Z-scores for weight.

Data Analysis:

The analysis was conducted using Stata version 12 and SPSS Statistics v20. Data were coded to identify the time the cue appeared (in seconds) and feeds were divided into three equal parts (beginning, middle and end), accounting for the total duration of each meal. The frequency in counts per minute was calculated per behaviour in each section of the meal. The analysis always addressed the specific filmed feed and not general feeding behaviours. Frequencies (number of behaviours per meal/part of a meal) were calculated for each cue separately first for the total number of appearances and then for each part of the feed. Histograms were plotted and kurtosis was calculated to identify any skewness from normality.

Means (standard deviation) were calculated for maternal and infant characteristics. Graphs and figures were produced in Stata version 12 and in Excel. In order to examine whether frequency of behaviour varied between sections of the meal and with mode of feeding, mixed analysis of variance (ANOVA) were carried out with a between subjects factor (mode of feeding: BF vs FF) and a within subjects factor (time: beginning, middle, end). Where these revealed significant differences appropriate post hoc tests were conducted. Bonferroni corrections were applied where paired comparisons where conducted.

In order to examine whether engagement and disengagement cues tended to cluster within each time period, Spearman correlation tests (non-parametric data) were conducted on the counts of each behaviour for each time period. It was predicted that the presence of these cues would be correlated, i.e. high frequency occurrence of one engagement cue would be accompanied by high frequency occurrence of other engagement cues and the same for disengagement.

Ethical considerations:

The study was approved by the ethics committee at the Institute of Psychological Sciences at the University of Leeds, reference no. #11-0137.

Results:

Twenty –seven infants from Israel (N=12) and the UK (N=15) were filmed while breastfeeding/formula feeding (13 breastfeeding; 14 formula feeding). No significant differences were identified between Israeli and UK infants for infants' age, weight and mode of feeding. The analysis was therefore combined across sites. Most mothers were married and for more than half of the sample (N=16; 60%) this was not the first child. Mean maternal BMI was 23 $\pm$ 2.9 kg/$m^2$ indicating that most mothers were within the healthy range of weight.

Infant age ranged from 3-22 weeks and was normally distributed. The mean duration of the feed was 8.6 (SD = 4.3) minutes and ranged from 2-15 minutes. No significant differences were identified for duration of the feed between breastfed compared to formula fed infants. Data was missing for weight/length for a total of 6 infants. Table 1 summarises the main characteristics of mothers and their infants.

**(Table 1 near here)**

Table 1; Participant characteristics

| **Breastfeeding (n = 13)** | **N (percentage)** | **Mean (SD)** | **Median** | **interquartile range** |
|---|---|---|---|---|
| Maternal age (years) | | 35.1 | 34 | 32-40 |
| Parity: | | | | |
| Primaparous | 7(54%) | | | |
| Multiparous | 6(46%) | | | |
| Maternal BMI (kg/m2) (n = 12) | | 24(4.4) | 23.5 | 19-37 |
| Infant age (weeks) (n = 12) | | 19.1(5.9) | 23 | 10-24 |
| Infant sex: | | | | |
| Male | 7(54%) | | | |
| Female | 6(46%) | | | |
| Z-scores for weight (n = 10) | | -0.62(0.94) | -0.67 | -2.09+1.07 |
| | | | | |
| **Formula feeding (n = 14)** | **N (percentage)** | **Mean (SD)** | **Median** | **interquartile range** |
| Maternal age (years) | | 35 | 36.5 | 26-40 |
| Parity: | | | | |
| Primaparous | 5(36%) | | | |
| Multiparous | 9(64%) | | | |
| Maternal BMI (kg/m2) | | 24.6(3.7) | 24.8 | 19-32.8 |
| Infant age (weeks) | | 16.7(6.5) | 18 | 5-24 |
| Infant sex: | | | | |
| Male | 8(57%) | | | |
| Female | 6(43%) | | | |
| Z-scores for weight (n = 11) | | -1.16(1.3) | -1.07 | -3.07+0.48 |

Feeding cues:

The process of viewing the films and coding the engagement and disengagement cues revealed 22 feeding cues. In all, eight cues were withdrawn from the list for coding since they appeared infrequently (appeared only in few of the films) and removal did not affect the overall interpretation of the data (as the analysis focused on the frequency of each cue/part of meal/mode of feeding). There were more observed disengagement cues listed compared to engagement cues and in terms of observed frequency there were more disengagement than engagement cues recorded during the feed. Figures 1 and 2 show the rate of each cue in each part of the meal, by mode of feeding. Higher levels of engagement and disengagement

cues were seen in breastfed compared to formula fed infants. This indicates a greater frequency of communication cues by breastfed infants.

Engagement cues: effects of time and mode of feeding:

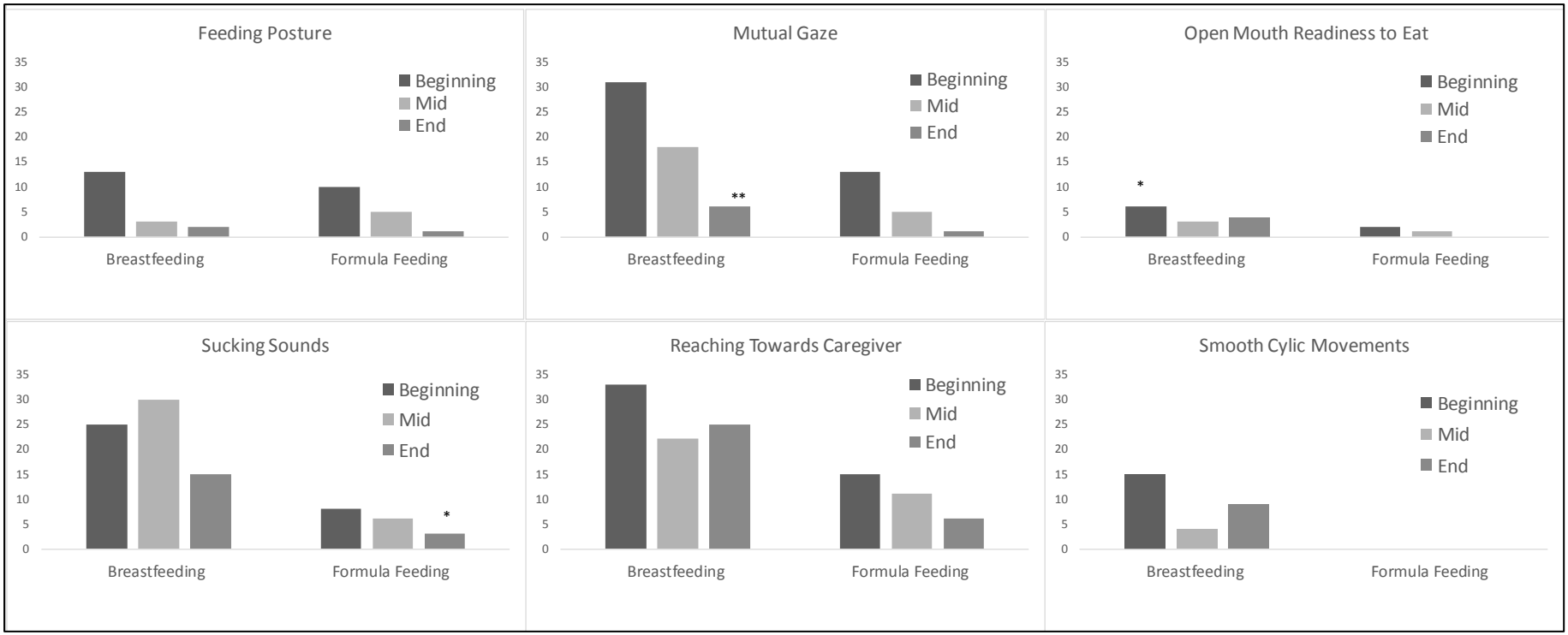
Breastfed infants made more sucking sounds compared to formula fed infants [$F_{(1, 21)} = 18.8$; $p=0.001$; figure 2a and did this more within early phases of the feed [$F_{(2, 42)} = 4.26$; $p=0.02$]. Breastfed infants also opened their mouth and indicated greater readiness to eat at the beginning of the feed compared to formula fed infants. A main effect of time was found for mutual gaze [$F_{(2, 26}=4.13$, $p=0.02$] where this was more evident at the beginning of the feed [$F_{(1, 10} = 21.2$, $P=0.001$; figure 1] compared to the end, confirming mutual gaze (indicative of interest) waning with satiation and satiety.

Several statically significant correlations were identified between the engagement cues. For example, at the end of the feed, reaching towards the caregiver was correlated with feeding posture ($r=0.43$, $p<0.05$), mutual gaze ($r=0.55$, $p<0.01$) and with smooth cyclic movements ($r=0.54$, $p<0.01$), all indicating on hunger.

Smooth cyclic movement was identified only in breastfed infants. It is possible that breastfeeding requires more upward movement to reach the breast whereas formula fed babies need less effort to obtain milk.

**(Figure 1 near here)**

Figure 1: Frequency of engagement cues by mode of feeding and by phase of feeding.




Repeated measures ANOVA. *P<0.05; **P<0.01

Disengagement cues: effects of time and mode of feeding:

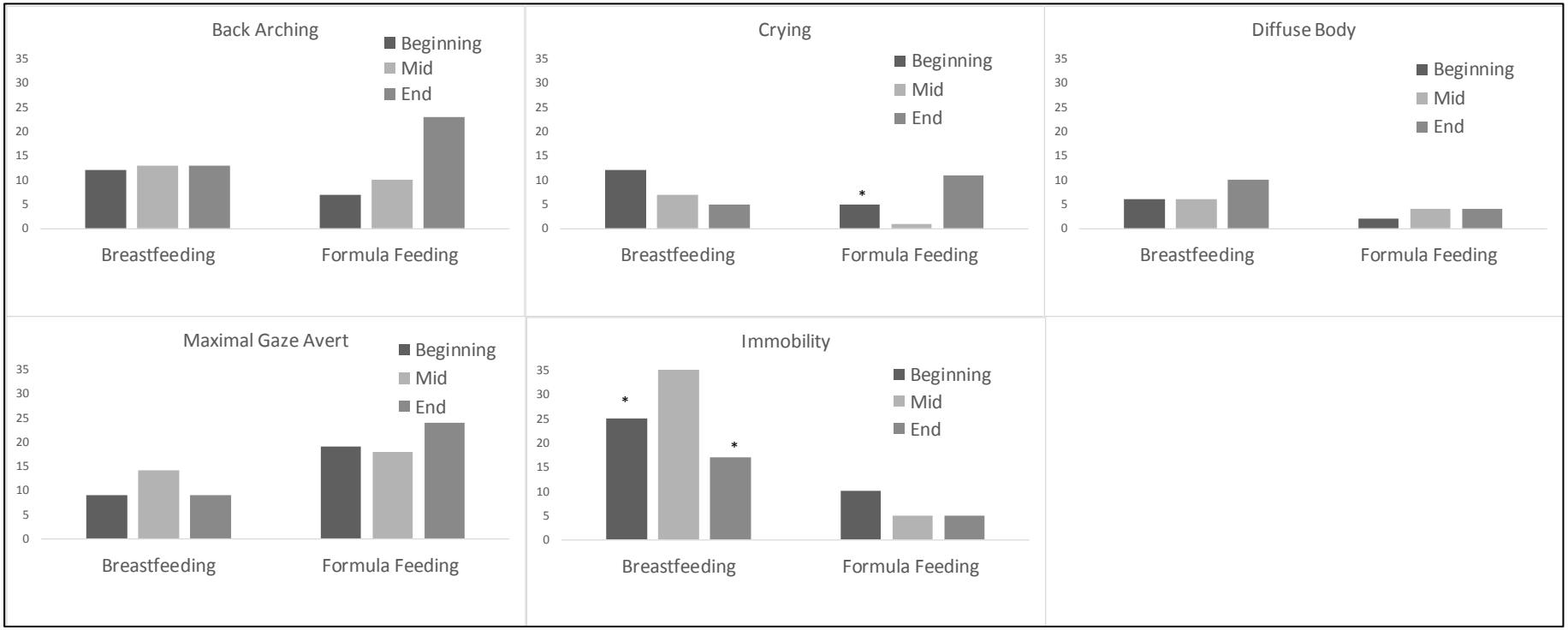
Inspection of figure 2 suggests that there are differences in the pattern of disengagement cues by both time and mode of feeding. While breastfed babies communicate more overall, the pattern of cues also seems different.

There was a significant interaction between time and mode of feeding for immobility (minimum movement of the body. [$F_{(2, 48)} = 4.05$; $p=0.024$]). Further analysis revealed this interaction was due to an effect of time for breastfed [$F_{(2, 24)} = 3.95$, $P=0.03$] but not for formula fed ($F_{2, 24} = 1.22$, $P=0.31$) fed babies. Pairwise comparisons revealed the effect of time in breastfed babies was due to differences in the rate of immobility in the middle of the feed, compared to the end of the feed (mean difference = .365, SE = .129, p = 0.045).There was a significant main effect of mode of feeding for immobility. Breastfed infants were significantly more immobile during the feed compared to formula fed infants [$F_{(1, 24)} = 10.69$; $p=0.003$; Figure 2].

There were few statistically significant correlations among disengagement cues. Specifically we found that at the beginning of the feed, and in the middle of the feed, crying correlated with back arching (for both: $r = .42$, $p<.05$). In the middle of the feed, back arching was correlated with diffuse body ($r=0.561$, $P<0.01$). Finally, at the end of the feed, maximal gaze avert correlated with both crying ($r=.43$, $p<0.05$) and immobility ($r = -.42$, $p< 0.05$). This suggests that disengagement cues occur together in a pattern which may reveal urgency of communication by the end of the meal.

**(Figure 2 near here)**

Figure 2: Frequency of disengagement cues by mode of feeding and by phase of feeding.




Repeated measures ANOVA. *P<0.05; **P<0.01

Discussion:

Findings from this study supported the hypothesis that engagement and disengagement feeding cues would vary by the mode of feeding.
Overall, engagement cues were observed more in the early part of the meal whereas disengagement cues appeared more frequently at the end of a meal. The assumption that engagement cues reflect interest in the feed as a function of hunger and disengagement cues might reflect a change in interest in the feed as a function of satiation is supported.

There were 22 feeding cues signalled during the milk feed with significantly more disengagement cues compared to engagement cues. This supports observations reported by Hodges et al (2013) in their development of the Responsive to the Child Feeding Cues Scale (RCFCS) in which 20 hunger cues were identified (engagement) compared to 28 satiation cues (disengagement). Eight cues were removed from the analysis in this study as they appeared infrequently.

The cues were originally identified as communication cues by Givens (1978) and the NCAST team (Sumner and Spietz. 1994) who identified eighty-three communication cues from the videos of feeding interactions. This list whilst useful has some limitations. For example, the cues are not age specific and so there are certain cues which can only be identified in older children as they require the ability to speak and move (e.g. say no, walk away etc.). In addition, few of the cues are provided in detail and some describe the same cue (such as gesture) but then relate to different parts of the body. For example, hand to mouth, hand to ear, hand to stomach which are all disengagement cues and are listed as three different cues.

Several of the feeding cues showed high levels of correlation with other feeding cues. It is therefore possible that infants used several cues simultaneously signalling to their mothers when they were ready to feed (engagement cues) and when they have had enough (disengagement cues). For example, in the beginning of the meal, infants' hands were placed towards their torso (feeding posture) and their mouth was open, both cues can be assumed to signal hunger. Similarly, towards the end of the

meal, when hunger levels are assumed to decline, infants were more likely to cry and turn their head away from their caregiver indicating their wish to stop the feed (assumed to signal satiation). Nevertheless, on many occasions mothers 'failed' to recognise such cues and adopted a less responsive feeding style by continuing to feed.

Disantis et al (2011) systematically reviewed the literature addressing the role of responsive feeding in overweight infants and toddlers. The authors suggested that feeding responses discordant with infant hunger and satiation cues could lead to impaired satiety responses in the infant. Thus mothers who repeatedly follow an unresponsive feeding method may negatively influence their infant's self-regulation processes. McNally et al (2015) reported that mothers' interpretation of feeding cues is based on maternal characteristics, infant temperament and external influences. There is therefore a need to better understand the possible associations between characteristics of the mother, child, feeding context and responsive feeding.

Time:

As predicted, engagement cues were observed more at the beginning of the meal compared to later in the meal. As such, infants were more likely to look into their mothers eyes at the beginning of the meal compared to its end. It is possible that the early phases of the meal required higher levels of "external" communication to learn about infant's engagement/disengagement behaviours. As the meal progressed, both infant and mother developed self-awareness and the awareness to each other and thus were more able to predict what the other will do.

Breastfeeding has been associated with several positive outcomes. For example, breastfeeding mothers were identified as more caring and less over-protective compared to formula feeding mothers (Horwood and Fergusson. 1998). The WHO and the United Nations International Children's Emergency Fund (UNICEF) introduced the Baby-Friendly Hospital Initiative (BFHI) which promotes breastfeeding. Thus mothers are advised to place the infant on skin-to-skin contact encouraging self-lactation (Mannel et al., 2013). In support, Bigelow et al (2010; 2012) explored breastfeeding, skin-to-skin contact and mealtime interactions during

the first three months of life observing more positive mealtime interactions in breastfeeding mothers who followed skin-to-skin contact than those who did not. The authors suggested that skin-to-skin contact increases mothers' ability to be more in-tune with their infant's needs and promotes a more positive mealtime interaction. Although in our study we did not specifically explore skin-to skin contact during breastfeeding, the importance of breastfeeding in promoting infant's ability to communicate hunger and satiety was evident. It is not to say that formula fed babies do not communicate with their mothers, however, breastfeeding may establish higher levels of sensitivity to infant's needs, especially in the first three months of life (Kuzela et al., 1990; Britton et al., 2007). Such early experiences are likely to be followed later in life as well (Britton et al., 2007). We therefore aim to follow the present cohort to examine the stability of these communication cues until infants are two years old and evaluate the effect of breastfeeding across time.

Mode of feeding: Breast or formula

Breastfed infants showed higher levels of engagement and disengagement cues compared to formula fed infants. Brown and Arnott (2014) reported that infant-led feeding approaches (associated with breastfeeding) were related to higher awareness of infant hunger and satiety cues. In this research the authors proposed a possible bidirectional relationship in which mothers may adapt their use of routine to their chosen feeding method (Brown and Arnott, 2014). It is suggested that breastfeeding is positively associated with less controlling feeding practices of the mother and this strengthens the claim that feeding is not only about the food content (**what infant eats**) but also about **how** an infant and a mother communicate during a feed (Shloim et al., 2015).

Breastfeeding involves an active engagement of infant in the feed. It is therefore possible that while breastfeeding the infant concentrates on the feed and demonstrates an active engagement behaviour. Moreover, this is the only cue which is addressed by the NCAST team as possibly associated both with engagement and with disengagement feeding cue. As the age of our sample was so young, it seemed more appropriate to relate immobility to represent disengagement. In support, Shloim et al (2015) noted that breastfed infants participated in the meal (reached towards

their caregiver, reached towards the breast) and set their own pace of feeding compared to formula fed infants. Moreover, breastfeeding was associated with a more positive meal interaction. Thus, encouraging mothers to breastfeed is important not solely as breastmilk is considered nutritionally more superior than formula milk, but also as breastfeeding promotes communication even in infants with limited capacity to communicate and when some feeding cues are relatively subtle.

Limitations:

Findings from this study should be treated with some caution and there are limitations to consider. Women were highly educated and from a relatively high socio-economic status which might have affected their feeding behaviours and their mealtime interactions in general. Therefore repeating the analysis within a larger and a more varied sample, with women from different SES might increase the understanding on the way infants communicate with their mothers during a feed. A second limitation is the filmed meal. We only have one filmed meal per participant and therefore might not be fully representative for the general mealtime interaction. An improved methodology should involve more than one recorded meal per participant in each follow-up. There was also no set time for the filmed meal (since it was left to mothers to determine when it was best to be filmed). This means that there was variability in time since the last feed and this resulted in some difficulty in estimating how hungry babies were. Another limitation associated with time is the duration of the feed and as such it is possible that a number of the breastfeeding babies fell asleep at the breast, and were not removed, resulting in some error in determining the duration of the feed. However, the method used was the least intrusive and most ecologically valid. For future studies mothers could be instructed to remove the baby from the breast or tell the researcher when the feed has paused. The third limitation addresses the NCAST feeding scale. The scale is not age specific and thus the cues (apart from crying) identified in this study were all non-verbal which is likely to be explained by our study subject's age. It is therefore possible that repeating the analysis within a sample of older babies might result in the identification of additional cues (e.g. verbal cues as saying "no" or other potent cues as pushing the food/caregiver away), as originally identified by the NCAST

team. Fourth, the analysis was conducted manually and was not based on specific coding software. The rationale for this was so that two different coding systems could be applied (SFES and NCAST) but in future specialist software could improve the accuracy of coding times. Finally, there was no difference in duration of meals for formula or breast fed babies this was not expected and could suggest that mothers were influenced by the presence of the researcher.

Clinical implications:

Research to examine communication during meals is needed to enhance our understanding of mealtime interactions and their importance in promoting self-regulation. Our findings demonstrate clearly that infants communicate engagement and disengagement cues during the course of a meal. Encouraging mothers to identify hunger and satiety cues might result in better communication and better interactions between mothers and their infant leading to more responsive feeding. Supporting mothers and empowering them to be able to identify and interpret feeding cues is likely to promote more responsive feeding and a better quality experience of feeding between mothers and their infants.

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