

Maternal responsiveness to child receptiveness and fullness cues from 8 to 24 months of age and their relation with complementary feeding approach and language proficiency

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ABSTRACT

We investigated the relationship between the complementary feeding approach (Baby-Led Weaning, Parent-Led Weaning or a mixed approach) and maternal responsiveness to child feeding cues in 166 children using mealtime observations at 8, 12, 18 and 24 months of age. We also explored whether maternally reported child linguistic proficiency was related to observed maternal responsiveness during mealtimes. Results suggest that mothers were more responsive to child receptiveness to eat when their children were 12 and 18 months old compared to when they were 8 months old. Mothers were increasingly responsive to their child's fullness cues at 8, 12, and 18 months. Mothers were less responsive to fullness when children were 24 months compared to 18 months old; although not assessed directly this may reflect a developmentally expected increase in child neophobia and picky eating as children age. Maternal responsiveness to fullness was positively correlated with child consumption of fruit and vegetables, which are usually among the least consumed food categories by neophobic and picky children. Furthermore, mothers who were more responsive to their infants' receptiveness to eat reported significantly lower levels of child verbal production at 12 months. In contrast, mothers who were more responsive to child fullness cues reported higher levels of infant verbal production, regardless of child age. Responsiveness to fullness was also positively related to proportion of self-feeding, which is a key feature of Baby-Led Weaning. In conclusion, in the first 18 months of life maternal responsiveness during mealtimes increased over time and was related to child language proficiency and ability to eat independently. These findings may extend to maternal responsiveness in contexts other than mealtimes with potential implications for the child socio-emotional development.

1. Introduction

The transition from milk feeding to complementary food represents a particularly delicate developmental step, with health implications

lasting as long as 6 years (Rose et al., 2017). Over the last 60 years, it has become common, at least in Western countries, for the first food offered to infants to be puréed baby food, presented by the caregiver on a spoon, at around 5–6 months of age (Agostoni et al., 2008; Seaman et al., 1996).

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This approach is generally known as *Parent-Led Weaning* (PLW; Cameron et al., 2013). However, in the last 15 years an alternative approach, *Baby-Led Weaning* (BLW; Rapley & Murkett, 2008), has gained popularity. In BLW, infants independently eat finger foods cut accordingly to their chewing and motor abilities, while participating in family meals (Fernández-Medina et al., 2023; Vilas Boas et al., 2020). This approach to complementary feeding provides infants with the opportunity to explore and manipulate food on their own, thus learning about the sensory aspects of foods, to develop food preferences and eating behaviors within the context of family meals, and to self-regulate food intake (Ventura, 2022). Another similar, alternative approach is the *On-demand Complementary Feeding* method (*Alimentazione Complementare a Richiesta*), proposed for the first time by the Italian pediatrician Lucio Piermarini, which recommends that caregivers, before offering any food to the infant, wait for the infant to show interest in and request the food eaten by other people during family meals (Piermarini, 2002). However, the research on this specific approach is limited and, due to its apparent similarity to BLW, the two approaches have not been differentiated in the literature so far (Addressi et al., 2021; Di Prete et al., 2023).

Whilst there is clear potential for the complementary feeding approach to shape child nutrition and eating outcomes, research has also begun to explore the potential relationships between different approaches to complementary feeding and infant experiences more generally. Emerging research has suggested that different complementary feeding approaches may shape maternal responsiveness during mealtimes. Indeed, in a questionnaire study Fernandes et al. (2023) reported that parents who followed a BLW or mixed feeding approach reported less pressure to eat and minimization of reactions to children's negative emotions, compared to parents who adopted a PLW approach. In an observational study Hodges et al. (2013) observed that mothers of 7–24-month-old children were more responsive to hunger (e.g., licking lips, excitatory limb movements) and fullness cues (e.g., gaze aversion, turning head, giving back food) with children who more often ate autonomously compared to children who were primarily parent-fed. Similarly, in our research with 8- and 12-month-old infants, we observed that maternal responsiveness to infant fullness, but not to receptiveness, was positively related to the proportion of infant self-feeding (Di Prete et al., 2023).

Maternal responsiveness to infant cues during feeding interactions has the potential to shape multiple areas of parenting and development. In terms of eating behavior, a mismatch in responsiveness can lead to failure to offer food when the child is hungry, or pressure to eat when the child is satiated, undermining their ability to regulate energy intake (Birch & Fisher, 1998). Indeed, lower responsiveness during mealtimes may unintentionally encourage over-eating in the absence of hunger (Di Santis et al., 2011) and could potentially influence weight gain during infancy (Farrow & Blissett, 2006). Infant verbalizations are among studied infant feeding cues (Hodges et al., 2013), yet to our knowledge, there is a gap in the literature about the relationship between children's communicative and linguistic skills and maternal responsiveness to their feeding cues. Children's linguistic proficiency may be an important factor associated with maternal responsiveness during the meal, considering that parent-child interaction is a key component in children's language development (Topping et al., 2013) and mealtimes provide regular daily occurrences for interaction.

In the present study, we aimed to extend our previous investigation of the relationship between complementary feeding approach and maternal responsiveness to hunger and fullness cues (Di Prete et al., 2023) with longitudinal follow up data from the same sample of children at 8, 12, 18, and 24 months of age. Our primary aims were to investigate:

- i) if maternal responsiveness differed between ages;
- ii) if maternal responsiveness was related to complementary feeding approach used at the onset of the complementary feeding period, and/or to the proportion of infant self-feeding;

- iii) if maternal responsiveness was related to infant language proficiency.

We expected both maternal responsiveness to child receptiveness to eat and fullness to increase over time as mothers increase their knowledge of their child's needs and their interpretation of the child's behavioral cues (Olson et al., 1986). However, we expected a decrease in maternal responsiveness to fullness at 24 months of age, when neophobia and picky eating are a concern for many parents (e.g., Dovey et al., 2008), and mothers may be more inclined to insist on trying to feed their children. To assess the relationship between maternal responsiveness and children's diet, we also measured the frequency of consumption of six main food groups (using the Food Frequency Questionnaire, modified from Cooke et al., 2003), which included fruit and vegetables, that are particularly disliked by neophobic and picky children (Cooke et al., 2003, 2006; Galloway et al., 2003, 2005; Taylor & Emmett, 2019; van der Horst et al., 2016). Additionally, since child-centered approaches to complementary feeding (such as the BLW approach) are believed to support the development of self-regulation of food consumption (Di Santis et al., 2011; Philippe et al., 2021), we hypothesized that, regardless of age, a higher level of maternal responsiveness to fullness would be positively related to an increased proportion of infant self-feeding, as previously reported in the same sample at 8 and 12 months of age (Di Prete et al., 2023) and in a US cross-sectional sample (Hodges et al., 2013). As for the role of infant language skills, to our knowledge no study has yet specifically investigated the relationship between maternal responsiveness to feeding cues during the context of the meal and infant concurrent productive vocabulary development. However, several studies have found significant relationships between parental responsiveness and infant cognitive and language development in other contexts (e.g., Landry et al., 2006, 2001; Paavola et al., 2005; Tamis-LeMonda & Bornstein, 2002). For instance, maternal responsiveness during play at 9 and 13 months of age significantly predicted the timing of children's achievement of language milestones (Tamis-LeMonda et al., 2001). Similarly, children whose mothers were consistently responsive in the first years of life showed better cognitive and linguistic skills, and this was particularly true for preterm children (Landry et al., 2001, 2006). Additionally, maternal responses scored in a play context at 10 months of age were correlated with children's vocabulary comprehension at 12 months (Paavola et al., 2005). Given the specificity of the feeding context, we hypothesized that mothers reporting a less advanced verbal production in their children will be more responsive to their hunger cues and, conversely, less responsive to their fullness cues, as they may perceive their children as more immature and at greater risk to be underfed (Hodges et al., 2013; LeVine, 1988).

2. Methods

2.1. Participants

Participants belonged to a broader longitudinal study on the relation between the complementary feeding approach and child cognitive, motor, and language development, and included 184 mothers with their 8-month-old children, 182 mothers with their 12-month-old children, 175 mothers with their 18-month-old children and 171 mothers with their 24-month-old children (Bellagamba et al., 2020). For the present study, we analyzed only the data for the 166 mother-child pairs who participated at each step of the study. Participants were recruited during mother's pregnancy or soon after birth via social media, posters in pediatricians' offices, and the newsletter of *Uppa Magazine* addressed to parents. All participants were Italian, mainly from the area of Rome (at 8 months of age: 72.8 % were from Central Italy, 23.4 % from Northern Italy, 3.3 % from Southern Italy and Islands, and .5 % were Italians living abroad). In the invitation letter, participants were invited to join in a study about child feeding practices. There was no mention of

baby-led weaning in the letter of invitation, nor was any information about complementary feeding approaches provided to the participants. Parents could freely choose the complementary feeding approach they considered to be most appropriate for their child. Children who were born prematurely, had congenital anomalies, severe neurological deficits, were twins and/or were bilingual (i.e., exposed to other languages beside Italian) were excluded from the sample. We did not recruit bilingual children to exclude a potentially confounding variable, as this population may have a different trajectory of language development from monolingual children (Volterra & Taeschner, 1978). Related data for 8- and 12-month-old infants have been previously reported elsewhere (Di Prete et al., 2023).

Both parents provided written parental consent for taking part in the study and to be video recorded. All procedures were approved by the Ethics board of the Department of Dynamic and Clinical Psychology and Health Studies of Sapienza University of Rome (Prot. N. 0000315, April 14, 2020, and n. 0001209, December 15, 2020) and by the Research Ethics and Integrity Committee of the National Research Council of Italy (Prot. N. 00721482019, October 18, 2019, and n. 0028810, April 23, 2021).

2.2. Measures

Mothers completed a survey providing information on demographics, breastfeeding, their child's complementary feeding habits, and food frequency consumption when children were 8-, 12-, 18- and 24-month-old. Moreover, at the same ages, mothers also completed the short form of the MacArthur-Bates Communicative Development Inventory (Caselli et al., 2015; Fenson et al., 2000). Furthermore, at each age we recorded a typical meal during a video call, to directly evaluate maternal responsiveness to children's receptiveness to eat and fullness cues and the proportion of feeding episodes in which the child ate independently. Further details are reported below.

2.2.1. Self-reported measures

When infants were 8 months old, mothers reported information about themselves (highest level of education) and about their child (sex, presence of siblings in the household, infant's age at the onset of complementary feeding, and complementary feeding approach used – BLW, PLW or Mixed). As for the complementary feeding approach, we asked mothers whether they were using “traditional weaning” (defined as “weaning with either homemade or commercial puréed baby food, prepared according to the pediatrician's directions”), “on-demand complementary feeding” (the Italian version of baby-led weaning, defined as “weaning with the food eaten by all the other family members, cut in small pieces, provided following the infant's behavioral or verbal requests”) or a “mixed method” (a mix of the two approaches). At each time of the study mothers also provided information about whether they were employed (or not) and if they were still breastfeeding their child. Moreover, they completed a Food Frequency Questionnaire (modified from Cooke et al., 2003) in which they were asked information about their child's frequency of consumption of six food groups: fruit, vegetables (excluding potatoes), fish or meat, rice/potatoes/pasta, sweets, and eggs. Mothers could respond on an eight-point Likert scale: “never” (0), “once or twice a week” (1), “three or four times a week” (2), “five or six times a week” (3), “once a day” (4), “twice a day” (5), “three times a day” (6), “four or more times a day” (7).

Additionally, mothers were required to complete the Italian short forms of the MacArthur-Bates Communicative Development Inventory (MCDI-SF; Fenson et al., 2000) – Il Primo Vocabolario del Bambino (Caselli et al., 2015). Specifically, they completed the Words & Gestures form when their child was 8- and 12-months old, and the Words & Sentences form when their child was 18- and 24-months old. The Words and Gestures form investigates vocabulary comprehension, productive vocabulary, and gestures in children aged between 0 and 17 months of age. The Words and Sentences form investigates productive vocabulary

and the ability to produce sentences in children aged between 18 and 36 months of age. The number of responses was compared with the reference sample using specific tables, and the final score was expressed as a percentile. For our analyses, we only considered the productive vocabulary (i.e., the number of words which mothers reported their children to produce) at each age. We focused on productive vocabulary as this is the only variable that is consistently assessed by the MCDI-SF from 8 to 24 months of age.

2.2.2. Mealtime observations

For each child, we recorded a typical meal during a Skype or Jitsi Meet video call (via parent smartphone, tablet, or laptop) by means of the software OBS Studio. Researchers' cameras were turned off during the recordings not to attract child's attention during the meal. At all ages about 73 % of the video clips did not contain any interruptions or any footage in which the child was not clearly visible; in the remaining video clips, coding was not possible for an average of less than 1 min. In total, we coded 664 mealtime videos.

During offline coding, we scored the number of times in which the child was either parent-fed (i.e., instances in which the parent offered the child food with a spoon, fork or fingers and the child accepted it) or in which the child self-fed (i.e., instances in which the child independently put food in their own mouth with a spoon, fork or fingers and swallowed it), from which we determined the proportion of time in which the child self-fed (proportion of self-feeding, calculated as the number of episodes in which the infant ate autonomously divided by the total number of feeding episodes).

Additionally, to rate the maternal responsiveness to child receptiveness to eat and to fullness cues, we scored the video recordings using the “Responsiveness to Child Feeding Cues” coding scheme (RCFCS, Hodges et al., 2013) by means of the BORIS software (Friard & Gamba, 2016). The RCFCS coding scheme allows scoring the child's behavioral hunger and fullness cues and parental responsiveness to them to perform both microanalytic and global analyses of dyadic transactions during a meal. The caregiver's responsiveness to hunger and fullness cues is coded separately due to the possibility that a caregiver could be differentially sensitive to the child's behaviors at the beginning or at the end of the meal. This coding scheme considers the possible presence of 48 different behaviors and their frequency: 20 hunger cues that reflect the child's interest in eating, and 28 fullness cues that reflect the child's disinterest or fullness (depending on whether these cues are scored within the first minute since the onset of the meal or after that time). All indicators are classified into early, active, and late cues, according to the temporal succession and intensity of the behavior. “Early” cues are subtle and primarily oral in nature; “active” cues are stronger and involve more complete movements of the body (for example, “refuse to open mouth when food is at lips”); “late” cues are even more evident and have a negative valence (for example, “crying”). The responsiveness to child receptiveness to being fed is defined by the number and type (early, active, late) of child's hunger and disinterest cues produced from the start of food preparation until 1 min after the first bite. The responsiveness to child fullness cues is defined by the number and type (early, active, late) of child's fullness cues produced in the period of time going from 1 min after the first bite to the last offer of food or the last bite, before the mother responds by interrupting the meal. The caregiver's responsiveness is coded on a five-point Likert scale, from “highly responsive” (5) to “highly unresponsive” (1). If no hunger or fullness cues are observed for a specific child, the corresponding cell is left empty (“can't tell”).

2.3. Inter-rater reliability

Inter-rater reliability was calculated on a total of 116 video clips (28 for the 8-month-olds, 29 for the 12-month-olds, 26 for the 12-month-olds and 33 for the 24-month-olds). We calculated the inter-rater reliability between ADP and EA for the 8-month-olds, between ADP and

DDG for the 12-month-olds (please see also Di Prete et al., 2023 for 8- and 12-month-olds), between ADP and SP and between ADP and GT for the 18-month-olds, between ADP and GMC and between ADP and EG for the 24-month-olds by means of (i) the intra-class correlation coefficient (ICC) for multiple raters (Bakeman & Quera, 2011; Shrout & Fleiss, 1979) for responsiveness to receptiveness to eat and responsiveness to fullness, and (ii) the index of concordance (IC) for parent-feeding and self-feeding (Bateson & Martin, 2021). The agreement was good for maternal responsiveness to child receptiveness (average ICC = .83) and excellent for maternal responsiveness to child fullness (average ICC = .95). The agreement for self-feeding and parent-feeding was, on average, IC = .95 and IC = .97 respectively.

2.4. Statistical analyses

We separately analyzed maternal responsiveness to child's receptiveness to eat and fullness by means of random-effects ordered logistic regression models with sex, age (8, 12, 18, 24 months), siblings (yes/no), still breastfeeding (yes/no), child's age at the onset of complementary feeding (months), maternal employment at the time of the study (yes/no), proportion of self-feeding (as scored during video clips of mealtimes, please see Methods), complementary feeding method used at 8 months of age (BLW, PLW or Mixed) as reported by mothers, and language production (MCCDI-SF) as factors. For both regressions, the identity of the participant was included as a random effect and the significance of interaction effects (between children's age and the other factors) was assessed using the Wald test. Non-significant interactions were dropped from the model and the analysis was run again.

We also assessed whether maternal responsiveness to child receptiveness and fullness, respectively, was significantly correlated with child's frequency of consumption of each food category by means of Spearman's correlations (Benjamini-Hochberg adjusted). Statistical analysis was performed using Stata 14 software (StataCorp. 2015. College Station, TX: StataCorp LP), SPSS 21 software (IBM Corp. Released, 2012) and Jamovi (The Jamovi project, 2023). Significance level was set at $p < .05$.

3. Results

Table 1 includes the demographic characteristics of the longitudinal sample ($N = 166$), and Table 2 includes the descriptive analyses for the language production score of MCDI-SF. As shown, all the MCDI-SF scores were consistent with the Italian normative data. In particular, at 8 months, the mean language production score was .23, falling between the 75th and the 90th percentiles in the normative sample (score range: 0–2). At 12 months, the mean score was 2.60, falling between the 50th and the 75th percentiles (score range: 2–5). Finally, at 18 and 24 months, the mean scores were 20.43 and 53.60, respectively, both falling between the 25th and the 50th percentiles (score ranges: 10–23 and 41–77, respectively). At 8 months of age, the distribution of children across the three complementary feeding methods considered in this study (BLW, PLW, and Mixed) was fairly similar, according to maternal reports. Participants were reasonably balanced for sex, started complementary feeding around six months of age, in line with the latest WHO recommendations (World Health Organization, 2023), and a high percentage (38.5 %) of them were breastfed until 24 months of age. As reported in Table 1, the majority of mothers had a high level of education (89.2 % attended college or above) and were employed at the time of the study (62.6 % when children were 8 months old, 82.5 % when they were 12 months old, 88.5 % when they were 18 months old, and 87.9 % when they were 24 months old).

3.1. Longitudinal analyses of maternal responsiveness to child receptiveness and fullness

Mothers were significantly more responsive to child receptiveness to

Table 1
Characteristics of the participants ($N = 166$). The table reports descriptive statistics for socio-demographic variables, onset of complementary feeding, and complementary feeding approach (assessed at 8 months of age), occurrence of breastfeeding and proportion of self-feeding (assessed at each time of the study).

Variable	8 months	12 months	18 months	24 months
Child age (mean \pm SD)	8.04 \pm .33	12.3 \pm .47	18.3 \pm .58	24.4 \pm .83
Child sex (n and %)				
Females	81 (48.8 %)			
Males	85 (51.2 %)			
Siblings (n and %)				
Yes	70 (42.2 %)			
No	96 (57.8 %)			
Maternal age (years, mean \pm SD)	35 \pm 3.78			
Maternal education (n and %)				
College and above	148 (89.2 %)			
No college	18 (10.8 %)			
Maternal employment (n and %)				
Yes	104 (62.6 %)	137(82.5 %)	147(88.5 %)	146 (87.9 %)
No	59 (35.5 %)	26 (15.7 %)	16 (9.6 %)	18 (10.8 %)
Missing	3 (1.8 %)	3 (1.8 %)	3 (1.8 %)	2 (1.2 %)
Onset of complementary feeding (months, mean \pm SD)	5.64 \pm .66			
Complementary feeding approach (n and %)				
PLW	69 (41.6 %)			
Mixed	40 (24.1 %)			
BLW	57 (34.3 %)			
Still breastfeeding (n and %)				
Yes	127 (76.5 %)	92 (55.4 %)	55 (33.1 %)	64 (38.5 %)
No	37 (22.3 %)	71 (42.8 %)	111 (66.9 %)	100 (60.2 %)
Missing	2 (1.2 %)	3 (1.8 %)	0	2 (1.2 %)
Proportion of self-feeding (mean \pm SD)	.23 \pm .35	.52 \pm .37	.76 \pm .28	.81 \pm .25

Table 2
MacArthur-Bates Communicative Development Inventory. The table reports the descriptive statistics for the MCDI language production score at each age.

MCDI language production score	Mean \pm SD	Italian normative data (percentiles)
8 months ($N = 165$)	.23 \pm 1.21	<90
12 months ($N = 165$)	2.60 \pm 4.26	75–50
18 months ($N = 164$)	20.43 \pm 18.33	25–50
24 months ($N = 165$)	53.60 \pm 26.91	25–50

eat when their children were 12 months old (OR = 2.582, $z = 2.86$, $p = .004$) and, marginally significantly, 18 months old (OR = 1.893, $z = 1.95$, $p = .051$), than when they were 8 months old; there were no other significant age differences (Fig. 1). Moreover, there was a significant main effect of sex, with mothers of girls being more responsive to receptiveness than those of boys (OR = 1.445, $z = 2.25$, $p = .025$). We also found a significant interaction between age and language

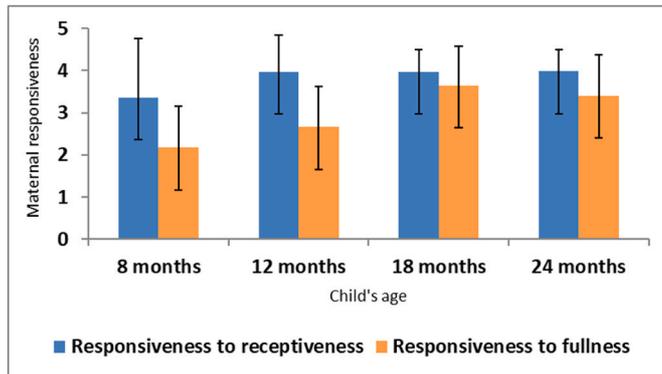


Fig. 1. The graph reports average maternal responsiveness to child receptiveness to eat and fullness cues at each time point.

production ($\chi^2(3) = 14.01, p < .01$) with post-hoc analysis showing that mothers reporting a lower level of infants' verbal production were more responsive to receptiveness when infants were 12 months of age ($OR = .922, z = -2.35, p = .019$). There were no significant main effects of siblings ($OR = 1.041, z = .27, p = .789$), breastfeeding ($OR = .892, z = -.70, p = .481$), child's age at the onset of complementary feeding ($OR = .902, z = -.85, p = .393$), maternal employment at the time of the study ($OR = .728, z = -1.09, p = .274$), proportion of self-feeding ($OR = 1.460, z = 1.35, p = .177$), and complementary feeding method used at 8 months of age (PLW vs. Mixed: $OR = .982, z = -.10, p = .922$; PLW vs. BLW: $OR = 1.272, z = 1.19, p = .235$; Mixed vs. BLW: $OR = 1.295, z = 1.29, p = .198$).

Mothers were more responsive to child fullness when their children were 12 months old than 8 months old ($OR = 2.037, z = 3.25, p = .001$), and when they were 18 months old compared to 12 months old ($OR = 4.961, z = 5.90, p < .001$), but they were less responsive to fullness when children were 24 months old rather than when they were 18 months old ($OR = .339, z = -3.60, p < .001$) (Fig. 1). Moreover, regardless of age, responsiveness to fullness was positively related to proportion of self-feeding ($OR = 2.867, z = 3.21, p = .001$), language production ($OR = 1.012, z = 2.33, p = .020$) and negatively related to mother employment ($OR = .595, z = -2.11, p = .035$). There were no

significant main effect of sex ($OR = 1.108, z = .63, p = .532$), siblings ($OR = 1.086518, z = .48, p = .631$), breastfeeding ($OR = .948, z = -.32, p = .750$), child's age at the onset of complementary feeding ($OR = .798, z = -1.28, p = .200$), and complementary feeding method used at 8 months of age (PLW vs. Mixed: $OR = .776, z = -1.11, p = .268$; PLW vs. BLW: $OR = .791, z = -1.04, p = .298$; Mixed vs. BLW: $OR = 1.019, z = .09, p = .927$).

3.2. Maternal responsiveness and children's food frequency consumption

As reported in Table 3, we found a positive correlation between maternal responsiveness to fullness and the frequency of children's fruit (significant, $r_s = .238, p = .014, N = 161$; Benjamini-Hochberg adjusted) and vegetables (marginally significant, $r_s = .187, p = .052, N = 161$; Benjamini-Hochberg adjusted) consumption. There were no other significant or marginally significant correlations between either maternal responsiveness to receptiveness or to fullness and the frequency of food consumption.

4. Discussion

The aim of the present study was to investigate if maternal responsiveness in 8- to 24-month-old children differed longitudinally according to the complementary feeding approach practiced by the families (BLW, PLW or Mixed), and whether it was related to the proportion of child self-feeding observed during meals (a key feature of BLW) and to mother-reported language production.

As expected, maternal responsiveness to both children's receptiveness to eat and fullness increased with age. Specifically, mothers were more responsive to receptiveness to eat when their children were 12 and 18 months old than when they were 8 months old, possibly due to the mothers' learned ability over time to better understand their children's internal states (Olson et al., 1986) and to the growing child's ability to intentionally communicate their needs to adult using gestures and words (Camaioni et al., 2003; Franco & Butterworth, 1996). The difference was no longer significant when children reached 24 months old, perhaps because 2-year-old children are typically more self-sufficient during meals (Carruth & Skinner, 2002).

Similarly, mothers were more responsive to child fullness when their children were 12 than 8 months old and 18 than 12 months old, showing

Table 3

For each time of the study, the relation between responsiveness to receptiveness to eat and to fullness, respectively, and the frequency of consumption of six food categories. Significant (**) and marginally significant (*) relations (Benjamini-Hochberg adjusted) are highlighted in bold.

Age	Responsiveness	Fruit	Vegetables	Fish/Meat	Sweets	Rice/potatoes/pasta	Eggs
8 months	Responsiveness to receptiveness	$r_s = .107$ p = ns N = 163	$r_s = .069$ p = ns N = 163	$r_s = .077$ p = ns N = 163	$r_s = -.100$ p = ns N = 163	$r_s = -.055$ p = ns N = 163	$r_s = -.075$ p = ns N = 163
	Responsiveness to fullness	$r_s = .091$ p = ns N = 164	$r_s = .047$ p = ns N = 164	$r_s = .014$ p = ns N = 164	$r_s = -.062$ p = ns N = 164	$r_s = -.179$ p = ns N = 164	$r_s = -.084$ p = ns N = 164
12 months	Responsiveness to receptiveness	$r_s = .041$ p = ns N = 164	$r_s = -.022$ p = ns N = 164	$r_s = -.039$ p = ns N = 164	$r_s = -.017$ p = ns N = 164	$r_s = -.103$ p = ns N = 164	$r_s = .120$ p = ns N = 164
	Responsiveness to fullness	$r_s = -.035$ p = ns N = 164	$r_s = .154$ p = ns N = 164	$r_s = -.015$ p = ns N = 164	$r_s = -.005$ p = ns N = 164	$r_s = -.020$ p = ns N = 164	$r_s = -.031$ p = ns N = 164
18 months	Responsiveness to receptiveness	$r_s = -.130$ p = ns N = 163	$r_s = -.039$ p = ns N = 163	$r_s = -.063$ p = ns N = 163	$r_s = .065$ p = ns N = 163	$r_s = -.071$ p = ns N = 163	$r_s = -.100$ p = ns N = 163
	Responsiveness to fullness	$r_s = -.062$ p = ns N = 164	$r_s = -.064$ p = ns N = 164	$r_s = -.133$ p = ns N = 164	$r_s = -.162$ p = ns N = 164	$r_s = -.133$ p = ns N = 164	$r_s = .029$ p = ns N = 164
24 months	Responsiveness to receptiveness	$r_s = -.025$ p = ns N = 161	$r_s = .035$ p = ns N = 161	$r_s = .057$ p = ns N = 161	$r_s = -.098$ p = ns N = 161	$r_s = -.095$ p = ns N = 161	$r_s = .076$ p = ns N = 161
	Responsiveness to fullness	$r_s = .237$ p = .014** N = 161	$r_s = .187$ p = .052* N = 161	$r_s = .004$ p = ns N = 161	$r_s = -.076$ p = ns N = 161	$r_s = .015$ p = ns N = 161	$r_s = -.120$ p = ns N = 161

an improved behavioral synchronization between mothers and children over the first two years of life. However, mothers were less responsive to fullness when children were 24 than 18 months old. Though we did not measure food neophobia and picky eating, our findings may be explained by the increases in food neophobia and picky eating that often emerge in children around 2 years of age (e.g., Dovey et al., 2008). Food neophobia is the refusal shown by toddlers and preschoolers to try new, unfamiliar foods (Addressi et al., 2005; Cashdan, 1994; Dovey et al., 2008). From an evolutionary perspective, this behavior is considered by many to be adaptive (Benton, 2004; Pliner & Hobden, 1992; Rozin, 1976; Rozin & Vollmecke, 1986) because it would prevent children from eating poisonous foods at an age when they become autonomous and independent in their movements. However, avoiding poisonous foods is less of a concern in modern society and food neophobia can instead result in young children avoiding healthy foods, especially vegetables, fruit, whole grains, and meat (Cooke et al., 2003, 2006; Galloway et al., 2003), while preferring foods containing high levels of sugar, fat, and salt (Ventura, 2022) and thus increasing the risk of obesity and dysfunctional eating habits (DiSantis et al., 2011; Worobey et al., 2009). Picky eating (defined as the rejection or restriction of familiar and unfamiliar foods, Dovey et al., 2008) is associated with reduced food intake, particularly fruit and vegetables (Galloway et al., 2005; Taylor & Emmett, 2019; van der Horst et al., 2016) and dietary diversity (Carruth et al., 1998). Picky eating extends further than food neophobia since children can reject food because of its textures and flavors (Dovey et al., 2008; Smith et al., 2005). Therefore, the observed decrease in responsiveness to fullness when children turned 2 years of age, may be due to mothers trying to deal with this new challenging period of their children's life, attempting to maintain (or expand) food variety during this phase, by being less sensitive to their fullness cues at the end of the meal. Moreover, the end of the second year of life is also characterized by an emerging ability to express oneself in a more deliberate and symbolic way: children of this age recognize their own image in the mirror, disobey, and use words and gestures to say 'no' (Rochat, 1995). All these achievements indicate a new sense of self-awareness and independence that parents have to gradually learn to manage. Thus, food neophobia, picky eating and gains in self-development could all influence maternal behavior. As noted earlier, we were unable to measure these dimensions and therefore these considerations should be considered as speculative.

Although in the present study we do not have data concerning children's food neophobia and picky eating, at 24 months of age we found positive correlations between maternal responsiveness to fullness and the frequency of children's consumption of fruit and vegetables, but no significant correlations between maternal responsiveness and children's consumption of other food groups (fish/meat, rice/potatoes/pasta, sweets, and eggs). This finding is consistent with previous literature showing that an authoritative feeding style (characterized by both high demandingness and responsiveness) was associated with a better diet quality (Arlinghaus et al., 2018) and a higher consumption of fruit and vegetables (Blissett, 2011). As children with a better diet quality (i. e., a higher consumption of fruit and vegetables) are also less neophobic (Perry et al., 2015), it may be possible that the observed decrease in maternal responsiveness to fullness at 24 months of age was a response to children's increased food neophobia and picky eating. According to Carruth et al. (2004), parents' understanding of their children's picky behavior increases with age (from 25 % at 7–8 months, to 35 % at 12–14 months, to 50 % at 19–24 months), probably because they are better able to verbalize their dislike for certain foods. The relationship between children's eating behaviors and parental feeding practices is likely bidirectional, with children's eating behaviors shaping parental practices around food, and these practices in turn shaping, and often reinforcing, children's eating behaviors (Costa & Oliveira, 2023). For example, in Jansen et al. (2017) and in Costa et al. (2021), parents' intentions to increase their child's food consumption by pressuring them to eat more, led to higher levels of food avoidance. Furthermore, according to Whitchurch and Constantine (1993), parents using

instrumental feeding practices (such as providing food as a reward) may lead their children to be more responsive to food and the increased children's food responsiveness may lead to further instrumental feeding behavior by parents.

Mothers employing different complementary feeding approaches showed similar levels of responsiveness to receptiveness to eat and fullness. The lack of differences in maternal responsiveness across the three complementary feeding approaches could be due to the fact that the Italian version of BLW, known as "on-demand complementary feeding", emphasizes infants' interest in participating in family meals and tasting the food eaten by other family members (Buglioni et al., 2017; Piermarini, 2002), rather than the mode of feeding (self-feeding vs. parent-feeding) and/or the texture of the food offered to the infant (finger food vs. purée) (Brown & Lee, 2011; Cameron et al., 2013; Campeau et al., 2021). However, regardless of age, maternal responsiveness to fullness was positively related to the child proportion of self-feeding – one of the main features of the BLW approach. This could indicate that a complementary feeding approach that emphasizes independence (not necessarily self-reported as BLW) promotes more child-centered maternal responses at the end of the meal. This outcome corroborates our previous observations on the same infants at 8 and 12 months of age (Di Prete et al., 2023) and the findings obtained in a US cross-sectional sample (Hodges et al., 2013). Specifically, we previously observed that maternal responsiveness to infant fullness, but not to infant receptiveness, was positively associated with the proportion of self-feeding observed at 8 and 12 months of age (Di Prete et al., 2023). Similarly, Hodges et al. (2013) reported that mothers of 7- to 24-month-olds were more responsive to both receptiveness to eat and fullness cues with those children who self-fed more frequently compared to children who were primarily fed by the caregiver. Although we replicated and extended our previous finding on maternal responsiveness to fullness (Di Prete et al., 2023), we were unable to replicate Hodges and colleagues' (2013) finding on responsiveness to receptiveness. As previously discussed elsewhere (Di Prete et al., 2023), this may be due to the different way in which mealtime recordings were obtained in Hodges et al. (2013) and in our studies (lab recordings from the onset of meal preparation in Hodges et al. vs. remote home recordings from the onset of food consumption in the present study and in Di Prete et al., 2023).

As expected, mothers that reported a lower level of verbal production by their children were more responsive to their receptiveness to eat. However, this held true only at 12 months of age, a developmental window in which recognizable language production is beginning. This may be a way to compensate for children's potential communications struggles showing a higher focus on their behavior at the beginning of the meal. Alternatively, it is possible that mothers who delay their responses to hunger cues when their infants are 12 months of age, drive the infant to communicate more explicitly. Additionally, regardless of age, mothers reporting a higher level of language production by their children were also more responsive to their fullness cues, lending further support to our hypothesis that maternal responsiveness depends on mother's understanding of their children's needs. However, it may also be hypothesized that it is maternal responsiveness itself that plays an important role in early language acquisition (as it was established in contexts different from feeding; Landry et al., 2006, 2001; Paavola et al., 2005; Tamis-LeMonda & Bornstein, 2002). This may occur not only because of the amount of language children are exposed to (more responsive mothers are likely to be talking more; Hoff et al., 2002) but because of the quality of responsive mothers' communication (Tamis-LeMonda & Bornstein, 2002). In fact, when considering both mother's language production and verbal responsiveness, the latter has been found to contribute uniquely to children's emerging language from 5 to 20 months of age (Baumwell et al., 1997; Bornstein & Tamis-LeMonda, 1989; 1999). Moreover, children with verbally responsive mothers achieve the vocabulary spurt and combine words into simple sentences sooner than children with less responsive mothers (Tamis-LeMonda & Bornstein, 2002). These findings further highlight

the importance of communication in the dyadic relationship between children and caregivers during their daily routines, and the relevance of encouraging responsiveness during meals.

Regardless of age, we also found a significant effect of child sex, with mothers being more responsive towards girls than boys. These results find support in previous works showing that mothers have a greater tendency to control the behavior of their daughters than of their sons (Pomerantz & Ruble, 1998) and that they report higher levels of weight-related concern for their daughters (Tiggemann & Lowes, 2002). Alternatively, this difference could be due to the fact that girls tend to be more verbal than boys (Eriksson et al., 2012). We also found a significant negative relation between maternal responsiveness to fullness and mother employment, where mothers who were employed at the time of the study were less responsive to their child fullness. It may be hypothesized that employed mothers have less opportunity to spend time with their children during mealtimes and therefore may be less used to interpreting and understanding their food-related behaviors. However, it is important to note that our sample was very homogenous with most mothers being employed at the time of the study (ranking from more than 60 % when children were 8 months of age to almost 90 % when children were 24 months of age; see Table 1); thus, the above results should be taken with caution and cannot be generalized.

Our study has several strengths, but also some limitations. We evaluated maternal responsiveness in a large longitudinal sample, assessed at multiple time points, by means of an observational method. Moreover, we remotely recorded mealtimes while children were at home (rather than in the laboratory), which likely provided a high ecological validity. However, the quality of the remote video recordings has sometime been affected by internet connectivity, as well as by variable features of the home setting (camera placement, light distribution, distractions), although these issues were limited by providing indications to the families to record good-quality video clips. Additionally, although parents were asked to allow us to record a typical child's meal, we recognize that meals can vary greatly and that only one observation per age may not be representative. As previously discussed, we did not collect data on child food liking and wanting and data about children's weight and length, that would have however enriched our discussion. Finally, the modality of recruitment (through social media, magazines, pediatrician offices) led to a self-selected sample, with a rather homogeneous, high maternal education and employment level.

In conclusion, in the first 18 months of life maternal responsiveness to receptiveness and fullness cues increased over time. It can be hypothesized that the more a mother knows her child, the better she seems to be able to understand their hunger and fullness signals during meals. These findings are supported by the observation that responsiveness to receptiveness was negatively related to language production, whereas responsiveness to fullness was positively related to language production. Although we did not find a significant difference in maternal responsiveness across the three complementary feeding methods (BLW, PLW, and Mixed), possibly due to a difficulty of mothers to precisely attribute their infant's complementary feeding approach to one of these categories or because they were not following a specific method, children who fed independently from an early age had mothers who were more responsive to their fullness cues (as in previous studies: Di Prete et al., 2023; Hodges et al., 2013). This result emphasizes the importance of children's independence and self-regulation during the meal, beyond the complementary feeding approach chosen by the parents. Overall, these findings may possibly extend to maternal responsiveness in contexts other than mealtimes with potential implications for better regulation of child socio-emotional development during the complementary feeding phase and beyond.

CRedit authorship contribution statement

Alice Di Prete: Writing – original draft, Investigation, Data curation. **Guido Maria Caruso:** Writing – review & editing, Investigation. **Denise**

Del Grosso: Writing – review & editing, Investigation. **Eleonora Giacomini:** Writing – review & editing, Investigation. **Sara Picuno:** Writing – review & editing, Investigation. **Giulia Trappetti:** Writing – review & editing, Investigation. **Valentina Focaroli:** Writing – review & editing, Investigation. **Melania Paoletti:** Writing – review & editing, Investigation. **Giulia Pecora:** Writing – review & editing, Investigation. **Barbara Caravale:** Writing – review & editing. **Corinna Gasparini:** Writing – review & editing. **Serena Gastaldi:** Writing – review & editing, Data curation. **Flavia Chiarotti:** Writing – review & editing, Formal analysis. **Claire Farrow:** Writing – review & editing, Conceptualization. **Amy T. Galloway:** Writing – review & editing, Conceptualization. **Eric A. Hodges:** Writing – review & editing, Supervision, Methodology. **Francesca Bellagamba:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization. **Elsa Addressi:** Writing – original draft, Supervision, Resources, Project administration, Methodology, Funding acquisition, Formal analysis, Conceptualization.

Informed consent statement

Both parents provided written parental consent for taking part in the study and to be video recorded.

Institutional review board statement

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics board of the Department of Dynamic and Clinical Psychology and Health Studies of Sapienza University of Rome (Prot. n. 0000315, April 14, 2020 and n. 0001209, December 15, 2020) and by the Research Ethics and Integrity Committee of the National Research Council of Italy (Prot. n. 00721482019, October 18, 2019 and n. 0028810, April 23, 2021).

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Declaration of competing interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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Data availability

Data will be made available on request.

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