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Complementary feeding approach and maternal responsiveness in 8- and 12-month-old Italian infants: A longitudinal study

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ABSTRACT

In Western countries, infants are usually introduced to solids through spoon-fed puréed foods (parent-led weaning, PLW). However, an alternative approach known as "baby-led weaning" (BLW), in which infants usually participate in family meals and eat independently, is becoming increasingly popular. We investigated the relationship between the type of complementary feeding approach and maternal responsiveness to infant feeding cues in a longitudinal sample of 178 infants observed at 8 and 12 months. Mothers reported the complementary feeding method used and, from video-recorded meals, we coded the proportion of time infants self-fed and rated maternal responsiveness by means of the Responsiveness to Child Feeding Cues Scale (Hodges et al., 2013). Responsiveness to infant receptiveness and fullness cues were significantly correlated at 8 months, but not at 12 months, when unresponsiveness decreased for receptiveness but remained stable for fullness cues. Thus, as infants got older, mothers were increasingly tuned in to their receptiveness cues. However, we did not observe the same pattern for fullness cues, perhaps because mothers were concerned that their infants did not eat enough. Moreover, at both time points, mothers were more responsive to infants' receptiveness than fullness cues, possibly due to an evolutionary drive to protect infants from starvation. Finally, responsiveness to fullness, but not responsiveness to receptiveness, was positively related to the proportion of infant self-feeding, but there were no significant differences in responsiveness depending on the self-reported complementary feeding approach. Thus, a weaning style that emphasizes independent feeding, regardless of whether this is labeled as BLW, may promote more infant-centered maternal responses at the end of the meal, with potential implications for promoting infant self-regulation not only at mealtimes, but also in other domains.

1. Introduction

The complementary feeding period refers to the phase in which caregivers progressively reduce milk feeding while gradually introducing solid foods to their infant. This is a crucial period in infant development as it is associated with eating preferences and body weight, not only in childhood, but also in adolescence and adulthood (Rose et al., 2017). Infants in many western countries are traditionally introduced to solid foods for the first time as spoon-fed puréed foods (WHO, 2009), with a gradual transition to purées with a coarser texture, finger foods, and lastly family foods (Agostoni et al., 2008; Seaman, D'Alessandro, & Swannie, 1996). This approach is known by a range of different names (reviewed in Addessi et al., 2021), but is perhaps best described as "parent-led weaning" (PLW) (Cameron et al., 2013). Over the last 15 years, however, alternative approaches to PLW have been introduced. The most popular alternative has been referred to as "baby-led weaning" (BLW). This approach was first proposed in the UK (Rapley & Murkett, 2008) and involves the infant participating in family

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meals and, after showing interest, being offered pieces of food (e.g., pieces of fruit, sticks of vegetables, strips of meat, pieces of toast and cheese), whilst allowing the infant to self-feed and to regulate the pace of the meal and the amount of food eaten (e.g., Brown et al., 2017; Brown & Lee, 2011a; Cameron et al., 2012). According to this approach, the child is considered an active partner in the feeding process and not a passive recipient (Sachs, 2011). Even earlier, a similar approach to BLW, known as "on-demand complementary feeding" ("*alimentazione complementare a richiesta*"), was proposed in Italy (Piermarini, 2002). This approach focuses on the importance of an infant showing interest in food and being involved in family meals, but places less relevance on the texture of food or the modality of feeding (Buglioni et al., 2017; Piermarini, 2002, 2006, 2020). A recent survey showed that around 21% of Italian paediatricians recommend this approach to new parents (Congiu et al., 2023) and between 8% and 36% of families follow this approach (Lacorte et al., 2018; Nacamuli et al., 2021). As there are no data comparing BLW and on-demand complementary feeding approaches, here we will refer to BLW in order to capture both approaches to complementary feeding.

There is still a lack of agreement on a formal operational definition of BLW (D'Auria et al., 2018). Brown and Lee (2011a) consider infants as exposed to BLW if their mothers report spoon feeding or offering puréed foods on less than 10% of feeding occasions, Campeau et al. (2021) proposed to raise this threshold up to 25%, whereas other authors (e.g., Cameron et al., 2013) consider infants exposed to BLW only if they feed independently for most of the meal. A continuous, observational measure of children's self-feeding during mealtimes may provide a more accurate representation of their adherence to either a BLW or PLW style, but to our knowledge no study has undertaken such an approach so far.

Regardless of the complementary feeding approach, infants are born dependent on their caregivers to meet their nutritional needs, and dyadic food interactions are important for their health and growth. The enduring nature of the caregiver-infant relationship in early development involves co-regulation that determines the onset and termination of feeding (reviewed in van Dijk et al., 2022), shaping the infant's ability to regulate their own satiety and hunger. In this respect, the WHO guidelines on complementary feeding (World Health Organization, 2003) do not specifically advocate either BLW or PLW, but explicitly recommends "responsive feeding", i.e., the practice of caregivers paying attention and reacting to their infant's cues of hunger and fullness. Responsive feeding refers to caregiver feeding practices that encourage the child to eat autonomously and in response to their physiological needs, which may encourage self-regulation in eating and support cognitive, emotional, and social development (Pérez-Escamilla et al., 2017). The WHO (2009) identified five key principles of responsive feeding: (i) feed infants directly and assist older children when they eat independently; (ii) feed children slowly and patiently and encourage them to eat, but without forcing them, (iii) if children refuse many types of food, offer different food combinations, tastes, textures and methods of encouragement, (iv) minimize distractions during meals, (v) as meals are an opportunity to learn and bond, talk to children and maintain eye contact while eating.

Responsiveness to infant hunger and fullness cues is a fundamental dimension of responsive feeding and refers to broad aspects of parenting behavior that are believed to support healthy food intake (Engle et al., 2000). A lack of responsiveness to hunger and fullness cues from caregivers may contribute to a lower ability for children to follow their own internal cues of hunger and fullness (Farrow & Blissett, 2006) and to failure to thrive or, conversely, overeating by promoting food consumption in the absence of hunger (Di Santis, Hodges, Johnson & Fisher, 2011). Responsiveness to the infant's hunger and fullness cues is central to the hypothesis that a mismatch between the infant's internal state (in terms of hunger and fullness) and the caregiver's behavior may alter self-regulation in food consumption and increase the risk of under- or overweight (Birch & Fisher, 1998). Responsive feeding requires an accurate perception and interpretation of the infant's hunger and fullness cues and an appropriate response. The caregiver should be aware of the meaning of the signals sent by the child, correctly interpret each signal, provide nutrition in response to hunger cues, and stop feeding the child in response to fullness cues.

Responsiveness is crucial both in lower- and middle-income countries, where there is a high risk of underweight (e.g., Chen et al., 2020; Fernandez Rao et al., 2020), and in food-rich industrial societies, where – conversely – there are concerns about overweight and obesity. Only a few studies have investigated the relationship between complementary feeding approaches and maternal mealtime behavior, mainly through self-report questionnaires and considering a wide age range. In Brown and Lee (2011a), mothers of 6–12-month-old infants following a BLW approach reported lower levels of restriction, pressure to eat, monitoring and concern over child weight compared to mothers following a PLW approach; however, this study was based on maternal report, and may be subject to response bias. In a more recent study, when researchers monitored maternal responsiveness during mealtime observations and infant self-feeding with 7–24-month-olds, Hodges et al. (2013) found that mothers of self-feeding infants were more responsive to hunger and fullness cues than mothers of parent-fed infants. However, this finding may reflect the increasing capacity of infants to communicate later in the first year (Feldman, 2007; Givens, 1978; Hodges et al., 2008), which may be relevant especially when self-feeding, since this modality requires the child to be more active in selecting the food and asking for assistance in order to reach the preferred food, as compared to parent-feeding. A better ability to communicate may not only increase the specificity of the child's cues but also the accuracy of the caregiver's interpretation. Mothers also showed a greater responsiveness to their child's hunger cues rather than to their child's fullness cues, which may reflect a universal parental goal of children's survival and health (LeVine, 1988). Moreover, maternal responsiveness to infant fullness cues was associated with longer breastfeeding durations, which may indicate an overall lower control (Blissett & Farrow, 2007; Brown et al., 2011) extending from milk feeding through complementary feeding. Furthermore, responsiveness to both hunger and fullness cues was positively related with maternal education levels, possibly indicating a better understanding of infant development and a more accurate recognition and interpretation of infant cues in more educated mothers (Hodges et al., 2013).

It is still unknown whether a complementary feeding approach that promotes the ability of infants to eat independently earlier than expected, as is the case for BLW, may be associated with higher maternal responsiveness, regardless of infant age. Thus, we aimed to investigate whether maternal responsiveness to hunger and fullness cues in a longitudinal sample of 8- and 12-month-old infants (i) differed depending on the mother's self-reported complementary feeding approach (BLW, PLW, or Mixed), (ii) was related to the infant's ability to eat independently, when controlling for several factors that may be related to maternal responsiveness to feeding cues, such as breastfeeding, maternal education, age of introduction of complementary food, and infant's communicative development. Since child-centered approaches to complementary feeding (such as the BLW approach) are believed to support the development of self-regulation in food intake based on appetite and the ability to pay attention to body signals during the meal (Di Santis et al., 2011), we hypothesized higher maternal responsiveness in infants given the opportunity to eat independently, rather than being primarily spoon-fed, regardless of age, and in infants exposed to a BLW approach, rather than in infants exposed to a PLW approach.

2. Methods

2.1. Participants

Participants were 184 mothers with their 8-month-old infants and 182 mothers with their 12-month-old infants, with data at both ages for 178 mother-infant pairs. We recruited participants during mother's

pregnancy or soon after birth for a larger longitudinal project on the relationship between the complementary feeding approach and infant cognitive, motor, and language development through advertising via social media, posters in pediatricians' offices, and the newsletter of the magazine "Uppa Magazine" addressed to parents. All participants were from Italy, mainly from the metropolitan area of Rome (72.8% Central Italy, 23.4% Northern Italy, 3.3% Southern Italy and Islands, 0.5% Italians living abroad). In the invitation letter, participants were informed that they would participate in a study on infant eating development. Baby-led weaning was neither mentioned in the invitation letter nor were participants provided with any information about complementary feeding approaches. Parents were free to choose the complementary feeding approach they preferred. Children who were born before 37 weeks of gestation, with congenital abnormalities, severe neurological deficits, born from twin births and/or were exposed to other languages beside Italian ("bilingual" children) were not recruited. We did not recruit bilingual children as this study is a portion of a larger research project that investigates also the relationship between complementary feeding and language development (considering that bilingual children may be delayed in their language acquisition and that the subsamples of non-bilingual and bilingual children would have been very unbalanced, we wanted to exclude a potentially confounding variable for which controlling would have been difficult).

Both parents provided a 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 were invited to complete a survey asking about demographic information, breastfeeding, and complementary feeding. Moreover, they were administered the MacArthur-Bates Communicative Development Inventory (Words and Gestures, Short form; Fenson et al., 2000; Caselli et al., 2015 et al.,). Furthermore, during a video call, for each infant we recorded, when they were 8-month-old and 12-month--old (±2 weeks), a typical meal, in order to assess their self-feeding ability and maternal responsiveness to infants' hunger and fullness cues. Further details are provided below.

2.2.1. Self-reported measures

When infants were 8 months of age, mothers provided information about themselves (age, highest level of education) and about their infant (age, sex, presence of siblings in the household, gestational age at birth, duration of exclusively breastfeeding, infant's age at the onset of complementary feeding, complementary feeding method used – BLW, PLW or Mixed). The complementary feeding questionnaire 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"), "complementary feeding upon demand" (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 to the child only following her behavioral or verbal requests) or a mix between the two (for instance, traditional weaning while in the care of others – as grandparents/babysitter/daycare – and complementary feeding upon demand when with parents). When infants were 8 and 12 months of age, mothers reported whether they were still breastfeeding and completed the MacArthur-Bates Communicative Development Inventory (MCDI, Words and Gestures, Short form; Fenson et al., 2000; Caselli et al., 2015), which investigates receptive and expressive language, as well as gesture production, in children ranging from 8- to 18- months of age. Mothers indicated, in a presence-absence answering format, what words children were able to understand and/or pronounce from a list of 100, and what gestures they produced choosing from a group of 18. Descriptive statistics are reported in Tables 1–3.

2.2.2. Mealtime observations

We recorded a meal of each child during a Skype or Jitsi Meet video call (via parent smartphone, tablet, or laptop) by means of the software OBS Studio. Parents were asked to choose what they considered to be a typical meal for their child. Researchers' cameras were off during the recording to not distract the parent-infant dyad. Only footages in which the child was clearly visible were retained for offline coding. At both ages, about 71% of the video clips had no interruptions or any footage in which the child was not visible; as for the remaining video clips, coding was not possible on an average of about 1.5 min (8 months: SE = 17.0 s, median = 34 s, mode = 8 s; 12 months: SE = 13.59 s, median = 36 s, mode = 3 s). We counted, during offline coding, the number of times in which the infant was either parent-fed (i.e., any instance in which the parent offered the infant food with a spoon, fork or fingers and the infant accepted and swallowed it) or self-fed (i.e., any instance in which the child put food in her/his own mouth with a spoon, fork or fingers and swallowed it, without the parent's help), from which we calculated the proportion of time in which the infant self-fed (Table 2).

Moreover, 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), in order to rate the maternal responsiveness to infant receptiveness and fullness cues. The RCFCS coding scheme (Hodges et al., 2013) allows scoring of a child's cues and parental responsiveness to perform both microanalytic and global analyses of dyadic transactions across the course of a meal. The caregiver's responsiveness to hunger cues is coded separately from her/his responsiveness to fullness cues to account for the possibility that a caregiver may be differentially sensitive to the child signals at the beginning compared to the end of the meal. This coding scheme scores the presence or absence of 48 different types of food signals and their frequency: 20 indicators of hunger reflect infant's motivation to eat, and 28 indicators of fullness reflect infant'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 divided into early, active, and late cues, according to the temporal succession and intensity of the cues. "Early" cues are subtle and primarily oral in nature; "active" cues are more evident 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 infant receptiveness to being fed is defined by the number and type (early, active, late) of infant's hunger and disinterest behavioral cues produced in the period of time going from the

Table 1
Demographic characteristics of the sample.

Variable	Group	Values
Maternal age (years, mean ± SD)		34.87 ± 3.83
Maternal highest level of education (n and %)	No college	19 (10.3%)
	College and above	165 (89.7%)
Employed at the time of the study (n and %)	8-month-olds	115 (63.5%)
	12-month-olds	165 (81.9%)
Infant's age (months, mean ± SD)	8-month-olds	8.05 ± .33
	12-month-olds	12.36 ± .47
Sex (n and %)	Males	95 (51.6%)
	Females	89 (48.4%)
Siblings (n and %)	Siblings	73 (39.7%)
	No siblings	111 (60.3%)
Gestational age at birth (n and %)	37 + 0–37 + 6	9 (4.9%)
	38 + 0–38 + 6	25 (13.6%)
	39 + 0–39 + 6	62 (33.7%)
	40 + 0–40 + 6	46 (25.0%)
	≥41	42 (22.8%)

Table 2
Information on breastfeeding and complementary feeding. Proportion of self-feeding corresponds to the number of episodes of self-feeding divided by the total number of feeding episodes (self-feeding + parent-feeding).

Variable	Group	Values
Duration of exclusive breastfeeding (months, mean ± SD)		4.28 ± 2.42
Still breastfeeding at 8 months of age (n and %)	Yes	139 (75.5%)
	No	45 (24.5%)
Still breastfeeding at 12 months of age (n and %)	Yes	94 (51.6%)
	No	85 (46.7%)
	Missing	3 (1.6%)
Age at the onset of complementary feeding (months, mean ± SD)		5.60 ± .70
Complementary feeding method at 8 months of age (n and %)		
	BLW	60 (32.6%)
	Mixed	48 (26.1%)
	PLW	76 (41.3%)
Proportion of self-feeding at 8 months of age (mean ± SD)		.24 ± .35
Proportion of self-feeding at 12 months of age (mean ± SD)		.51 ± .37

Table 3
Scores of the MacArthur-Bates Communicative Development Inventory (MCDI, Words and Gestures, Short form; Fenson et al., 2000; Caselli et al., 2015).

Variable	Mean ± SD
MCDI comprehension score at 8 months of age (number of words)	10.82 ± 17.08
MCDI production score at 8 months of age (number of words)	.23 ± 1.15
MCDI gesture score at 8 months of age (number of gestures)	2.15 ± 1.63
MCDI comprehension score at 12 months of age (number of words)	34.91 ± 23.8
MCDI production score at 12 months of age (number of words)	2.48 ± 4.11
MCDI gesture score at 12 months of age (number of gestures)	7.87 ± 2.89

commencement of food preparation until 1 min after the first bite, before the mother responds by initiating feeding. The responsiveness to infant fullness cues is defined by the number and type (early, active, late) of infant'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 feeding/food offering. The caregiver's responsiveness is coded separately for infant receptiveness and fullness on a five-point Likert scale, from "highly responsive" (5) to "highly unresponsive" (1). Please see Supplementary Material for a detailed description of how the caregiver's responsiveness categories were coded. If no hunger or fullness cues are observed for a particular child, the corresponding cell is left blank ("can't tell"). Due to the nature and timing of our remote, home-based recordings, we were unable to code responsiveness to hunger cues as described by Hodges et al. (2013), in which coding for hunger occurs from 10 min prior to the first bite until the infant is placed in the feeding location and/or the parent initiates food preparation.

2.3. Inter-rater reliability

Both ADP and EA have been trained in the use of the RCFCS during multiple online meetings with EAH (co-developer of the RCFCS and trainer in its use) and review of the training video clips together. Then, both ADP and EA scored a portion of the video clips for the purpose of reliability, but only ADP coded the remaining 8-month-olds' video clips; instead, two observers (ADP and DDG) scored the video clips for the 12-month-olds. Inter-rater reliability was calculated on a total of 57 video clips (28 for the 8-month-olds and 29 for the 12-month-olds, about 15% of the observations for each age class). We calculated the inter-rater reliability between ADP and EA for the 8-month-olds and between ADP and DDG for the 12-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 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 infant receptiveness (average ICC = 0.77) and excellent for maternal responsiveness to infant fullness (average ICC = 0.96). The agreement for parent-feeding and self-feeding was, on average, IC = 0.97 and IC = 0.95, respectively.

2.4. Statistical analyses

At each point of the study, we assessed whether the proportion of observed self-feeding at mealtimes differed according to the self-report approach to complementary feeding (BLW, PLW, or Mixed) by means of Kruskal Wallis non-parametric ANOVA. Then, at each time point of the study, we evaluated whether responsiveness to receptiveness and to fullness significantly differed by means of Wilcoxon signed-ranks tests; moreover, we assessed whether responsiveness to receptiveness and to fullness were significantly correlated by means of Spearman correlations. Then, we separately analyzed responsiveness to receptiveness and to fullness by means of random-effects ordered logistic regression models with sex, age (8/12 months), siblings (yes/no), maternal education level (no college/college and above), duration of exclusive breastfeeding (number of months), still breastfeeding (yes/no), infant's age at the onset of complementary feeding (months), maternal employment at the time of the study (yes/no), MCDI comprehension, production, and gesture scores (number of words or gestures), proportion of self-feeding events (as scored during video clips of mealtimes), and complementary feeding method used (BLW, PLW or mixed feeding, as self-reported by the mothers when infants were 8 months old) as factors. For both regressions, the identity of the subject was included as a random effect and the significance of interaction effects (between children's age and, respectively, maternal education level, duration of exclusive breastfeeding, still breastfeeding, maternal employment at the time of the study, MCDI variables, proportion of self-feeding, and complementary feeding method) was assessed using the Wald test. Non-significant interactions were dropped from the model and the analysis was run again. Statistical analysis was performed using Stata 14 software (StataCorp. 2015. College Station, TX: StataCorp LP). Significance level was set at $p < .05$.

3. Results

As reported in Table 2, at 8 months of age infants were relatively evenly distributed across the three possible approaches to the introduction of complementary foods (BLW, PLW, Mixed), as reported by their mothers. Moreover, the average proportion of time spent self-feeding during mealtimes, as observed from video clips, doubled from 8 to 12 months of age. At 8 months of age, the observed proportion of self-feeding was significantly higher in infants exposed to BLW (mean ± standard deviation: 0.48 ± 0.39) and to a mixed complementary feeding approach (mean ± standard deviation: 0.29 ± 0.37), respectively, than in infants exposed to PLW (mean ± standard deviation: 0.01 ± 0.05) and in infants exposed to BLW than to a mixed complementary feeding approach (Kruskal Wallis: $H_2 = 70.43$, $p < .001$, Bonferroni corrected pairwise comparisons: BLW vs. PLW: 69.08, $p < .001$; Mixed vs. PLW: 45.22, $p < .001$; BLW vs. Mixed: 23.86, $p = .035$). Similarly, at 12 months of age, the observed proportion of self-feeding was significantly higher in infants that were exposed to BLW at 8 months of age (mean ± standard deviation: 0.70 ± 0.33) and to a mixed complementary feeding approach (mean ± standard deviation: 0.58 ± 0.37), compared to infants exposed to PLW (mean ± standard deviation: 0.31 ± 0.31), but there was no significant difference between infants exposed to BLW compared to a mixed complementary feeding approach (Kruskal Wallis: $H_2 = 37.55$, $p < .001$, Bonferroni corrected pairwise comparisons: BLW vs. PLW: 54.72, $p < .001$; Mixed vs. PLW: 37.68, $p < .001$; BLW vs. Mixed: 17.05, $p = .276$).

Maternal responsiveness to infant receptiveness and fullness cues were significantly correlated, although mildly, at 8 months ($r_s = 0.256$,

$p < .001$, $N = 183$), but not at 12 months of age ($r_s = 0.139$, $p = .110$, $N = 182$). At both 8 and 12 months of age, mothers were more responsive to infants' receptiveness than fullness cues (8-month-olds, responsiveness to receptiveness: 3.38 ± 1.37; responsiveness to fullness: 2.18 ± 0.93; $z = 8.791$, $p < .001$; 12-month-olds, responsiveness to receptiveness: 3.97 ± 0.88; responsiveness to fullness: 2.65 ± 0.95; $z = 10.202$, $p < .001$). See Figs. 1 and 2 for a graphical representation of the distribution of responsiveness scores across the six possible responsiveness categories obtained from the "Responsiveness to Child Feeding Cues" coding scheme (Highly Responsive, Responsive, Moderately Responsive, Unresponsive, Highly Unresponsive, Can't Tell; Section 2.2.2 "Mealtime observations") at 8 and 12 months of age, respectively.

Responsiveness to receptiveness was not significantly related to proportion of self-feeding ($OR = 1.356$, $z = 0.90$, $p = .370$), nor did it significantly differ between the different self-reported approaches to complementary feeding (BLW: 3.77 ± 1.20; PLW: 3.57 ± 1.27; Mixed: 3.70 ± 1.07; for OR see Table 4); on the contrary, it was significantly related to maternal education level ($OR = 0.432$, $z = -2.66$, $p = .008$), to the MCDI comprehension score ($OR = 0.989$, $z = -2.09$, $p = .037$), and to the duration of exclusive breastfeeding, although marginally ($OR = 0.905$, $z = -1.92$, $p = .055$). There was no other significant main effect or interaction between age and the relevant independent variables (see Section 2.4 "Statistical analyses", Table 4 for the final model and Supplementary Table 1 for the full model).

Regardless of age, responsiveness to infant fullness was positively related to proportion of self-feeding ($OR = 3.305$, $z = 3.11$, $p = .002$), but it did not significantly differ between the different self-reported approaches to complementary feeding (BLW: 2.56 ±0 .99; PLW: 2.29 ±0 .97; Mixed: 2.46 ±0 .94; for OR see Table 5). Moreover, there was a significant interaction between age and maternal education level ($OR = 4.450$, $z = 2.64$, $p = .008$): responsiveness to fullness was negatively related to the maternal education level at 8 months ($OR = 0.235$, $z = -3.06$, $p = .002$), but not at 12 months of age ($OR = 1.372$, $z = 0.58$, $p = .563$). There was no other main effect or interaction between age and the relevant independent variables (see Section 2.4 "Statistical analyses", Table 5 for the final model and Supplementary Table 2 for the full model).

4. Discussion

In the present study, we aimed to investigate whether, in a longitudinal sample of 8- and 12-month-old infants, maternal responsiveness to infant receptiveness and fullness cues was related to the observed infant's ability to eat independently and/or differed depending on the mother's self-reported complementary feeding approach (Baby-Led weaning, Parent-Led weaning, or Mixed). Maternal responsiveness to receptiveness and fullness were significantly correlated at 8 months, but not at 12 months; moreover, at both ages, mothers were more responsive to infants' receptiveness than fullness cues. Responsiveness to receptiveness was not significantly related to the proportion of self-feeding, nor did it significantly differ according to the complementary feeding approach. In contrast, responsiveness to fullness was positively related to the proportion of infant self-feeding, but again it did not differ according to the complementary feeding approach. Regardless of age, responsiveness to receptiveness was negatively related to the maternal education level, to the child's linguistic comprehension score, and to the duration of exclusively breastfeeding. Similarly, responsiveness to fullness was negatively related to the maternal education level, but only at 8 months of age. Overall, these results showed that, despite individual differences due to contextual variables or mother/infant characteristics, infants feeding more often independently were observed to have mothers who were more responsive to fullness cues, with potential implications for promoting infant self-regulation not only at mealtimes, but also in other domains.

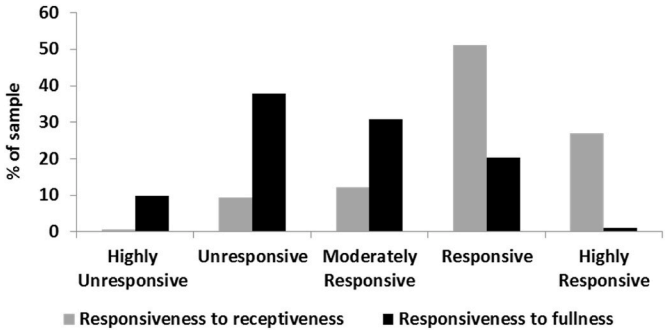

Fig. 2. Frequency distribution of maternal responsiveness to infant receptiveness and fullness cues at 12 months of age.

The finding that maternal responsiveness to infant receptiveness and fullness cues were positively correlated at 8 months corroborates the results reported for the cross-sectional sample of 7–24-month-old children observed by Hodges et al. (2013). In contrast, at 12 months of age mothers were differentially responsive to infant cues at the beginning and at the end of the meal. If we look at the different categories of maternal responsiveness as scored at 8 and 12 months of age (Figs. 1 and 2), across almost all categories there was the same pattern of variation for both receptiveness and fullness: the "highly unresponsiveness" score decreased (*receptiveness*: 8 months: 9.2%; 12 months: 0.55%; *fullness*: 8 months: 23.9%; 12 months: 9.9%), the "responsive" score increased (*receptiveness*: 8 months: 22.3%; 12 months: 51.1%; *fullness*: 8 months: 7.1%; 12 months: 20.3%), the "moderately responsive" and the "highly responsive" scores were rather stable (moderately responsive: *receptiveness*: 8 months: 11.4%; 12 months: 12.1%; *fullness*: 8 months: 22.8%; 12 months: 30.8%; highly responsive: *receptiveness*: 8 months: 29.3%; 12

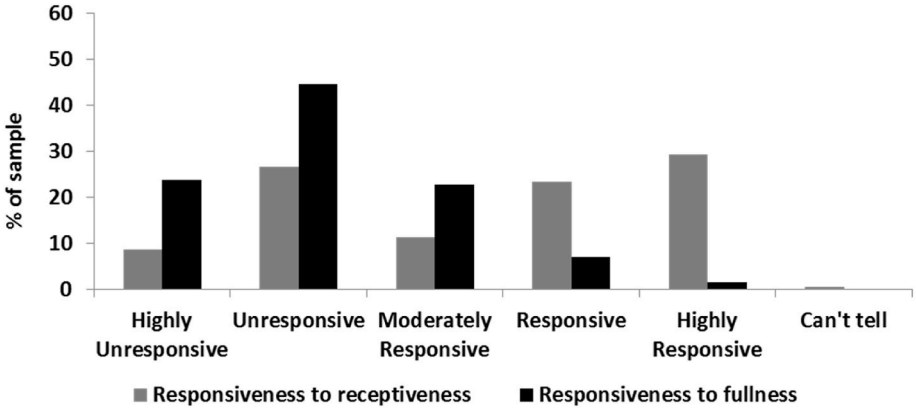

Fig. 1. Frequency distribution of maternal responsiveness to infant receptiveness and fullness cues at 8 months of age.

Table 4
Parameters from the final model predicting maternal responsiveness to infant receptiveness. Significant values are highlighted in bold.

Factor	Odds Ratio	Robust Standard Error	z	*p* value	*95% Confidence Interval*	
MCDI comprehension score	**.989**	**.005**	**−2.09**	**.037**	**.979**	**.999**
MCDI production score	.958	.023	−1.71	.087	.913	1.006
MCDI gesture score	1.077	.046	1.74	.081	.990	1.171
Sex (reference: males)	1.226	.263	.95	.342	.805	1.867
Age category (reference: 8 months)	1.763	.571	1.75	.080	.934	3.327
Siblings (reference: no siblings)	1.041	.204	.21	.835	.709	1.529
Proportion of self-feeding	1.355	.460	.90	.370	.696	2.637
Complementary feeding method						
Mixed vs. PLW (2 vs. 1)	1.108	.299	.38	.704	.652	1.883
BLW vs. PLW (3 vs. 1)	1.390	.364	1.26	.208	.832	2.323
or PLW vs. Mixed (1 vs. 2)	.902	.244	−.38	.704	.530	1.533
BLW vs. Mixed (3 vs. 2)	1.254	.314	.90	.366	.767	2.051
Maternal education (reference: no college)	**.431**	**.136**	**−2.66**	**.008**	**.232**	**.801**
Exclusive breastfeeding (months)	.905	.046	−1.92	.055	.817	1.002
Still breastfeeding (reference: no)	1.155	.298	.56	.575	.696	1.916
Age at the onset of complementary feeding (months)	1.045	.158	.29	.770	.776	1.406
Mother employment (reference: no)	.920	.242	−.31	.753	.549	1.542

months: 26.9%; *fullness*: 8 months: 1.6%; 12 months: 1.1%). The only exception was represented by the "unresponsive" score, that decreased for receptiveness (8 months: 27.2%; 12 months: 9.3%) but remained rather stable for fullness (8 months: 44.6%; 12 months: 37.9%). Thus, for the latter category, maternal responsiveness to receptiveness and to fullness did not follow the same pattern of variation, with unresponsiveness decreasing for receptiveness cues but remaining stable for fullness cues (and, notably, entailing at both times of the study almost half of the participants). It appears that, as infants get older, mothers are increasingly tuned in to infants' receptiveness cues and ready to respond to them, suggesting that mothers may learn more about their infants' cues over time. However, the findings also show that this pattern is not the same for infant fullness cues. Perhaps, mothers may be concerned that their infants did not eat enough towards the end of the meal and therefore were less responsive to their satiety signals. The data indicated that most mothers continued to encourage their infants to eat more food despite what they signaled about being full. However, these findings have to be taken with caution as we do not have information on the maternal responsiveness' trajectories across the two time points.

Indeed, at both times of the study, mothers were overall more responsive to infants' receptiveness than fullness cues. These results parallel Hodges et al.'s (2013) findings in a US cross-sectional sample and can be explained by an evolutionarily ancient drive to protect infants against hunger (LeVine, 1988), which is however no longer adaptive in food-rich Western societies, where this response increases the risk of overweight and obesity. The latter hypothesis may also explain why, regardless of infant's age, we observed a negative relationship between maternal responsiveness to infant receptiveness and a self-report measure of language comprehension. We can tentatively hypothesize that mothers perceiving their infants as having higher linguistic ability were less attentive to their receptiveness, mainly nonverbal, cues. Conversely, mothers of infants perceived as having lower language skills, and possibly more in need of assistance, were more responsive to their signals of receptiveness to eat.

As expected, regardless of infant's age, maternal responsiveness to fullness was positively related to the proportion of observed infant's self-feeding. Thus, mothers of more independent infants were more sensitive to their fullness cues and they stopped offering food more rapidly when witnessing signs of satiety compared to mothers of less independent infants. This result is similar to what has been reported by Hodges et al.'s (2013), in which – however – mothers of self-feeding children were more responsive to both hunger and fullness cues. This slight discrepancy between the two studies may be linked to the dissimilar way of collecting the video clips of mealtimes. Differently from Hodges et al.'s (2013) study, in which video clips were collected in a laboratory setting, the mealtimes used in the present study took place in a more natural home setting and were recorded during video calls. For this reason, many of our video clips began when the infant was already sitting in the highchair and almost ready to eat, and not when the mother was preparing the food. Thus, in our analysis of maternal responsiveness to hunger cues, we took into account only the responsiveness to the infant's receptiveness to being fed and not also the responsiveness to infant's hunger cues occurring from 10 minutes prior to the first bite until the infant was placed in the feeding location and/or the parent initiated food preparation, as in Hodges et al. (2013).

Despite the discrepancy between the two studies, it is noteworthy that mothers who were observed to allow their infants to self-feed more often were more responsive to their satiety cues. A comparable finding was obtained by Brown and Lee (2011b) using the Child Feeding Questionnaire: mothers of 6–12-month-old infants following a BLW approach (i.e., spoon feeding or offering puréed foods on less than 10% of the feeding occasions, and thus leaving infants self-feeding on finger foods for most of the meals) reported significantly lower levels of restriction, pressure to eat, and monitoring compared to mothers following a PLW approach. It is well established that controlling feeding styles are associated with negative health outcomes (e.g., Ventura & Birch, 2008), and lower maternal control at six months of age has been related to better regulation in terms of child weight gain across the first year of life (Farrow & Blissett, 2006). Hence, it can be speculated that a complementary feeding approach potentially involving lower maternal control, and more self-feeding opportunities, may promote better self-regulation of appetite during infancy and lead to a positive impact upon child feeding and weight later in life (Brown & Lee, 2011b).

Notwithstanding the positive relationship between responsiveness to fullness and infant's self-feeding, in our study we failed to observe a significant relationship between maternal responsiveness and the self-reported complementary feeding approach (BLW, PLW, or Mixed). Although infants exposed to BLW or mixed complementary feeding at 8 months of age self-feed more frequently at mealtimes than infants exposed to PLW, the lack of a significant main effect of the complementary feeding approach on maternal responsiveness could be due to the fact that the Italian version of BLW, known as "on-demand complementary feeding", emphasizes the interest infants show in trying the food eaten by the other family members and in being involved in family meals (Buglioni et al., 2017; Piermarini, 2002, 2006, 2020), rather than the modality of feeding (self-feeding vs. spoon-feeding) and/or the

Table 5
Parameters from the final model predicting maternal responsiveness to infant fullness. Significant values are highlighted in bold.

Factor	Odds Ratio	Robust Standard Error	z	*p* value	*95% Confidence Interval*	
MCDI comprehension score	1.000	.007	.07	.942	.986	1.015
MCDI production score	1.003	.036	.09	.929	.933	1.077
MCDI gesture score	1.021	.053	.41	.683	.921	1.132
Sex (reference: males)	1.057	.248	.24	.812	.666	1.677
Age category (reference: 8 months)	.490	.293	−1.19	.233	.151	1.582
Siblings (reference: no siblings)	1.147	.275	.58	.565	.717	1.836
Proportion of self-feeding	**3.305**	**1.268**	**3.11**	**.002**	**1.557**	**7.014**
Complementary feeding method						
Mixed vs. PLW (2 vs. 1)	1.046	.327	.15	.884	.567	1.930
BLW vs. PLW (3 vs. 1)	.989	.326	−.03	.974	.517	1.890
or PLW vs. Mixed (1 vs. 2)	.956	.299	−.15	.884	.518	1.763
BLW vs. Mixed (3 vs. 2)	.945	.279	−.19	.849	.530	1.686
Maternal education (reference: no college)	**.253**	**.109**	**−3.19**	**.001**	**.108**	**.588**
Exclusive breastfeeding (months)	.960	.069	−.55	.581	.833	1.107
Still breastfeeding (reference: no)	1.208	.358	.64	.522	.675	2.162
Age at the onset of complementary feeding (months)	.762	.182	−1.13	.259	.476	1.220
Mother employment (reference: no)	.776	.201	−.97	.330	.467	1.291
Maternal education * Age category	**4.449**	**2.520**	**2.64**	**.008**	**1.466**	**13.503**

texture of the food provided to the infant (finger food vs. purée) (Brown & Lee, 2011a; Campeau et al., 2021; Cameron et al., 2013; Pérez-Ríos et al., 2020). Thus, a continuous, observational measure of self-feeding, as the one used in the present study, may allow to detect more fine-grained differences in approach to complementary feeding than maternal reports.

We found a few differences from the Hodges et al.'s (2013) study in the relationship between maternal responsiveness and some contextual variables, as maternal education and duration of breastfeeding. First, Hodges et al. (2013) found that the maternal education level was not significantly related to responsiveness to receptiveness but positively related to responsiveness to fullness. In our sample both responsiveness to receptiveness and to fullness were negatively related to the maternal education level (although for responsiveness to fullness this held true only at 8 months of age). We can exclude that the discrepancy between the two studies was due to differences in measuring maternal education (as in both datasets maternal education was categorized as a binary variable, i.e., no college vs. college and above) or to a different distribution of participants across the two groups, which was similarly unbalanced (no college vs. college and above: 10.3% vs. 89.7% in the current study; 16.7% vs. 83.3% in Hodges et al.'s study). Since in our sample mothers with a lower educational level were also more likely not to have resumed work at 8 months of age (working mothers: no college: 39%; college: 61%), it may be hypothesized that these mothers were generally more responsive to infant feeding cues, and thus more knowledgeable about their needs, as they were the primary caregiver during most meals compared to working mothers who potentially fed their infants less often. In other studies, focused on maternal work and child outcomes, some negative findings were associated with maternal work during the first year of infant development (Lucas-Thompson, Goldberg, & Prause, 2010). However, this hypothesis does not seem supported by our data, as mothers who were not employed at the time of the study were not significantly more responsive to infant feeding cues than working mothers. Second, Hodges et al. (2013) reported that the duration of exclusive breastfeeding was not significantly related to responsiveness to receptiveness, but positively related to responsiveness to fullness. In contrast, in the present study the duration of exclusive breastfeeding was negatively, although marginally, related to responsiveness to receptiveness and not significantly related to responsiveness to fullness. Thus, mothers breastfeeding for longer were less responsive to receptiveness cues, possibly because they could still offer breastmilk as a potential alternative to solids. However, this hypothesis seems unlikely as we did not find a higher responsiveness to receptiveness in mothers who were still breastfeeding at the time of this study. It is similarly difficult to explain why we did not find any significant relationship between breastfeeding duration and responsiveness to fullness, as longer breastfeeding durations have been repeatedly associated with lower subsequent levels of control in infant feeding (e.g., Blissett & Farrow, 2007; Brown & Lee, 2013). It may be that these different results between the present study and Hodges et al.'s (2013) reflect cross-cultural differences, the distinct designs employed in the two studies (longitudinal, involving the same infants at 8 and 12 months of age in the present study, vs. cross-sectional, involving children between 7 and 24 months of age in the Hodges et al.'s study), or the high occurrence of breastfeeding in our sample (75% at 8 months of age and 52% at 12 months), as compared to 25% of the participants in Hodges et al. (2013). Further investigation of maternal responsiveness in our longitudinal sample will help to disentangle these issues.

Our study had the relevant strength of longitudinally assessing maternal responsiveness in a large sample of infants whilst also using observational methods. Additionally, because of the COVID-19 pandemic emergency, we recorded video clips of mealtimes during video calls. The feasibility of this method of data collection was recently assessed by Venkatesh and DeJesus (2021). From their study, it emerged that mealtime recordings garnered through synchronous videoconference sessions have a number of advantages. Specifically, researchers can observe the child's face, the feeding setup, and the food intake clearly, with reasonable audio and video quality. For instance, in the present study 71% of the video clips had no interruptions and in the remaining 29% interruptions accounted on average for about 1.5 min on an average video length of about 24 min. Moreover, as children are observed remotely while in their familiar home environment, this method preserves ecological validity compared, respectively, to observations performed in presence in the laboratory or in home settings.

Our approach to data collection has also some potential limitations. In general, collecting data during synchronous videoconference sessions may be impaired by a limited availability of internet connectivity, that could reduce the socioeconomic diversity of the sample. Moreover, the home environmental context (including the furniture disposition, the lighting condition, the presence of potentially distracting objects) necessarily differs across participants, making it impossible to fully standardize the observational conditions and risking the data being influenced by interfering factors (see also Tsuji, Amso, Cusack, Kirkham, & Oakes, 2022). However, in the present study these factors did not impair our data collection or analysis. Furthermore, although we asked parents to choose, for the videorecording, what they considered to be a

typical meal, without any restrictions about the time of the day, future studies should evaluate whether the type of meal selected (i.e. mid-day or evening meal) might influence eating behavior and responsiveness.

In conclusion, we showed that infants feeding independently since an early age have mothers who are more responsive to their fullness cues. This finding may have implications for healthier socio-emotional development beyond the weaning period and the feeding domain. As reviewed in Saltzman et al. (2018), appetite self-regulation is closely related with the capacity to self-regulate in non-food domains (Anderson & Keim, 2016). General self-regulation skills critically develop during infancy and early childhood (Bernier et al., 2010) and the quality of parent-infant interactions, i.e., the attachment style (Ainsworth & Bell, 1969; Bowlby, 1969), is crucial for the development of children's self-regulation (Anderson & Keim, 2016), by providing infants with a secure base upon which to rely when needed. Children experiencing an insecure attachment at 15 months of age are more likely to have poor general self-regulation skills during toddlerhood and preschool years (Kochanska et al., 2009) and greater BMI (Anderson & Whitaker, 2011). Conversely, from a metanalysis of studies including participants younger than 20 years, better parent-child relationships and higher parents' emotional responsiveness are related to healthier weight outcomes (Pinquart, 2014). Overall, our data extend and strengthen the flourishing literature on complementary feeding approaches alternative to parent-led weaning, and confirm that these methods have often positive outcomes or, at least, a lack of negative consequences (Brown, 2018; Brown et al., 2017; Cameron et al., 2013; Daniels et al., 2018; Doğan et al., 2018; Fangupo et al., 2016; Fu et al., 2018; Morison et al., 2016; Williams Erickson et al., 2018). This suggests that an introduction to solid foods that encourages the involvement of the infant within the context of the family meals and provides an early exposure to the food eaten by the rest of the family should be promoted, supported and offered as a viable and safe complementary feeding alternative to new parents.

Author contributions

Conceptualization: A.G., C.F., F.B., E.A.; data curation, A.D.P., D.D.G., S.G.; formal analysis, F.C., E.A.; funding acquisition, F.B., E.A.; investigation, A.D.P., D.D.G., V.F., M.P., G.P.; methodology, E.A.H., F.B., E.A.; project administration, F.B., E.A.; supervision, E.A.H., F.B., E.A.; writing—original draft, A.D.P., E.A.; writing—review and editing, E.A.H., A.G., C.F., F.C., B.C., S.G., F.B., E.A. All authors have read and agreed to the published version of the manuscript.

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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).

Ethical statement

Hereby, I Elsa Addessi, in the quality of corresponding author, consciously assure that for the manuscript "*Complementary feeding approach and maternal responsiveness in 8- and* 12-month-*old Italian infants: a longitudinal study*" the following is fulfilled:

1) 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). Informed consent was obtained from all participants involved in the study.
2) This material is the authors' own original work, which has not been previously published elsewhere.
3) The paper is not currently being considered for publication elsewhere.
4) The paper reflects the authors' own research and analysis in a truthful and complete manner.
5) The paper properly credits the meaningful contributions of co-authors and co-researchers.
6) The results are appropriately placed in the context of prior and existing research.
7) All sources used are properly disclosed.
8) All authors have been personally and actively involved in substantial work leading to the paper, and will take public responsibility for its content.

I agree with the above statements and declare that this submission follows the policies of Appetite as outlined in the Guide for Authors and in the Ethical Statement.

Informed consent statement

Informed consent was obtained from all subjects involved in the study.

Declaration of competing interest

The Authors declare no conflict of interests.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

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