



Synchronization of mother-infant feeding behavior

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ABSTRACT

In the weaning period, infants are introduced to solid food after being fed solely on milk, which involves a deliberate reorganization of the infant-caregiver feeding interaction. This multiple case study, involving 5 dyads with 10 repeated observations, analyzed its dynamical structure using Cross-Recurrence Quantification Analysis. The results showed that an optimal interaction occurs when the caregiver is leading by roughly 1–2 seconds. During the weaning period, all dyads showed signs of increased synchronization, although there are interesting differences between dyads. These findings indicate that infant-caregiver dyads co-regulate their behavior within a relatively short period.

During the first year of life, much of the infant-caregiver interaction is centered around feeding (e.g. Lindberg, Bohlin, & Hagekull, 1991; Negayama, Norimatsu, Barrat, & Bouville, 2012). In the weaning period, which generally starts around the age of 4–6 months, infants are introduced to solid food after being fed solely on milk. Because in the beginning of weaning infants are not yet capable of efficient self-feeding, parents play a prominent role in feeding (Young & Drewett, 1998). The introduction of solid food can be a challenging task (Young & Drewett, 1998). Infants have to learn how to use their oral motor and oral sensory skills for effective eating (Parkinson & Drewett, 2001), while caregivers have to follow the rapid changes in infants' oral motor and self-feeding abilities (Toyama, 2013) and have to attune to the infants' pre-verbal communication (Green, Gustafson, Irwin, Kalinowski, & Wood, 1995). Feeding problems can arise from a mismatch between infants' cues and caregivers' interpretation of these cues (Toyama, 2013, 2014; Benoit, 2009).

In the first year of life, caregiver and infant 'synchronize' their behaviors (e.g. Feldman, 2007). In a synchronous interaction, the behaviors of both partners cannot be seen as separate units; because both infant and caregiver each match their behavior to the other continuously (Fogel, 1993; Harriot & Waugh, 2002). Toyama (2013, 2014) studied infant-caregiver synchronization in feeding interactions and described spontaneous mouth opening of the infants one month after the introduction of solid food, and a peak incidence of non-fluent arm movements of the caregivers at 2–3 months, suggesting that caregiver and infant coordinate their behavior during weaning. In a previous study, we argued that the feeding interaction between caregiver and infant can be seen as a complex dynamic system (Van Dijk, Hunnius & van Geert, 2009, 2012). Such a system consists of a great number of elements that interact at different timescales (Van Geert, 2003). During feeding, infant and caregiver can also be seen as a system, with the infants' appetite, food preferences, behaviors and the caregiver's skills, concerns and goals continuously interacting and mutually influencing each other (Van Dijk et al., 2009, 2012). In this system, the constituent elements self-organize into a functional unit, a behavioral synergy for feeding interaction, typical for each individual infant-caregiver dyad. Whereas stability points to a well-coordinated behavioral synergy, in the context of feeding, variability points to an interaction in which parent and infant are still exploring (Thelen & Smith, 1993). In earlier studies, we investigated the infant-caregiver feeding interaction during the first 12 weeks of weaning and

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Table 1

Background information of the participating infants (pseudonyms) and their mothers.

	Name	Sex	Age mother (age in years)	Birth order	Seating arrangement	Birth weight (gram)	Milk type	Age (weeks) at introduction
1	“Floris”	M	37	1	All sessions high chair	4150	Breast	21
2	“Femke”	F	28	1	All sessions high chair	4050	Both	26
3	“Jens”	M	27	1	w1: baby seat, w2: on lap	3540	Both	19
4	“Lily”	F	35	3	All sessions on lap	2980	Formula	20
5	“Milou”	F	27	2	All sessions on lap	3210	Formula	22

found a decrease in day-to-day variability over a period of 6 weeks (Van Dijk et al., 2009). In a further study, we reported an increase of smooth feeding interactions (such as offering-accepting) (Van Dijk et al., 2012).

Although there are descriptions of qualitative changes in the feeding interaction, changes in the *temporal structure* of feeding are still unexplored. Complexity metrics offer the possibility to quantify the degree of coordination in terms of the structure and stability of the underlying processes (e.g. Wallot & Van Orden, 2011). These metrics result from nonlinear time-series analysis techniques, such as cross recurrence quantification analysis (CRQA). CRQA has already proven to provide valuable and unique information about parent-child interaction patterns, for instance in parent-child talk (Cox & van Dijk, 2013), in gaze coordination (Nomikou, Leonardi, Rohlfing, & Raczaszek-Leonardi, 2016) and in infant-adult vocalizations (Abney, Warlaumont, Kimbrough Oller, Wallot, & Kello, 2015). These examples illustrate that CRQA provides unique information which is also relevant for understanding the dynamics of feeding in infancy.

The research question for the current study was: What are the temporal patterns of synchrony between caregiver and infant and how do these change during the weaning period?

The study was based on the video data of the First Bites Project (collected in 2005/2006 and reported on in Van Dijk et al., 2009, 2012) which was re-coded in a very detailed manner. Because of the labor-intensive nature of coding, the current sample consisted of 5 infant-caregiver dyads who were selected based on three criteria: (a) The infant's mouth was clearly visible at all times, (b) All caregiver's arm movements (2 cm back or forth) were visible, and (c) no more than two seating arrangements were used. The dyads came from a typical population, were from middle to upper SES, and living in the Netherlands. At the start of the study, the infants were between 19 and 26 weeks of age ($M_{days} = 154.2$; $SD = 19$) and were feeding solely on milk. See Table 1 for further characteristics. Ethical guidelines of the respective universities where the original data collection took place were followed and ethical approval was gained (OUNL-U2006-219CBO).

The caretaker's behavior was coded as: a) Food scooping: caregiver gathers food with the spoon, b) Moving: caregiver moves the spoon to infant's mouth, c) Offering: caregiver offers the spoon to infant within 2 cm distance, d) Inserting: caregiver holds the spoon inside infant's mouth, e) Pulling back: caregiver retracts her arm, and f) Other: this includes all other behavior. The infant's behavior was coded as: a) Reject: infant rejects the food, b) Chewing/munching: infant's jaw is making chewing/munching movements, c) Accessible: infant's mouth is open far enough to bring at least half of the spoon into the mouth, d) Touch open: infant opens the mouth after the spoon has touched the lips, and e) Other: all other moments. See Table 2 for the coding guidelines.

The observations were originally grouped in three waves (at the introduction of solids, and 4 and 10 weeks later). Each wave consisted of five observations within a period of two weeks. Because previous studies showed that the most important changes took place between wave 1 and 2, we included only the first 10 observations in the current study. This means that the total observation period for this study covered the first 6 weeks of eating solid food.

The data was collected by researchers/research assistants who knew the families. Caregivers were instructed to feed their infant as usual. Choice of food was free, although the observations were scheduled around fruit or vegetable feedings. In the current study, we analyzed the entire feeding sessions with a duration of between 3.7 and 19.4 min each ($M = 9.9$ min, $SD = 3.9$ min).

Table 2

Guidelines for coding caregiver and infant.

Code	Name	Description
Caregiver		
F	Food scooping	Caregiver gathers food with the spoon
M	Moving	Caregiver moves the spoon with the food to infants' mouth
O	Offering	Caregiver offers the spoon to the infant
I	Inserting	Caregiver holds the spoon inside infants' mouth
P	Pulling back	Caregiver moves her arm away from infants' mouth
B	Other	All other behavior
Infant		
R	Reject	Infant rejects the offered food
C	Chewing	Infant's jaw is making chewing/munching movements
A	Accessible	Infant's mouth is open
T	Touch-open	Infant accepts the food after the spoon has touched the lips
D	Other	All other behavior

Note: high chair and baby seat feeding was face to face, feeding on lap was with a roughly 90-degree angle.

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