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The ontogenesis of smiling and its association with mothers' affective behaviors: A longitudinal study

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ABSTRACT

Two babies were observed from their third week to their sixth month of life. Our goals in the study were: to investigate developmental changes in smiling patterns; to analyze the smiling patterns observed in the presence of mother's affective behaviors, and to verify whether the babies can answer contingently, with smiles, to mothers' affective behaviors. The babies and their mothers were videotaped at home. It was verified a positive linear trajectory tendency for the babies' smiles. The babies revealed a particular tendency to display one or two kinds of smiles. Babies answered contingently with smiles to their mothers' affective behaviors. Correlations between the most frequent types of babies' smiles and his/her mothers' smiles were verified ($r = .77$, $p < .0017$ – baby1, and $r = .62$, $p < .0017$ – baby2). Different types of smiles were exhibited by the babies as contingent answers to mothers' behaviors. The results show an association between babies' smiles and their mothers' affective behaviors.

Infant smiles are considered a prototypical expression of early joy and a window to the development of positive emotions (Fogel, Hsu, Shapiro, Nelson-Goens, & Secrist, 2006; Messinger, 2002; Messinger, Cassel, Acosta, Ambadar, & Cohn, 2008; Oster, Hegley, & Nagel, 1992). They have different forms, and evidence suggests that different types of smiles express different degrees and types of positive emotions (Fogel, Nelson-Goens, Hsu, & Shapiro, 2000; Messinger, Fogel, & Dickson, 2001). Smiling may be considered an adaptive expression (Ekman, 1999, chap. 3; Plutchik, 1997). Like other facial expressions, smiling communicates emotional states, orients behaviors, and increases the probability for survival and reproduction. Thus, it can be seen as a manifestation that facilitates interactions and social abilities. Babies' smiles attract the caregivers' attention, and elicit warmth and care (Bowlby, 1969/2002).

Besides communicating positive engagement and happiness, smiles elicit positive engagement and happiness from those around the infant (Bigelow, 1998; Fogel et al., 2000; Symons & Moran, 1994). The interactive process of being positively engaged to another person may be part of the process through which joy and social competence develop. Some authors argue that early smiles also help to predict later development (Campbell, Cohn, & Meyers, 1995; Forbes, Cohn, Allen, & Lewinsohn, 2004; Fox, Henderson, Rubin, Calkins, & Schmidt, 2001), and indicate a crucial transformation in intersubjectivity (Rochat & Striano, 1999).

At the same time, contemporary theories on self, affect and cognitive development emphasize the significance of interpersonal interactions, especially in what regards their emotional and affective aspects (Keller, 2007; Walker-Andrews, 1997).

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Many studies on mother–infant interactions have focused on their developmental characteristics, and their importance for babies' development (Keller, 2002; Lavelli & Fogel, 2005; Seidl-de-Moura et al., 2008).

Seidl-de-Moura et al. (2008) compared dyadic interactions features in two groups: of 1 and 5 months-old babies. A significant difference was found, with higher scores for the 5 months-old group, when comparing the interactions in which affective manifestations of both the mother and the infant (smile) occurred and the cases in which no affective manifestations was observed.

Early face-to-face interactions, which are related to the expression of warmth, are common in mother–infant engagements, when western urban groups are considered (Fogel et al., 2006; Keller, 2002; Seidl-de-Moura et al., 2008). This form of mutual visual attentiveness and eye contact involves synchronic aspects, co-regulation and contingent behaviors, establishing affective communicative events. It seems that in these episodes babies learn about emotions, their expression, and expectations about others' behaviors.

Studies focusing on infants' smiling report both qualitative and quantitative transformations in this facial expression at around 2 months, when social smile emerges (Lavelli & Fogel, 2005; Messinger et al., 2001). Mother–infant emotional engagement involving smiling has been analyzed in several studies (Lavelli & Fogel, 2002, 2005; Legerstee & Varghese, 2001; Montagne & Walker-Andrews, 2002). Lavelli and Fogel (2005) showed evidences on the developmental changes in infants' patterns of attention and emotion during face-to-face communication. At a dyadic level, infant smiling becomes sequentially linked to maternal talk/smile in the 2nd and 3rd months of age (Lavelli & Fogel, 2002).

Despite this set of evidences, much remains to be investigated about how early smiles unfold in time, and about the meaning of different facial features that configure different types of smiles. Moreover, longitudinal studies that focus on early development are necessary to better understand the ontogeny of infants' facial expressions, and the infants' capacity to act in affective interactions using these expressions (Izard et al., 1995; Messinger et al., 2002).

We hypothesize an association between infants' smiles and their mothers' affective behaviors, and that different types of smiles are elicited by mothers' affective behaviors in interactional contexts. It seems plausible to expect developmental changes in infants' positive facial expressions, as well as developmental changes in the association between infants' smiling and mothers' affective behaviors.

This study aims to shed light on both smile ontogeny and infants' emotional experience. It is also an answer to the lack of longitudinal investigations on infants' smiling development. The goals of the study are: (1) to investigate patterns of smile exhibition, and possible transformations in these patterns during the first 6 months of life; (2) to analyze smiling patterns observed in the presence of mothers' affective behaviors during the first 6 months of life; (3) to verify whether babies can answer contingently, with smiles, to mothers' affective behaviors, and if there are specific patterns for these answers related to specific types of smile. In order to address these questions, the manifestation of smiling during mother–infant interactional contexts was examined weekly from the 3rd week to the 6th month of life of two babies. Comparable studies in the literature were not identified.

1. Methods

1.1. Participants

Two Brazilian mother–infant dyads participated in the study. They were recruited through contact established with a pediatrician who collaborated in the recruitment process. Our first contact with the mothers, which had the goal to present the study and to check on mothers' availability, took place during the babies' second week of life. According to the pediatrician's information, the babies (one boy and one girl) were healthy, full-term infants, and there were no complications during pregnancy or delivery. Mothers' age, occupation, and declared educational level were 34 years-old, housewife, and high school level for the girl's mother (mother1), and 40 years-old, elementary school teacher with a BSc in Education, and university degree for the boy's mother (mother2). Both mothers, who were Brazilian and lived with the babies' fathers at the time of the study, signed an informed consent and an authorization to videotape images to be used for research purposes.

1.2. Materials

Mothers and infants were videotaped using one manual camera and one fixed camera. The fixed camera images were used only to confirm some details in mothers' faces. Following the assessment, mothers' affective behaviors and babies' smiles were coded.

1.3. Procedures

Mother–infant dyads were weekly visited by the first author. In the first visit, mothers read and signed the consent forms. During all visits (observations), three sections were recorded, each one lasting 10 min. In two of them the mother could leave the room if she wanted (NM), and in one section the mother was asked to stay with the baby during the whole time (WM). The idea was to create different settings that could elicit varied dynamics within the interactional episodes. In the WM condition, it was expected an increase in interactional episodes, especially in face-to-face interactions, which are frequent in infants' early development (Seidl-de-Moura et al., 2008).

Mothers were instructed to interact with their babies "as they normally do" in the room of their choice. During WM sections, mothers were instructed to stay with their babies or, at least, close to them. In the dyad with the female infant, the living room was chosen as a site for interaction in all visits but one. For the dyad with the male infant, the bedroom was chosen in all visits but one.

1.4. Coding

The WM section and one of the two NM sections (chosen randomly) of each observation were coded according to the study-specific criteria. These criteria were based on definitions used in recent research in the area: for infants' smiles (Dickson, Walker, & Fogel, 1997; Fogel et al., 2000; Messinger et al., 2001), and for mothers' affective behaviors (Seidl-de-Moura et al., 2008).

Because of the naturalistic observational data and the low resolution of some images, *undefined* code was adopted when the infants' smiles were not sufficiently clear or when infants covered their face with their hands. Moreover, smiles considered *endogenous smiling* (Lavelli & Fogel, 2005) were not of interest for our aims, so they were coded and considered in some descriptive statistics but they were not included in the analyses.

The observation categories used were defined as the following:

- Infant's smiles – four different categories of smiles, distinguished by their morphology (1 to 4) – classified depending on the combination of facial action units (AU), in accordance to FACS coding system – and two categories, one of unclassified smiles (5), and another for smiles expressed during sleep or during the transition between alert and sleeping state (6).
  1. Simple (ss) – involves a lip corner raise (only AU12 involved) that pulls the lips upward and toward the side of the face; based on the *basic smile* definition adopted by Dickson et al. (1997) and Fogel et al. (2000).
  2. Duchenne (sd) – involves lip corner raise (AU12) and cheeks raise (AU6), with eyes constriction; based on the *duchenne smile* definition adopted by Dickson et al. (1997) and Fogel et al. (2000).
  3. Ample (sa) – involves a lip corner raise (AU12) and a jaw drop (AU26/27); based on the *play smile* adopted by Dickson et al. (1997) and Fogel et al. (2000).
  4. Mixed (sm) – includes a lip corner raise (AU12), a jaw drop (AU26/27), and a cheek raise (AU6); based on the *duplay smile* adopted by Dickson et al. (1997) and Fogel et al. (2000).
  5. Undefined (si) – unclassified smile as a result of visual limitation.
  6. Endogenous (se) – smile that occurs during sleep or during the transition between alert and sleeping state. This study did not focus on this type of smile, and they were not distinguished in terms of their morphology.
- Mother's behaviors – four different kinds of affective behaviors (1 to 4)
  1. Smile (so) – smile directly addressed to the baby. For the purposes of this study, it was not necessary to identify the different types of mothers' smiles. Any smile directly addressed to the baby, as well as eventual laughs were considered. The latter were coded even when not appearing in the video image, when the sound was audible. Their durations were registered through the sound heard.
  2. Speech/vocalization (fv) – all mother's speech and vocalizations directly addressed to the baby (including sounds of toys, animals or vocal games) were considered. The following were excluded: mother's speech addressed to other people, vegetative sounds like whispers, hiccups, belches, yawns, sneezes, coughs, tongue smacking, and whistling.
  3. Affective touch (ta) – intentional touch of any part of the baby's body with any part of the mother's body, related to affective expressions, excluding daily activities related to the baby's care (diaper changing, bathing, etc.). This category (ta) does not depend on the baby being in the mother's arms or lap.
  4. Kiss (be) – to kiss the baby, touching any part of his body with the lips. When the mother touches the baby with her lips or face, but not seeming like a clear kiss, the code adopted was (ta).

Data codification was based on the following two-components structure: (a) Component 1 – directed to the baby's smiles, mutually exclusive behaviors and exhaustive codification; and (b) Component 2 – considering mother's behaviors that are not mutually exclusive and the codification is not exhaustive.

The video excerpts selected for analysis were watched in order to identify babies' and mothers' target-behaviors, according to the defined categories. Infants' smiles and mothers' affective behaviors were assessed during separate viewing by a trained coder (the first author), who is experienced in coding infant behaviors. For each part selected, the coder first viewed the tape and assessed the infant's smiles continually in time. Then, the coder watched the videotape, pausing when a category changed, so she could record the smile category and the time displayed in the digital clock on the screen. Coding was done with mutually exclusive and exhaustive categories (the offset of the prior category is the onset of the succeeding category).

In the second viewing, the coder watched the tape until a defined category for mother's behaviors occurred, without consultation to the previous coding of infant's categories. For instance, if the mother started to caress the baby's face, the coder would take note of the precise time (in minutes and seconds) when the behavior started and finished, and the behavior code. Obviously, simultaneous affective behaviors were possible and expected.

1.5. Reliability

Inter-rater reliability was calculated on a random sample of 16% of the observations (visits). Cohen's Kappa, which measures agreement (correcting for random agreement) on the duration of all codes within a particular coding category, were calculated with a data-analysis pack, the GSW – *Gseq for Windows* (see Bakeman, Deckner, & Quera, 2005).

The mean Kappa for the infants' smile coding was .65, and the mean Kappa for the mothers' behavior coding was .83. The first author coded 100% of the observations, and another trained coder viewed 16% of them to assess for reliability. Reliability coder worked independently and was blind to the hypotheses of the study.

1.6. Data analysis

Correlations between the target-behaviors were calculated, and the trend effects of these behaviors were analyzed. Descriptive statistics furnish global results for NM and WM conditions and age measures of the babies (0–2, 2–4 and 4–6 months-old segments). GSW (Bakeman & Quera, 1995) was used in the contingency analysis between babies' and mothers' behaviors. Contingent analyses using Yule's *Q* were conducted, considering a one-second latency window (the onset of mother's behavior and the next second).

2. Results

Initially, some observations about mothers' general characteristics and interactional styles should be made. It was clear that the two mothers interacted with their babies with positive affect. However, they differed in their ways of giving affect and warmth. The girl's mother (mother1) showed a more equitable distribution of affective behaviors, whereas mother2 (the boy's mother) showed an affective communication with her baby marked primarily by speech.

The idea of creating alternative settings (NM and WM) to elicit different dynamics in mother–infant interactions was partially unsuccessful. Mother2 was engaged in breast-feeding in 65% of the total observation time in the WM condition, which made it difficult to register manifestations of her baby's facial expressions.

As it was expected, infants smiling occupied a small percentage of the total observation time (less than 5%), which seems to correspond to a common pattern at this age range, as mentioned by Messinger et al. (2001). In relation to the diversity of smiles, all the types but one (mixed smile) were present before the 9th week of age.

Proportional durations and frequencies of each smile type were calculated (Table 1). The results indicate that each baby displayed a predominant type (or two types) of smile. While baby1 (the girl) showed predominantly *ample smiles* (*sa*), baby2 (the boy) most frequently displayed *simple* and *ample smiles* (*ss* and *sa*). These tendencies were maintained throughout the 6 months of observation.

Trend (polynomial) analyses were also conducted for smile types across observation time. Significant trend effects were found in some cases, as can be seen in Fig. 1. Significant trend effect (linear and positive) was found for baby1, in NM

Table 1
Distribution of smiles by types.

Codes	NM				WM			
	Dur.	RelD	Freq.	RelF	Dur.	RelD	Freq.	RelF
Baby1								
ss – Simple	39	.0027	20	.0816	80	.0059	38	.1162
sa – Ample	244	.0169	68	.2775	271	.0199	108	.3302
sd – Duchenne	4	.0003	2	.0081	11	.0008	5	.0152
sm – Mixed	87	.0060	29	.1183	63	.0046	23	.0703
si – Undefined	5	.0003	2	.0081	4	.0003	2	.0061
se – Edogenous	2	.0001	1	.0040	4	.0003	2	.0061
ns – no smiling	14,084	.9737	123	.5020	13,193	.9682	149	.4556
Total	14,465	1.0000	245	1.000	13,626	1.0000	327	1.000
Baby2								
ss – Simple	263	.0174	123	.2248	76	.0051	33	.2024
sa – Ample	271	.0180	100	.1828	73	.0049	22	.1349
sd – Duchenne	41	.0027	15	.0274	48	.0032	9	.0552
sm – Mixed	117	.0078	37	.0676	8	.0005	2	.0122
si – Undefined	9	.0006	3	.0054	8	.0005	3	.0184
se – Endogenous	0	.0000	0	.0000	9	.0006	4	.0245
ns – no smiling	14,375	.9535	269	.4917	14,804	.9852	90	.5521
Total	15,076	1.0000	547	1.000	15,026	1.0000	163	1.000

The table shows total time in each smile's type in each condition (NM and WM), for the two babies, expressed as a proportion of total time in all codes (RelD) and in seconds (Dur.). This table also shows total number of occurrences in each smile's type in each condition (NM and WM), for the two babies, expressed as a proportion of total number of occurrences in all codes (RelF) and in number of occurrences (Freq.).

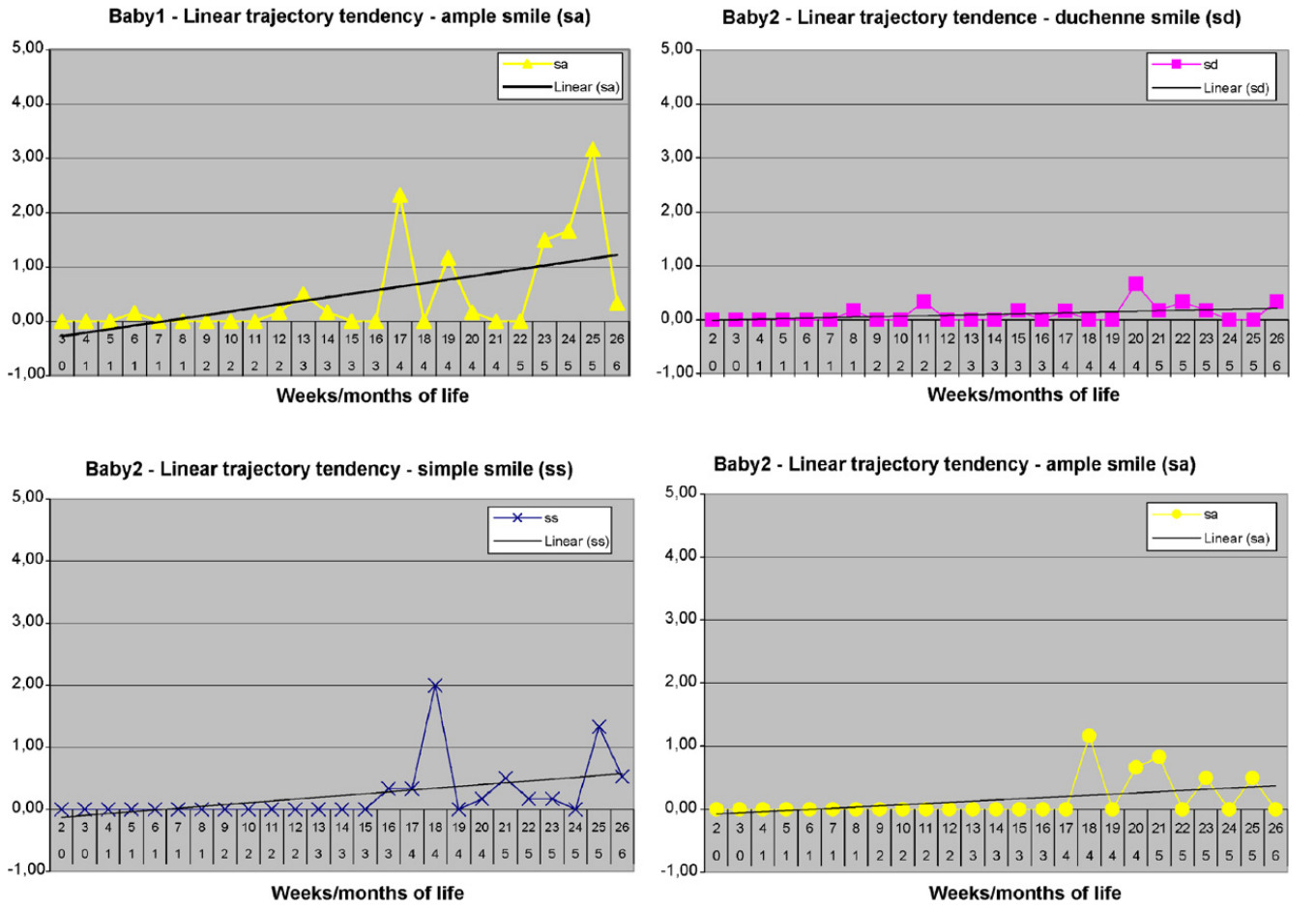

Fig. 1. Linear trajectory tendency of smiles types – baby1 and baby2.

condition, for *ample smile* (*sa*), during total observation time, $F(1,22) = 8.91$, $p < .05$. For baby2, it was found significant trend effects (linear and positive) in NM condition, for *duchenne smile* (*sd*), $F(1,23) = 4.56$, $p < .05$, and in WM condition, for *simple smile* (*ss*), $F(1,23) = 6.00$, $p < .05$, and *ample smile* (*sa*), $F(1,23) = 5.33$, $p < .05$.

Considering the total number of smiles of all types, it was found a significant trend effect for baby1, in NM condition, $F(1,22) = 6.77$, $p < .05$, and for baby2, in WM condition, $F(1,23) = 7.85$, $p < .05$. These results (Fig. 2) suggest that babies' smiling becomes more frequent when we observe the first 6 months of life. Especially during the second and third months, it was registered a high frequency of babies' smiles. Significant trend effects were not found either for mothers' smiling, or for their total affective behaviors.

In order to analyze the associations between infants' smiles and their mothers' affective behaviors, Pearson correlation and contingent analysis were conducted. At first, it was used relative frequencies (frequency/observation time in seconds) of all types of infants' smile and of all mothers' affective behaviors. The results show that for baby1, in WM condition, these two measures were correlated ($r = .77$, $p < .05$). No correlations were found for baby2.

Other possible correlations were verified using the relative frequencies of each type of infants' smile, and each kind of mothers' affective behavior. Mothers' smiles and speech/voc. were the most frequently correlated behaviors to infants' smiles. For baby1, only simple and ample smiles correlated to mother's behaviors (for NM, simple/smile ($r = .49$, $p < .05$), ample/smile ($r = .74$, $p < .05$), ample/kiss ($r = .53$, $p < .05$); and for WM, simple/smile ($r = .66$, $p < .05$), ample/smile ($r = .97$, $p < .05$), ample/speech/voc. ($r = .55$, $p < .05$), ample/affect touch ($r = .62$, $p < .05$)). For baby2, simple, ample and mixed smiles correlated to mother's behaviors (for NM, ample/smile ($r = .62$, $p < .05$), and ample/speech/voc. ($r = .49$, $p < .05$); and for WM, simple/speech/voc. ($r = .44$, $p < .05$), ample/speech/voc. ($r = .43$, $p < .05$), and mixed/kiss ($r = .60$, $p < .05$)).

For contingent analysis, Yule's *Q* was calculated considering a one-second latency window. Infants answered contingently smiling to their mothers' affective behaviors. Different types of smiles were exhibited by the infants as contingent answers to the mothers' observed behaviors. Mothers' smiles elicited contingent infant smiling of two types, ample and mixed smiles, but did not elicit simple or duchenne smiles. Although all mothers' behaviors have promoted contingent smiling in their infants, smile and speech/vocalization, besides eliciting different types of smiles in the different age periods analyzed, have also presented high Yule's *Q* values. Despite these similarities, distinctive characteristics of the two babies can be identified.

As shown in Table 2, until 2 months of age, baby1 did not present contingent reaction to her mother's expressions of affect. Between 2 and 4 months, however, different associations between the infant's smiles types and her mother's behaviors can

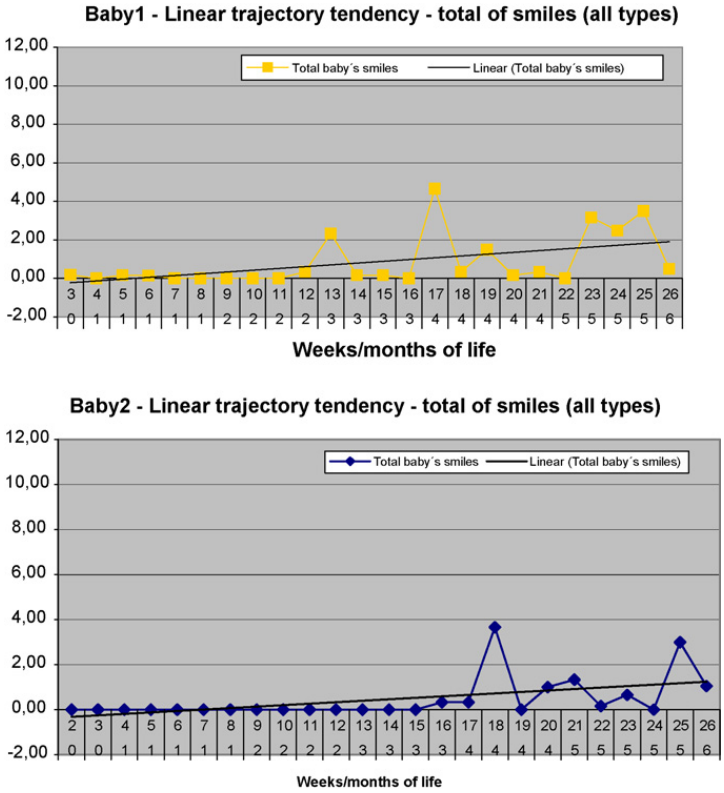

Fig. 2. Linear trajectory tendency of smiles (all types) – baby1 and baby2.

Table 2
Contingent behaviors by age – baby1 (the girl) and baby2 (the boy).

Observational condition	Age	Smile	Mother's affective behaviors	Yule's *Q*
Baby1				
SM	Until 2	–	–	–
	From 2 to 4	ss	be	1.0*
	From 4 to 6	sa	so	0.92*
		sa	be	0.72*
		sm	so	0.83*
WM	Until 2	–	–	–
	From 2 to 4	ss	fv	0.65*
		ss	ta	0.59*
		sa	fv	0.64*
		sa	so	0.91*
		sa	ta	0.53*
		sm	so	0.63*
	From 4 to 6	sa	so	0.90*
		sm	so	0.95*
Baby2				
SM	Until 2 months	ss	fv	0.90*
	From 2 to 4	sa	so	0.79*
	From 4 to 6	ss	ta	0.72*
		sd	fv	0.65*
		sm	fv	0.70*
WM	Until 2 months	–	–	–
	From 2 to 4	ss	fv	0.96*
	From 4 to 6	ss	be	0.91*
		sa	so	0.82*
		sm	fv	0.85*

The table shows contingent behavior in the observation conditions NM (mother not necessarily with the baby all the observation time), and WM (mother with the baby during all observation time).

* $p < .05$.

be seen. During the period between 4 and 6 months of age, ample smiles were expressed as a response to smiles and kisses, and mixed smiles were contingent to the mother's smiles.

Baby2 presented also specific associations in contingent analyses (Table 2). Until 2 months of age, he responded with simple smiles to speech/voc. From 2 to 4 months, in addition to this same association, it was observed contingent ample smiles to his mother's smiles. Between 4 and 6 months of age, he presented more diversity in his reactions to mother's affective behaviors.

In relation to changes attributed to the developmental course, it was verified that mothers' smiles are likely to promote contingent infants' smiles after 2 months of age. Although simple smiles was manifested as contingent answer since 2 months, morphologically more complex expressions, such as mixed smiles, are likely to be contingent to mothers' behaviors only after 4 months of age. It was verified an increasing specificity of links between mothers' and infants' expressions with age, and also differences between the dyads. Table 2 shows these results (Yule's Q varying from -1 to $+1$).

3. Discussion and conclusions

In this study, we were able to present data on the diversity of infants' smiling in mother–infant interactional contexts. Data also presented the developmental process of infants' smiling, as well as the relationship between this expression and maternal expressions of affect during dyadic interactions over the first 6 months of life.

Infants' smiles were present since the beginning of the observations until the end of the 6th month. Simple, ample and duchenne smiles were exhibited even before the 9th week. The absence of mixed smiles on the first 8 weeks of life (for the two babies), perhaps may be due to maturative factors. Another plausible reason for this absence is the characteristics of dyadic interactions in this period, which could be not appropriate to promote this type of smile.

The observed tendency, for the two babies, to manifest more frequently certain types of smile, perhaps configuring an individual pattern, need to be further investigated, taking into account evidence found by Dickson et al. (1997) and Fogel et al. (2000). Despite any possible individual tendency or smiling pattern, the authors report that each type of smile has a systematic pattern of association with specific contexts, and with each step in mother–infant games. Specificities in each dyad's interchanges may be one reason for the found prevalences of infants' smiles types. Further studies are needed in order to clarify this issue.

According to the literature, both qualitative and quantitative transformations can be seen in babies' smiles at 2 months, when the frequency of smiles increases (Lavelli & Fogel, 2005; Messinger et al., 2001). Our observations confirmed this evidence in the case of the two Brazilian babies investigated.

Significant trend effects were found for the two infants, suggesting that infants' smiling becomes more frequent with age (considering the first 6 months of life). Along the same lines, Messinger et al. (2001) found an increase in the proportion of both simple smiles and smiles with cheek rising in this same age period, and Lavelli and Fogel (2005) reported a linear positive trend when they analyzed babies' first 3 months of life.

These findings point out to two different phases in the development of smiling in the first 6 months of life: shortage of social smiles during the first month, and a higher proportion of smiles during the next months. In relation to mothers' behaviors, results suggest certain stability across these months. Proportional frequencies of mother–infant interactions which include infants' smiling, however, rose due to an increase in infants' social smiles.

Simultaneously, it was observed a more general change in the infants' behaviors and reactions in relation to the environment and the presence of their mothers. They seemed more attentive to events and person's movements, and demonstrated motor excitement as a reaction to several stimuli, such as sonorous toys. In addition, their faces seemed much more expressive in these occasions. Their mothers accompanied these changes and it was evident their effort to call the infants' attention to themselves and to a new way of playing with them. These attempts suggest that the partners develop sensitivity to the other's behaviors during interactions.

Lavelli and Fogel (2002, 2005) reported on these qualitative changes in the dyad's communication process, emphasizing a transition that started in the 2nd month of age, which seemed to affect the whole process of mother–infant interaction. In our study, the affective dimension of mother's behaviors was considered in a more ample diversity of expressions, including other categories beyond smile and talk with the baby. Hence, it was possible to establish more detailed associations and interpretations.

At a dyadic level, infant smiling becomes sequentially linked to maternal affective behaviors, especially starting from the 2nd month, as had been reported by Lavelli and Fogel (2002, 2005). Analysing each mother category independently, it can be noted that all mothers' behaviors correlated to some type of infants' smile, and that all types of smiles but one (the duchenne smile) correlated with some of the mothers' behaviors. These results seem to corroborate the links we infer between infants' and mothers' behaviors. Ample smiles (predominant for the two babies) significantly correlated with all mothers' categories, which can indicate an expression commonly used by the two infants to manifest affect.

Taking into account the total number of mothers' affective behaviors, and the total of infants' smiles, without discriminating them by types, only one dyad presented a positive correlation between these two global measures (baby1). We can speculate that baby2 normally increased exhibitions of specific smile types when his mother increased manifestations of specific behaviors, and that these correlations are not general enough to produce global correlations.

Our hypothesis about the association between infants and mothers' behaviors was then confirmed, in part, by the correlations found. On the other hand, contingent analysis showed how infants' smiles are contingent to mothers' affective

behaviors. All mother's behaviors elicited some type of infant's smile, and all types of infant's smile are manifested contingently to some of the mother's behaviors, which reinforces the expected association between infants' smiling and mothers' affective behaviors. In addition, our results show that the infants responded to mothers' smiles using only two types of smiles, ample and mixed smiles, which can indicate some special relationship between infants and mothers' target behaviors.

It was verified an increasing specificity in the association between mothers and infants' expressions with age, as well as differences between the dyads. For the dyad with the male infant, mother's speech/voc. (a behavior that marked primarily her affective communication) elicited infant's smiles in all the analyzed age periods (until 2 months, from 2 to 4 months, and from 4 to 6 months of age), involving three different kinds of infant's smiles. For the dyad with the female infant, occurrences of contingency including speech/voc. were more restricted. In this case, ample smiles (the infant's predominant type of smile) were elicited by three different behaviors of the mother (smiling, kissing, and affective touching), while for the other dyad, ample smiles was only elicited by mother's smiles.

As a whole, these findings suggest that smiling gradually develops as infants and their caregivers co-create specific forms of social communication and affective interchanges. It is possible that there is a dynamic social-emotional communicative system within which smiling develops. Mothers' smiles and talking reached high scores when correlation and contingency indexes were calculated, indicating that these behaviors may be considered relevant components in this system. The increasing association between certain types of infants' smiling and mothers' manifestations of positive affect was most evident after the babies' 2 months of age. It is tempting to think that complex positive emotions and their expressions are the result of a developmental process that begins early and continues across the life span.

This study provides new data on how the relationship between infants' smiling and their mothers' affective behaviors is established within the first 6 months of life. It was also possible to notice developmental changes in two Brazilian infants' early smiling. Certainly, some limitations in the study can be pointed out. A long-term research, covering at least the whole first year of life, could provide important information about the ontogeny and significance of infants' smiling. Other technological resources would improve image quality, such as a higher resolution and a composite split-screen video image. Resources like these could reduce many of the difficulties faced in the coding process.

A further limitation is that our results are referred only to Brazilian participants from Rio de Janeiro, and from families of lower and middle-class. Thus, they are specific, and they require other complementary evidence. Comparisons involving other contexts may be planned, such as infants from different parenting contexts and cities of different urbanization levels.

Further studies can be considered, such as the analyses using this same database with the purpose of investigating temporal sequences in mothers' behaviors and infants' smiling in dyadic interactions. Another possibility is to verify the role played by infants' positive emotional expressions in the process of self construction, in different socialization contexts.

Although aware of the presented limitations, we are convinced that this study represents a contribution to the literature on early facial emotional expressions. It has allowed for the investigation of the hypothesized association between infants' smiling and mothers' affective behaviors. In addition, the study contributes to the understanding of some aspects of the ontogenesis of smiling. Finally, the relevance of investigating babies' smile contrasts to the lack of Brazilian studies on the topic.

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