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The Emergence of Social Smiling: The Interplay of Maternal and Infant Imitation During the First Three Months in Cross-Cultural Comparison

Viktoriya Wörmann[1], Manfred Holodynski[1], Joscha Kärtner[1], and Heidi Keller[2]

Abstract

The study addresses the emergence of the social smile in two different sociocultural contexts during the first 12 postnatal weeks. We examined different eliciting mechanisms like mutual gazing, maternal smile during mutual gazing, and reciprocal maternal and infant imitation of smiling. In co-constructivist theories of emotional development, all of them are considered social mechanisms that foster the emergence of social smile in early infancy around the 2-month shift. During the 6th postnatal week, we assumed that mutual gazing and the accompanying maternal smiles are the primary mechanisms that correspond with first infants' social smile. From the 2-month shift onward, thus during the 8th, 10th, and 12th postnatal weeks, we assumed maternal imitation of infant smile moderates the positive relationship between infant imitation of maternal smile and the duration of infant social smile. We compared face-to-face interactions between 20 mother–child dyads from an independent sociocultural context (urban middle-class families from Münster, Germany) and 24 mother–child dyads from an interdependent sociocultural context (rural Nso families, Cameroon) when the infants were 6, 8, 10, and 12 weeks old. The first hypothesis could be corroborated for both cultural contexts, the second hypothesis only partly for the independent cultural contexts and staggered for the interdependent context. The consequences of culture-specific developmental pathways of social smile are discussed.

Keywords

social smile, maternal imitation, infant imitation, cross-cultural context

The emergence of the social smile represents one of the first clearly observable signs of socio-emotional development in the first three months of life. Infants' first social smiles begin to emerge around the second month of life across different sociocultural contexts (Kilbride, 1980; Super & Harkness, 2010). However, evidence supports substantial cross-cultural differences in

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the age (from fifth to seventh week) of the first appearance of the social smile, as well as in its duration and absolute frequency between the second and seventh month of life (Anisfeld, 1982; Camras et al., 1998; Fogel, Toda, & Kawai, 1988). Moreover, the emergence of infant social smiling relates to the behavior of their mothers (Gewirtz, 1965; Kuchner, 1989). Gewirtz (1965) showed that Israeli infants brought up by families smiled more during the first three months of life than infants from institution nurseries. European American mothers were demonstratively more affectionate with their 3-month-old infants than Chinese American mothers that correspond with the observation that the European American infants smiled more frequently than the Chinese American infants (Kuchner, 1989).

In spite of such cross-cultural differences in social smile development during the first months of infants' life, only a few studies have investigated the underlying mechanisms of its development. A study by Wörmann, Holodynski, Kärtner, and Keller (2012) included samples from two different sociocultural contexts and examined key mechanisms that contribute to the emergence of the social smile in mother–child dyads, namely, maternal and infant smiling imitation. They found that mothers and their 12-week-olds from the Münster (urban City in Germany) sample imitated the smiling of each other more frequently than mothers and their 12-week-olds from the Nso (rural ethnic group in Cameroon, Africa) sample. Correspondingly, they found significantly longer duration of the social smile in 12-week-old infants from Münster sample comparing to the 12-week-old Nso infants. They did not find any differences during the sixth postnatal week. Taken together, these findings suggest that maternal and infants' mutual imitation of the other's smiling may foster the development of the social smile around the 2-month shift. Moreover, these behaviors may be culture-specific. The present study is a sequel of the above-mentioned study of Wörmann et al. (2012) and investigates the mechanisms underlying social smiling during the 6, 8, 10, and 12 postnatal weeks across both sociocultural contexts in detail.

Infants' First Social Smile: Developmental Mechanisms Before 2-Month Shift

Former studies on first infants' smiling argued for an innate mechanisms of its emergence. For example, Freedman (1965) found that identical twins showed greater concordance in the onset of the first visual fixation and smiling than fraternal twins. Moreover, he found that blind infants showed smile at this age as well, although these smiles were rather fleeting (Freedman, 1964). In his later works, (1974) Freedman discussed not only the innateness of smiling but also the role of the social environment and different kinds of stimulations (visual, auditive, tactile), which are necessary to elicit an infant's smile. Later studies showed that the inborn aspects like intermodal and multimodal perception (Bahrick, 2010) or imitation (Bjorklund, 1987) are necessary but not sufficient preconditions for the emergence of the social smiling. The first infant social smile at the beginning of the second month of life is associated with the development of infants' abilities of face perception (Mondloch et al., 1999) as well as with *contextual* (*mutual gazing*) and maternal *affective* (*smiling*) aspects. Bertin and Striano (2006) showed that 6.5-week-olds (but not newborns) are able to discriminate between normal (contingent) and "still-face" interaction with a stranger and showed a decrease in directed gaze (visual attention) and smiling behavior during still-face stimuli presentation. In addition, Lavelli and Fogel (2002, 2005) found a developmental shift in infants toward social attentiveness ("effortful concentration" on the mother's face) at the beginning of the second month of life, which is marked by a strong increase of infants' active engagement and decrease of simple gazing in face-to-face interactions. This concentration is often paired with the emergence of expressive configurations that reflect active and emotionally positive forms of attention, such as smiling and cooing while looking at the mother's face.

The emergence of concentrated attention coincides with infants' gazing while smiling at their mothers' face, which also significantly increases in duration during the second month. Hence, we assume that *mutual gazing* is the first pre-condition for the emergence of infants' first social smile during the sixth week of life.

Furthermore, we assume that *maternal smiling during mutual gazing* represents the second pre-condition for the emergence of infants' first social smile during the sixth week of life, which functions as a *moderator*. Maternal affective behavior is largely defined by attentive gazing at the infant when talking, as well as continuous maternal smiling and sometimes also playing episodes during mutual gazing. During these displays, mother–infant interactions seem to shape the emergence of infants' social smiling in terms of different kinds of infant smile. A "cautious" kind of infant smile (with only the corner of the lips raised) appears at the beginning of face-to-face interactions at around 6 to 7 weeks of age and could indicate less excitement (Messinger, Fogel, & Dickson, 2001). Maternal *continuous* smiling during mutual gazing at this age (not yet selective imitation because of the sparse and light infants' first social smile) supports the adaptive, moderator capability of mothers to changes in their infants' behavior. Mothers regulate their infants' smiling because infants while gazing at their mothers' face start to reciprocate their mothers' smiling behavior during mutual gazing.

Therefore, we hypothesized that the more mothers smile at their infants during mutual gazing, the stronger the positive correlation is between mutual gazing and the duration of infants' social smile during the sixth week of life. We assumed furthermore that the moderator function of maternal smile during mutual gaze should be a universal mechanism in order to contribute to the emergence of social smile.

Infants' Social Smile: Developmental and Sociocultural Aspects from the 2-Month Shift Onward

Between the second and third months of life, important maturational processes arise, such as the decline of subcortical control and the increase of cortical mechanisms for face recognition (Morton & Johnson, 1991), increased alertness (Emde & Buchsbaum, 1989; Kärtner, Keller, & Yovsi, 2010; Wolff, 1987), or changes in infants' face perception and attention (Blass, Lumeng, & Patil, 2007; Wolff, 1963). Lavelli and Fogel (2005) showed that during the end of the second month of life, infants' simple attention to their mothers' face shifts to a dominance of emotionally tinted (expressive) attention to their mothers. In addition, in line with co-constructivist developmental approaches, infants have to experience specific patterns of social interaction with their mothers or caregiver (Camras, 2000; Fogel et al., 1992; Gergely & Watson, 1999; Holodynski & Friedlmeier, 2006; Messinger, Fogel, & Dickson 1997; Stern, 1996). Social smile is, hence, fostered by contingent *infant and maternal smile imitation* during face-to-face interactions (Holodynski & Friedlmeier, 2006), and thus are further conditions that contribute to an increase of infants' social smile during the 2-month shift.

Infant Imitation of Maternal Smile

Bjorklund (1987) ascribed to newborns' imitation a function, which is changing after about the second month. At this age, the "innate" function of newborns' imitation disappears and is replaced by a more "intentional" function of *infants' imitation* because of the infants' controlling over their movements (head-, eyes-, and mouth-control) and directing them toward social stimuli (Anisfeld, 1991; Bjorklund, 1987). Several studies showed that 8- to 12-week-olds are able to discriminate different emotional expressions and respond with their own imitations (Barrera & Maurer, 1981; Haviland & Lelwica, 1987; Samuels & Ewy, 1985; Serrano, Iglesias, & Loeches, 1995).

Moreover, during the 2-month shift, infants' interest in the effects their actions elicit starts to grow. They are sensitive to temporal contingencies between events and develop expectancies for social contingency with regard to the caregivers' reactions from very early on (Nadel, 2002). From the 2-month shift onward, infants are able to adapt to the responsive contingency levels of their mothers. For example, infants of depressed mothers adapt themselves to the low level of their mothers' contingency. As a consequence, even at the age of 3 months, these infants remained relatively unresponsive when interacting with a nondepressive person (see Bigelow, 2009).

Thus, we assume that *infants' imitation* of maternal smile from the 2-month shift onward represents the *first mechanism*, which is linked up with infants social smile. Furthermore, maternal (imitative) contingency while interacting with their infants seems to have an important role during the 2-month shift as well. Mothers contingently adapt their facial, vocal, and tactile expressions as a response to their infants' expressions so that infants notice the effect of their behavior on mothers' behavior (Bigelow, 2009).

Maternal Imitation of Infants' Smile

Caregivers' providing of contingent and expectable responses affects the infants' attention, capacity to learn, memory, as well as social, emotional, and cognitive developmental processes (Beebe & Lachmann, 1994; Bigelow & DeCoste, 2003). Studies of Legerstee and Varghese (2001) and Soussignan, Nadel, Canet, and Geradin (2006) could show that 2- to 3-month-olds who experienced a high degree of maternal imitation of their behavior in daily interactions were able to perceive the difference between life and replay interactional settings and exhibited significantly more smiles if they recognized the distinction between life and replay settings.

Such ongoing regulations represent the principle of "mutual regulation," hence caregivers have "greater range and flexibility in this process" than their infants (Beebe & Lachmann, 1994, p. 134) and therefore provide a moderating path. For example, Legerstee, Markova, and Fisher (2007) found a positive moderator effect of maternal attunement on the relation between the proportion of infant's gaze monitoring with 3 months and infant-coordinated attention with 10 months. Messinger et al., (2001) found that infants' smiling episodes did not increase from the second to the sixth months of life in those time windows in which infants are not gazing at their mothers compared with those time windows in which infants are gazing at their smiling mothers. Furthermore, mother can provide smiling imitation only when the infant is smiling. During the 2-month shift, infants start to smile during face-to-face interactions more often, and thus mothers have much more possibilities to imitate their infants' smile comparing to the previous weeks. At the same time, infants are able to imitate maternal smile during such interactions more often as well. As a result, the duration of infants' social smile increases.

Such dynamic interplay of both mechanisms lets us hypothesize that *caregivers' imitation* of their infants' smile is the *second mechanism*, which is linked up with infants social smile and has a *moderator* effect: The more caregivers imitate their infants' smiles, the more positive the relationship is between infants' imitation of maternal smile and the duration of infants' social smile from eighth week onward.

Sociocultural Aspects of Maternal Imitation of Infants' Smiling

Caregivers' imitative behavior of infants' actions and expressions are strongly bounded to the cultural context in which the infant is growing up. In terms of their ethnotheory, caregivers know and choose what is important to imitate in order to achieve the developmentally causal ends with respect to the social-communicative goals of their community (Keller, 2007). Sociocultural contexts appear to differ regarding parenting ethnotheories and appropriative parental behavioral

strategies, such as face-to-face interactions with mutual gazing that is required for the emergence of the social smile.

Caregivers from *independent* sociocultural contexts in European or North American, industrialized societies (Camras et al., 1998; Keller, 2007) socialize their infants toward autonomy, self-actualizing, and emotional expressiveness. They establish a lot of face-to-face interactions with mutual gazing and accordingly use imitation of their infants' emotional expressions to reinforce and maintain their expression of positive emotions (Fahrman, Mazzaglia, & Jonsson, 1991; Jonsson et al., 2001; Keller et al., 2004; Kokkinaki, 2003; Nadel, 2002). In contrast, caregivers from *interdependent* sociocultural contexts in rural African, Indian, Palestinian, and Bedouin agricultural societies (Feldman, Masalha, & Alony, 2006; Keller, 2007; Kilbride & Kilbride, 1974; Konner, 1976; Landau, 1977) socialize their infants toward relatedness (e.g., obey parents, share with others, and facilitate social harmony), and thus toward the minimization of their infants' negative emotions. Accordingly, they use more proximal parental behavioral strategies (e.g., body contact and body stimulation) to regulate infants' negative emotions and foster a "calm infant" (Kärtner et al., 2010; Keller et al., 2004; Richman, Miller, & LeVine, 1992).

Thus, we assume that the moderator effect of maternal imitation of infant smile, mentioned above, can be found at the age of 8, 10, and 12 weeks only in the Münster sample, but not in the Nso sample because of the minor significance of Nso mothers attribute to mutual gazing and the imitation of their infants' smiling.

Goal and Hypotheses of the Study

The overarching goal of the present study was to examine the interplay of maternal and infant smiling and gazing behavioral patterns during the 6th, 8th, 10th, and 12th postnatal weeks that contribute to an increase of infants' social smile in a sample belonging to an independent sociocultural context, namely, a sample from an urban middle class from Münster, Germany, in comparison to a sample belonging to an interdependent sociocultural context, namely, a sample from a rural society of the Nso, Cameroon. With respect to the above-mentioned developmental changes in the first three postnatal months, we focus our analysis on a time window before the 2-month shift (the 6th week of life) and on a time window after the entrance of the 2-month shift (the 8th, 10th and 12th week of life) and tested two specific hypotheses:

Hypothesis 1: During the 6th week of infants' life, maternal smile during mutual gazing has a moderator effect on the relation between mutual gazing and duration of infant social smile in both cultural contexts.

Hypothesis 2: During the 8th, 10th, and 12th weeks of infants' life, maternal imitation of infant smiling has a positive moderating effect on the relationship between infants' imitation of maternal smile and the duration of infants' social smile in the Münster sample but not in the Nso sample.

Method

Participants

Twenty-four mother–infant pairs from the ethnic Nso group in the village of Kikaikelaki, a rural region around Kumbo, in the northwest province of Cameroon and 20 mother–infant pairs from middle-class families in Münster, a city in the northwest part of Germany[1] participated in the study when the infants were 6, 8, 10, and 12 weeks of age. The mothers in both samples were the primary caregivers of their infants (Keller, 2007; Yovsi, 2003). Infant gender was distributed as follows: 45% girls in Münster and 54% girls in Nso.

There are some differences in sociodemographic features between the two samples, which are, based on our conception of culture, constitutive for the different sociocultural environments (Keller, 2007). Nso mothers were significantly younger (M = 27.40, SD = 8.15 years) than the mothers from Münster (M = 30.70, SD = 3.76 years), $t(42) = 1.67$, $p < .10$, $d = 0.51$. Mothers from Münster had a higher degree of formal education (M = 14.35 years, SD = 3.23) than Nso mothers (M = 8.00 years, SD = 1.91), $t(42) = 8.09$, $p < .01$, $d = 2.45$. All mothers from Münster and only seven of the Nso mothers were first-time mothers. In this sense, we had homogeneous groups with respect to the sociodemographic marker variables that can be regarded as prototypical for each examined sociocultural contexts. The exposure to formal education and the economic resources of the families are inextricably interwoven with the shared systems of meaning and actions, and thus with the practices of everyday life within the family. Because these differences in sociodemographic features are constitutive for the cultures under observation, we do not control for them statistically. As a further consequence, this approach does not allow generalizations about countries or societies as a whole.

Procedure

The mothers were asked to interact freely with their infants for 10 min as they would in their normal daily routines, and there were no instructions to engage in face-to-face interactions. The mothers were asked not to involve other persons for the interaction with the infant, and it was assured that only the mothers were engaged in the interactions. All infants were awake, calm, and fed before the observation, and all interactions were videotaped. We selected a 3-min sequence of each 10-min interaction, beginning with the second minute of each film. Mothers and their infants spent the first minute of each interaction getting familiar with the recording process. Thus, we took always the second, the third, and the fourth minutes of interaction. There were no essential or systematic interruptions (e.g., feeding, sleeping, etc.) during the interactions. So we could ensure that the contingent gazing and smiling behavior of the mothers and infants were accurately observed.

Coding of Infants' and Mothers' Behavior

We conducted a stepwise frame-to-frame microanalysis of 3-min of mother–infant interaction using an INTERACT 9.0.7 software. In the first step, three categories were coded with the exact time of the onset and offset of gazing, smiling, and intensity of smiling.

We used the following codes for *gazing behavior*: (a) gazing at mother/gazing at infant (gaze is focused on the mother's/infant's face), (b) not gazing at mother/not gazing at infant (gaze is not focused on the mother's/infant's face (e.g., gaze away, swivel gaze), and (c) gazing could not be coded (impossible to identify the gaze due to insufficient film quality, face being hidden, etc.).

We coded *smiling behavior* as follows: (a) smile, (b) nonsmile (other facial expressions, except smiling), and (c) smile could not be coded (impossible to identify smiling expressions due to insufficient film quality, face being hidden, etc.), and (d) intensity of smile. We used a 5-point intensity scale for the coding of intensity of infants' and mothers' smiles with regard to the ratings of infants' smile intensities by naïve adult raters: From 1 = *very low-intensity* smile (i.e., low raising or sideways movement of lip corners without eye constriction and cheek raising, with closed mouth) to 3 = *middle intensity* (i.e., clearly distinctive raising or sideways movement of lip corners, mouth can be slightly open, eye constriction, cheeks are clearly raised) to 5 = *very high-intensity* smile (i.e., maximum constriction of eyes with highly raised cheeks, mouth opened, and a very high raising or sideways movement of lip corners). Our intensity coding is based on the results of Bolzani-Dinehart et al. (2005) who found that greater smiling lip corner movement

(Action Unit 12A-E of the BabyFACS (Oster, 2000), eye constriction (AU6) by which the cheeks are raised, and mouth opening (AU25A-E) were rated as more intensive positive emotion.

In the second step, we coded the *frequencies of imitations of maternal smiles by the infant and infant smiles by the mother* with the aid of an integrated design environment (IDE) application Software in Visual Studio 2010, which we developed for scoring these variables. These codes represent a combination between *time* and *event analysis* because our question was whether the maternal or infant imitation occurred within a certain time frame (see as follows) as well as whether it occurred as the very next behavior following the determined criteria (Barratt, Roach, & Leavit, 1992; Sackett, 1979). We coded the *frequencies of imitations* separately for the onsets (increase of intensities) and offsets (decrease of intensities) of maternal/infant intensities of smile. We assume that the direction of contingency influences the infants' learning about the social smiling. The beginning (onsets) and the ending (offsets) of the caregiver's smile shows behavioral changes and leads not only to the infants' experiences to learn the beginning of the emotional states (onsets) but also infants learn the constraints of new contingent experiences, and at the same time they learn the setting down of emotions (offsets) as well (quasi the "boundary of emotion").

We coded *maternal imitation of infants' smiles* when mothers responded within 3 s to the intensification (onset) or reduction (offset) of their infant's smile by intensifying or reducing their own smile during mutual gazing. At the same time, we assured that within this 3-s response, window mutual gazing was constantly maintaining and no further codes (except for the smiling codes) were occurring (e.g., mother's *not gazing at infant* or infant's *smile could not be coded*). In this way, we assured that these maternal responses were the contingent responses to the previous infant's behavior (see Figure 1). Our choice of a 3-s window for maternal responses is based on the results of studies that examined maternal responsiveness with regard to expressive behavior. For example, van Egeren, Barratt, and Roach (2001) showed that response windows within mother–infant interactions are different for diverse behavioral expressions: Vocalizations revealed the shortest response windows (2 s) whereas contingencies for smile signals and responses regularly accrued in a linear fashion for at least 3 s and even longer. Similar results were found by Feldman, Greenbaum, and Yirmiya (1999) in their longitudinal study of 3-, 9-, and 24-month-old infants: The time it took mothers to commence affect-synchronous behavior with their 3-month-old infants (time lag to synchrony) amounted to 2.8 s on average.

We coded *infant imitation* each time the infant responded during mutual gazing within 6 s to the intensification (onset) or reduction (offset) of maternal smile by intensifying or reducing his or her own smile, respectively. At the same time, we assured that within this 6-s response, window mutual gazing was constantly maintained and no further codes (except for the smiling codes) occurred (e.g., infant's *not gazing at mother* or infant's *smile could not be coded*). In this way, we interpreted the beginning/intensification or ending/reduction of the infant smile as contingent responses to the previous maternal smile behavior (see Figure 1).

We used a longer response window for infants than for mothers for several reasons. First, in the above-mentioned study of van Egeren et al. (2001), the number of infants' smiling responses to maternal smiles decreased only after 4 s. These infants were already 4 months old. Second, there are not only behavioral findings, mentioned above, but also physiological indicators with respect to the longer reaction time of infants' expressive behavior at this age. Brock, Rothbart, and Derryberry (1986) analyzed smiling responses of 3-month-old infants to social stimulation and found that smile occurred after a heart-rate deceleration that lasted for 3.6 s on average ($SD = 2.6$). These findings are very similar to the results reported by Sroufe and Waters (1976) as well as of Beebe and Lachmann (1994), who found a 5-s heart-rate deceleration. Third, we wanted to take into account individual differences in the typical response windows of mother–infant dyads as well as infants' temperamental patterns (see Fox, 1998).

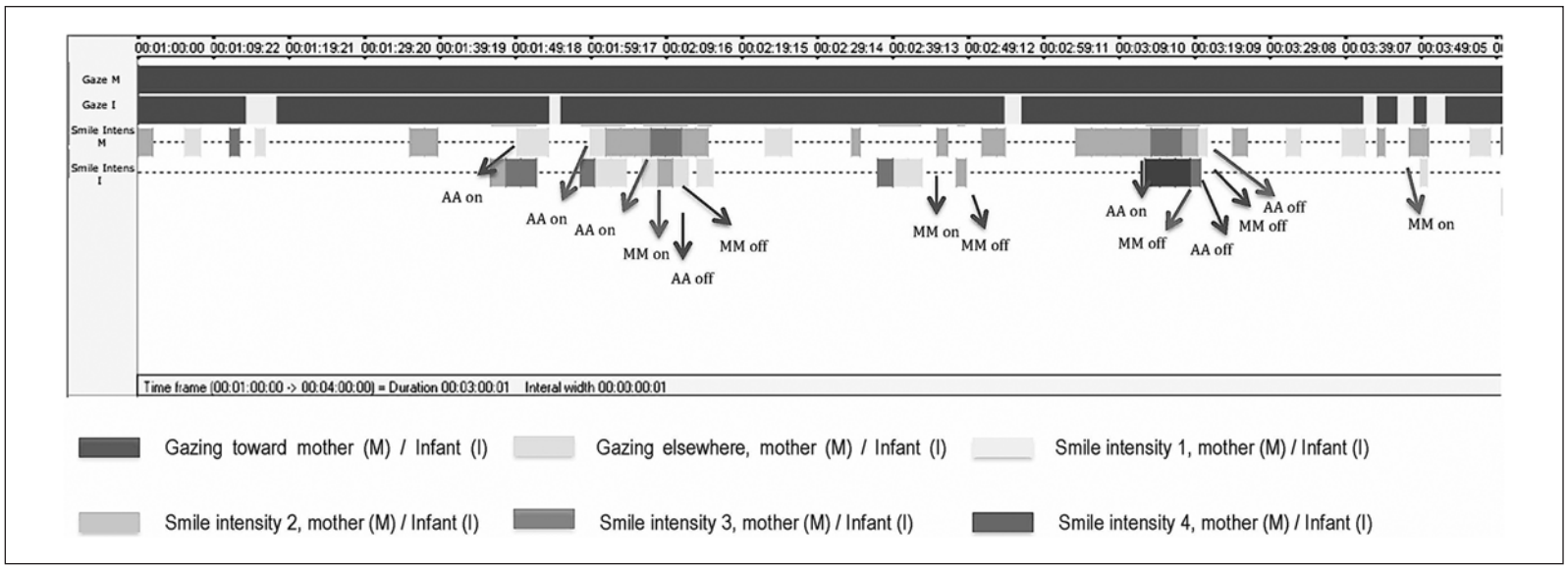

Figure 1. Coding of maternal and infant imitation behavior. The figure represents an original interact graph. The upward-pointing arrows show how the codes were defined. "AA on/off" means that mother imitates the beginning (on) or the ending (off) of infant smile. "MM on/off" means that infant imitates the beginning (on) or the ending (off) of maternal smile.

Interrater Reliability and Final Variables

To calculate the interrater reliability, 23% of the 176 video sequences (44 Pairs × 4 time points) with an equal distribution of sociocultural contexts and infants' ages were coded by two independent coders. Each of the six categories (gazing, smiling, and smiling intensity separately for infants and mothers) were coded by two different coders. We calculated Cohen's Kappa by using the INTERACT evaluation tool for each mother–infant pair in each category. We set two criteria for the matching of events: The onset of each event recorded by both coders should occur within 1 s and should have an overlap of 85% between both events. From a total of 240 Kappa values [40 pairs (23% of 176 sequences) × 6 categories], 159 kappa values exceeded 0.8 and 74 values were between 0.6 and 0.8 and only 7 values were between 0.5 and 0.6. Therefore, 63% of the codes reached a very good interrater reliability and 31% of the codes a good reliability.

As the final scores, needed for our preliminary analyses, we used two types of variables: *Duration* and *frequency*. Because the "*could not be coded*" category for the smiling and gazing behavior was unequal in each mother–infant interaction, we calculated adjusted percentage values of all *duration variables* concerning the duration of noncoded events. During this step, the duration of noncoded events for each variable was subtracted from the total session time (3 min) during the calculating of duration scores. For example, the percentage adjusted value of mutual gazing duration: $(A / (B - C)) \times 100$, where A = total mutual gazing duration in seconds, B = duration of the total interaction (180 s), and C = duration of noncoded mutual-gazing episodes in seconds. The frequency scores represented the absolute numbers of episodes without any adjustment.

In this way, the following duration and frequency scores were calculated for each age (6, 8, 10, and 12 weeks):

1. Percentages of mutual gazing expressed as a proportion of total session time (%)
2. Percentages of maternal smile during mutual gazing expressed as a proportion of total session time (%)
3. Percentages of infant social smile during mutual gazing expressed as a proportion of total session time (%)
4. Frequencies of maternal imitation (absolute number for onset- and offset-imitations together)
5. Frequencies of infant imitation (absolute number for onset- and offset-imitations together)

Finally, to testing our research questions and to examine the interplay of both mechanisms at infant social smile in *both* sociocultural contexts, we decided to relativize all the duration and frequency variables described above at the duration of mutual gazing for each pair and interaction accordingly, to get the final variables for our regression analyses. For example, the percentage adjusted value of *duration of infant social smile:* $A / B \times 100$, where A = percentages of infant social smile during mutual gazing and B = percentages of mutual gazing. One exception was the variable "duration of mutual gazing," which could not be relativized and is left the same one from the preliminary analyses (percentages of mutual gazing). Through such an adjustment, we could compare sociocultural contexts with a very different occurrence of face-to-face interactions, as was the case for our samples, and test whether the above-mentioned mechanisms have comparable effects on the emergence of the social smile in sociocultural contexts with different occurrences of face-to-face interactions. Therefore, we used the following final variables as dependent variables, predictors, and moderator variables in the regression analyses:

1. *Duration of infant social smile* (dependent variables)—expressed as a proportion of the duration of mutual gazing (%)
2. *Duration of mutual gazing* with 6 week (predictor)—expressed as a proportion of total session time (%)

3. *Duration of maternal smile during mutual gazing* with 6 week (moderator variable) — expressed as a proportion of the duration of mutual gazing with 6 week (%)
4. *Frequencies of infant imitations* with 8, 10, and 12 weeks (predictors)—number for onset- and offset-imitations together expressed as a proportion of the duration of mutual gazing with 8, 10, and 12 weeks (%)
5. *Frequencies of maternal imitations* with 8, 10, and 12 weeks (moderator variables)—number for onset- and offset-imitations together expressed as a proportion of the duration of mutual gazing with 8, 10, and 12 weeks (%)

Statistical Analyses

First, we provided preliminary analyses on maternal and infant smiling and gazing behavior in both sociocultural contexts in order to analyze the age-related changes through all the four examined weeks. We computed repeated measures analyses of variance (ANOVAs) with age (6, 8, 10, 12 weeks) as a within-subjects factor and cultural context (Münster, Nso) as a between-subjects factor. To analyze the time course of age-related changes, we reported linear contrasts by age and age × cultural context interactions for each analysis. In case of significant interactions, we computed separate one-way ANOVAs of polynomial age trends for each cultural group.

Second, to test our hypotheses, eight linear multiple regression analyses for each week and cross-cultural context were conducted with *duration of infant social smile* as dependent variable. To test the significance of moderator effects, we computed an interaction term between the predictor and moderator variables, respectively, for each week. For the sixth week, we used the *duration of mutual gazing* as predictor variable and *duration of maternal smile during mutual gazing* as moderator variable. For the 8th, 10th, and 12th week, we used the *frequency of infant imitations* as predictor variable and *frequency of maternal imitations* as moderator variable. In order to keep in mind the problem of multicollinearity caused by the interaction term, we centered the predictor variable for each of the eight regression analyses and controlled the VIF (Variance Inflation Factor) scores that should not be higher as 10. When a significant interaction term was found, its quality was clarified by calculating the dependent scores (*duration of infant social smile*) at values one *SD* below and above the mean for the predictor variable (Cohen, Cohen, West, & Aiken, 2003). Simple slope tests were performed after partialing out additional covariates from all the variables involved in the interaction analysis (O'Connor, 1998).

Results

Preliminary Analysis

Descriptive statistics for durations of maternal and infant gazing and smiling behavior during mutual gazing and frequencies of infant and maternal imitations (adjusted scores) for both sociocultural contexts and all the weeks are presented in Table 1.

There was a main effect of cultural context for all the variables (see Table 1). In addition, for the "duration of infant social smile," there was a significant linear increase with age, $F(1, 42) = 6.02$, $p < .05$, $\eta^2 = .12$ and a marginally significant linear contrast for the interaction between cultural context and age, $F(1, 42) = 3.74$, $p < .10$, $\eta^2 = .08$. Looking at the two cultural contexts separately, one-way (age) ANOVAs of age trends yielded a significant linear increase of the duration of infant social smile with age for the Münster sample, $F(1, 19) = 5.14$, $p < .05$, $\eta^2 = .21$, but not for the Nso sample, $F(1, 23) = .362$, $p = .55$, $\eta^2 = .02$.

For the "frequency of maternal imitations," there was a significant linear increase with age, $F(1, 42) = 7.38$, $p < .05$, $\eta^2 = .15$, and also a significant linear contrast for the interaction between cultural context and age, $F(1, 42) = 5.51$, $p < .05$, $\eta^2 = .12$. Subsequent one-way ANOVAs of age for each

Table 1. Means (*SD*) of Maternal and Infant Gazing and Smiling Behavior in Both Sociocultural Contexts and Inference Statistic of Main Effects of Cultural Contexts.

	6th week	8th week	10th week	12th week	$F_{(1, df)}$	*p*	η^2
Duration of mutual gazing (%)							
Münster	29.97 (33.27)	42.82 (35.65)	39.22 (36.83)	38.75 (31.62)	$33.20_{(1, 42)}$	<.001	.44
Nso	14.25 (23.58)	8.58 (17.27)	10.20 (19.21)	7.94 (14.91)			
Duration of maternal smile during mutual gazing (% of total interaction)							
Münster	11.67 (22.43)	23.81 (29.15)	20.08 (22.84)	20.48 (18.17)	$10.84_{(1, 42)}$	<.01	.21
Nso	9.12 (19.05)	6.12 (14.18)	7.99 (15.91)	6.15 (12.80)			
Duration of infant social smile (% of total interaction)							
Münster	2.61 (8.08)	10.95 (21.56)	10.10 (11.34)	13.32 (15.15)	$18.14_{(1, 42)}$	<.001	.30
Nso	1.46 (5.82)	2.06 (5.19)	3.08 (6.20)	2.35 (5.93)			
Frequencies of maternal imitations (absolute number for both onset- and offset-imitations)							
Münster	0.85 (1.95)	3.25 (6.29)	3.60 (5.39)	4.35 (4.74)	$16.37_{(1, 42)}$	<.001	.28
Nso	0.50 (2.45)	0.37 (1.01)	1.17 (3.33)	0.50 (1.10)			
Frequencies of infant imitations (absolute number for both onset- and offset-imitations)							
Münster	0.70 (2.00)	3.15 (6.07)	4.05 (5.01)	3.9 (4.27)	$9.17_{(1, 42)}$	<.01	.18
Nso	0.58 (2.65)	0.92 (2.20)	1.58 (3.51)	0.83 (1.88)			

cultural context yielded only a significant linear increase with age for the Münster sample, $F(1, 19) = 7.28$, $p < .05$, $\eta^2 = .28$, but not for the Nso sample, $F(1, 23) = .152$, $p = .70$, $\eta^2 = .01$.

For the "frequency of infant imitations," we found a significant linear increase with age, $F(1, 42) = 7.35$, $p < .05$, $\eta^2 = .15$, and also a significant linear contrast for the interaction between cultural context and age, $F(1, 42) = 4.27$, $p < .05$, $\eta^2 = .09$. Analyzing both cultural contexts separately, one-way ANOVAs of age trends yielded a significant linear increase with age only for the Münster sample, $F(1, 19) = 8.08$, $p < .05$, $\eta^2 = .30$, but not for the Nso sample, $F(1, 23) = .30$, $p = .59$, $\eta^2 = .01$.

Taken together, mutual gazing and maternal smile with mutual gazing lasted significantly longer in the Münster sample than in the Nso sample. Moreover, from the 6th to the 12th week of age, only the infants of the Münster sample showed a linear increase of their smiling duration during mutual gazing and of their frequency of smiling imitations, whereas Nso infants showed no age trends. We found a similar age-related increase for maternal smile imitations only for the Münster mothers but not for the Nso mothers.

Maternal Smile During Mutual Gazing as a Moderator at the Sixth Week of Age

Table 2 shows the results of the moderator analyses at each week respectively.

For the sixth week, we assumed that maternal smile during mutual gazing (MS) has a moderator effect on the relation between the duration of mutual gazing (MG) and infant social smile during mutual gazing in both cultural contexts. The results of regression analysis show significant changes in R^2 due to the interaction term (Münster: $R^2_{Block1} = .35$, $R^2_{Block2} = .60$, $R^2_{Block3} = .73$; Nso: $R^2_{Block1} = .64$, $R^2_{Block2} = .64$, $R^2_{Block3} = .81$) and positive βs in both sociocultural contexts. Multicollinearity analysis showed very good VIF scores for all predictors, the biggest VIF scores were 1.7 in Münster and 2.5 in Nso sample, which is considerably smaller as 10. Simple slope tests indicated that only the slopes corresponding to a longer duration of maternal smile (called "high" in Figure 2) with mutual gazing in the Nso ($t_{10} = 6.19$, $p < .001$) and in the Münster sample ($t_{12} = 2.42$, $p < .05$) differed significantly from zero. Figure 2 depicts interaction effects for both samples, Münster and Nso.

Table 2. Results of Cross-Sectional Moderator Analysis of Maternal Behavior on the Duration of Infant Social Smile in Both Sociocultural Contexts.

	Münster sample				Nso sample			
Predictors[a]	β	*t*	$\Delta R^{2\,b}$	ΔF	β	*t*	ΔR^2	ΔF
6th week of age		n^c = 16				*n* = 14		
Mutual gazing (MG)	.18	.96	.13*	6.05	.31	1.42	.17*	9.01
Maternal smile during MG (MS)	.45*	2.32			.27	1.67		
Interaction MG × MS	.42*	2.46			.61*	3.00		
8th week of age		*n* = 19				*n* = 13		
Infant imitation of smile (ISI)	.80**	7.62	.03**	11.61	.78*	2.95	.00	.00
Maternal imitation of smile (MSI)	−.08	−.66			.27	.83		
Interaction ISI × MSI	.31**	3.41			.01	.03		
10th week of age		*n* = 18				*n* = 15		
Infant imitation of smile (ISI)	.79**	3.59	.18*	5.21	.67*	2.54	.08	1.88
Maternal imitation of smile (MSI)	−.03	−.16			.18	.74		
Interaction ISI × MSI	−.47*	−2.28			.33	1.37		
12th week of age		*n* = 17				*n* = 13		
Infant imitation of smile (ISI)	.55**	3.12	.00	.36	.75**	3.40	.15*	6.09
Maternal imitation of smile (MSI)	.39*	2.24			.51*	3.20		
Interaction ISI × MSI	−.07	.56			.46*	2.47		

[a]All predictors and dependent variables were adjusted to the duration of mutual gazing.
[b]The change in R^2 due to the interaction term.
[c]Participants who met the inclusion criteria: At least one episode of mutual gazing.
*$p < .05$. **$p < .01$.

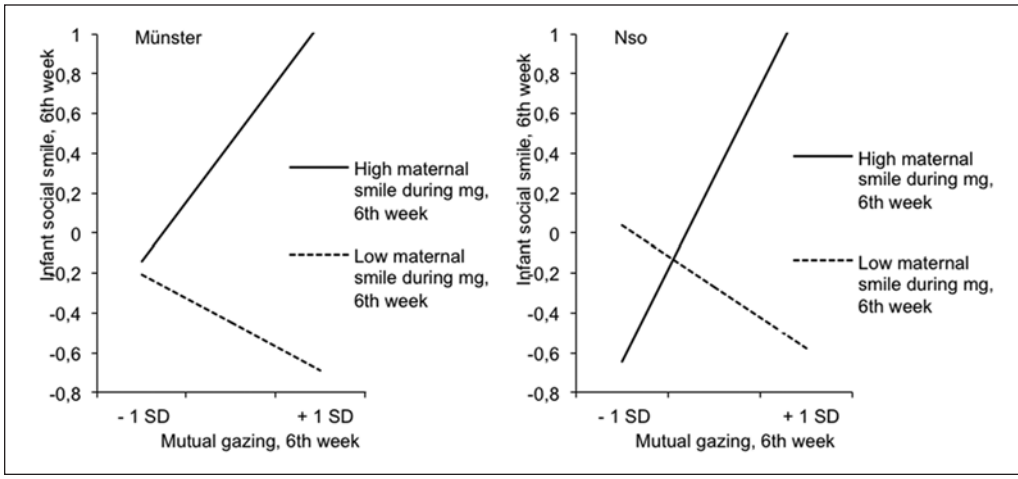

Figure 2. Moderator effect of maternal smile during mutual gazing on the relation between mutual gazing (mg) and the duration of infant social smile at six weeks of age for the Münster and the Nso sample.

Thus, at the age of 6 weeks, the relation between mutual gazing and infant social smile is stronger when mothers smiled longer at their babies during mutual gazing. This result confirms our first hypothesis.

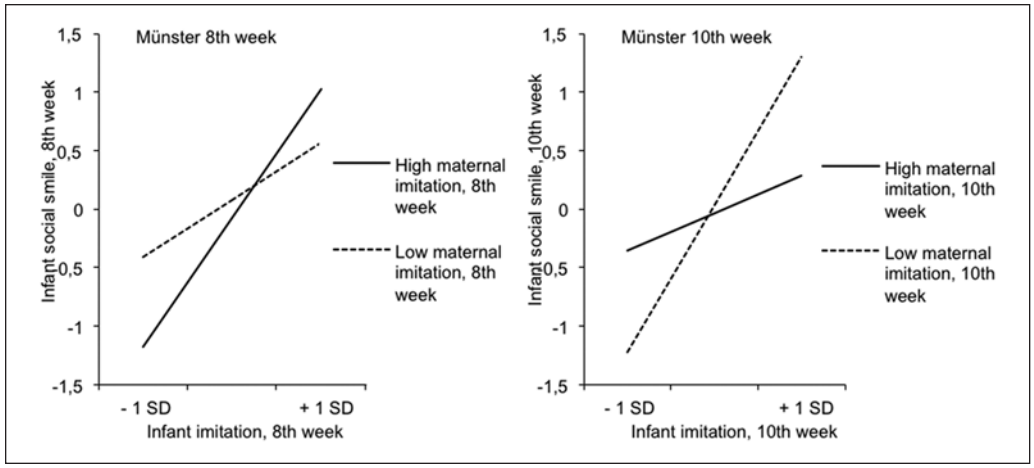

Figure 3. Moderator effect of maternal imitation (frequency) on the relation between infant imitation (frequency) and the duration of infant social smile at 8 respectively 10 weeks of age in the Münster sample.

Maternal Imitation of Infant Smiling as a Moderator During the 8th, 10th, and 12th Weeks

Our second hypothesis refers to a culture-specific differentiation: From the 2-month shift onward, mothers' imitation of their infants' smiling during mutual gaze has a moderator effect, which amplifies the positive relation between infants' imitation of their mothers' smiling and the duration of their smiling at their mothers, for the Münster sample but not for the Nso sample. The results show a kind of differential pattern not only for the age (in weeks) but also for the sociocultural contexts (see Table 2).

Münster Sample

The results of regression analysis showed only significant changes in R^2 due to the interaction term and βs at the 8th and 10th week of age (8th week: $R^2_{Block1} = .91$, $R^2_{Block2} = .92$, $R^2_{Block3} = .95$; 10th week: $R^2_{Block1} = .34$, $R^2_{Block2} = .35$, $R^2_{Block3} = .53$). Figure 3 demonstrates the interaction between infant and maternal imitation on the duration of infant smiling at the 8th and 10th week. Multicollinearity analysis showed good *VIF* scores for all the predictors at the 8th week, the biggest *VIF* score was 4.5 and very good *VIF* scores for all the predictors in 10th week, the biggest *VIF* score was 1.4.

Week 8. Tests indicated that slopes linked to low ($t_{15} = 4.40$, $p < .005$) and high ($t_{15} = 9.19$, $p < .001$) degree of maternal smile imitation frequency differed significantly from zero. Thus, the frequency of infant smiling imitation of maternal smiles is generally related to the duration of infant social smile regardless of the frequency of maternal smile imitation: Infant smiling imitation and duration of his or her smiling during mutual gazing were more positively associated among those infants who experienced high frequencies of maternal smile imitation.

Week 10. The negative β for the interaction term indicates the reversal of the moderator effect of maternal imitation. Simple slope tests indicated that only slopes linked to a low ($t_{14} = 3.62$, $p < .005$) frequency of maternal smile imitation differed significantly from zero. As Figure 3 shows, only low frequencies of maternal imitation of infant smiling has a strengthening effect on the relation between infant imitation and infant social smile but not a high frequency.

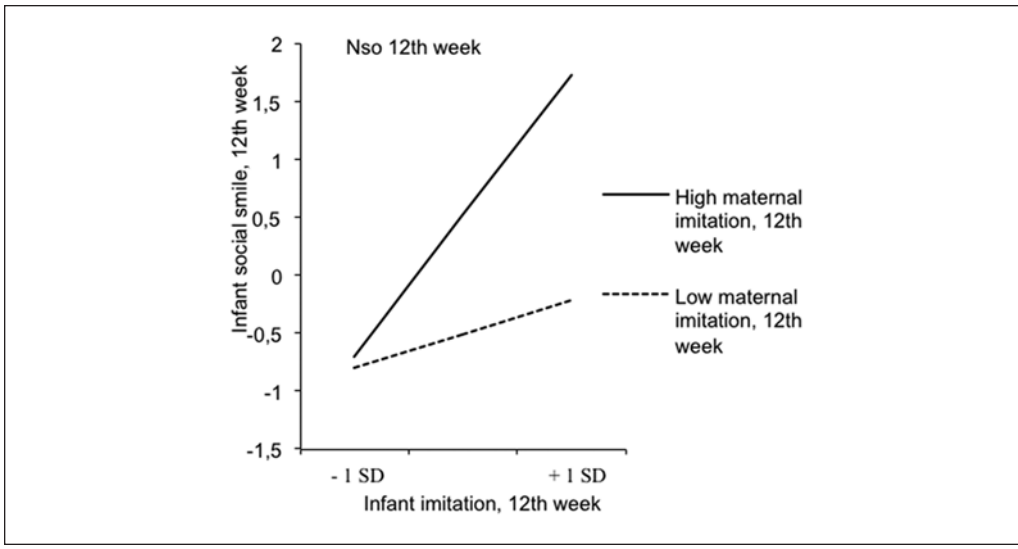

Figure 4. Moderator effect of maternal imitation (frequency) on the relation between infant imitation (frequency) and the duration of infant social smile at 12 weeks of age in the Nso Sample.

Week 12. We did not find any significant change in R^2 (R^2_{Block1} = .75, R^2_{Block2} = .82, R^2_{Block3} = .82) and β due to the interaction term in the Münster sample. Rather both predictors—infant and maternal imitation—have an independent influence on the duration of infant smiling at the 12th week, as both significant βs show.

Nso Sample

Weeks 8 and 10. We did not find any significant effects for the interaction term between infant and maternal smile imitation at both age. However, the significant βs of infant smiling imitation at both weeks indicate its sole influence on the duration of infant social smile during mutual gazing (see Table 2).

Week 12. We found a significant change in R^2 (R^2_{Block1} = .34, R^2_{Block2} = .63, R^2_{Block3} = .78) due to the interaction term and β for the 12th week of age. Multicollinearity analysis showed very good *VIF* scores for all the predictors, the biggest *VIF* score was 1.5. *t* Tests indicated that only slope linked to high (t_9 = 3.63, $p < .05$) frequency of maternal smile imitation differed significantly from zero. Thus, infant smiling imitation and the duration of infant social smile are more closely associated among those infants whose mothers showed high frequencies of smiling imitation. Figure 4 represents the slopes of interaction.

Summing up, the results of our week-per-week analysis confirmed our second hypothesis only partly. We found a positive moderating influence of maternal imitation of infant smiling on the relation between infant imitation and infant social smile at the 8th week in the Münster sample but not in the Nso sample. Thus, the hypothesis for the 8th week was fully confirmed. We found a negative moderating influence of maternal imitation of infant smiling on the relation between infant imitation and infant social smile at the 10th week in the Münster sample and again no moderator effect in the Nso sample. Thus, the hypothesis for the 10th week was confirmed only partly. The results of the 12th week in the Münster sample demonstrate the independent influence of both maternal and infant imitation on the duration of infant social smile, whereas in the Nso

sample, we found a positive moderating influence of maternal imitation of infant smiling on the relation between infant imitation and infant social smile at the 12th week. Thus, the hypothesis for the 12th week was not confirmed. Figure 5 represents the overall results of our analysis.

Discussion

The purpose of the study was to examine in detail how and which mechanisms contribute to the emergence of infants' social smile at the 6th, 8th, 10th, and 12th week of age cross-culturally. To address this issue, we tested our hypotheses using samples from two different sociocultural contexts: one oriented toward autonomy (Münster sample) and the other toward relatedness (Nso sample). Both cultures differed with respect to features of the mother–infant interaction. Additionally, we provided our analyses with respect to two different developmental periods in the first three months of infants' life, namely, before the 2-month shift, at the 6th week of age, and after the 2-month shift, at the 8th, 10th, and 12th weeks of age. We analyzed both sociocultural contexts separately. To base our examination on comparable conditions in both contexts, we adjusted all the variables to the duration of mutual gazing at each age accordingly. We found culture-specific developmental pathways for the development of infants' social smile.

As we assumed for the sixth postnatal week in our first hypothesis, maternal smile during mutual gazing has a moderator effect on the relation between mutual gazing and duration of infant social smile in both sociocultural contexts. Simple slope analysis showed that infants of those mothers, who smiled longer during mutual gazing, have also longer duration of smiling during mutual gazing. Based on these results, we can surely assume that at this developmental stage, mutual gazing in connection with maternal smile during mutual gazing play an essential role for the further development of infants' social smile cross-culturally. It is consistent with the assumption of the internalization model of emotional development (Holodynski & Friedlmeier, 2006) that maternal smile at this age is a necessary premise for the emergence of infant's social smile cross-culturally.

In our second hypothesis, we assumed that from the 2-month shift onward, thus, during the 8th, 10th, and 12th weeks of age, infants' imitation of maternal smile is related to the increase of their social smile. In addition, maternal imitation of infants' smiling has a moderator effect on this connection in order to strengthen it during the 8th, 10th, and 12th week of age. In line with the parental behavioral strategies regarding dominant face-to-face interactions with mutual gazing, we expected to find this effect only for the Münster sample. Our hypothesis was only partly confirmed. We found differential developmental paths of social smile in both sociocultural contexts, respectively.

During the eighth week, we found a moderator effect of maternal imitation on the relation between infants' smiling imitation and duration of infants' social smile in the Münster sample. Simple slope analysis showed that the connection between infants' imitation of their mothers' smiling and the duration of infants' social smile was stronger for those mothers who are highly imitative of their infants' smiling. In Nso sample, only infants' imitation of maternal smile was linked up with the duration of their social smile. The moderator effect of maternal imitation was not found here. Thus, our hypothesis for the eighth week was fully confirmed.

During the 10th week of age, we found a moderator effect of maternal imitation on the relation between infants' smiling imitation and duration of infants' social smile in Münster sample as well. However, simple slope analysis showed that only infants of those mothers, who have a low level of imitation of their infants' smiling, have a stronger connection between imitation of their mothers' smiling and duration of social smile. This is a reversal result to our assumption. In the Nso sample, we found again only infants' imitation of maternal smile as a predictor for the duration of social smile; the moderator effect of maternal imitation was not found here at the 10th week. Thus, our hypothesis for the 10th week of age was confirmed only partly: It was not

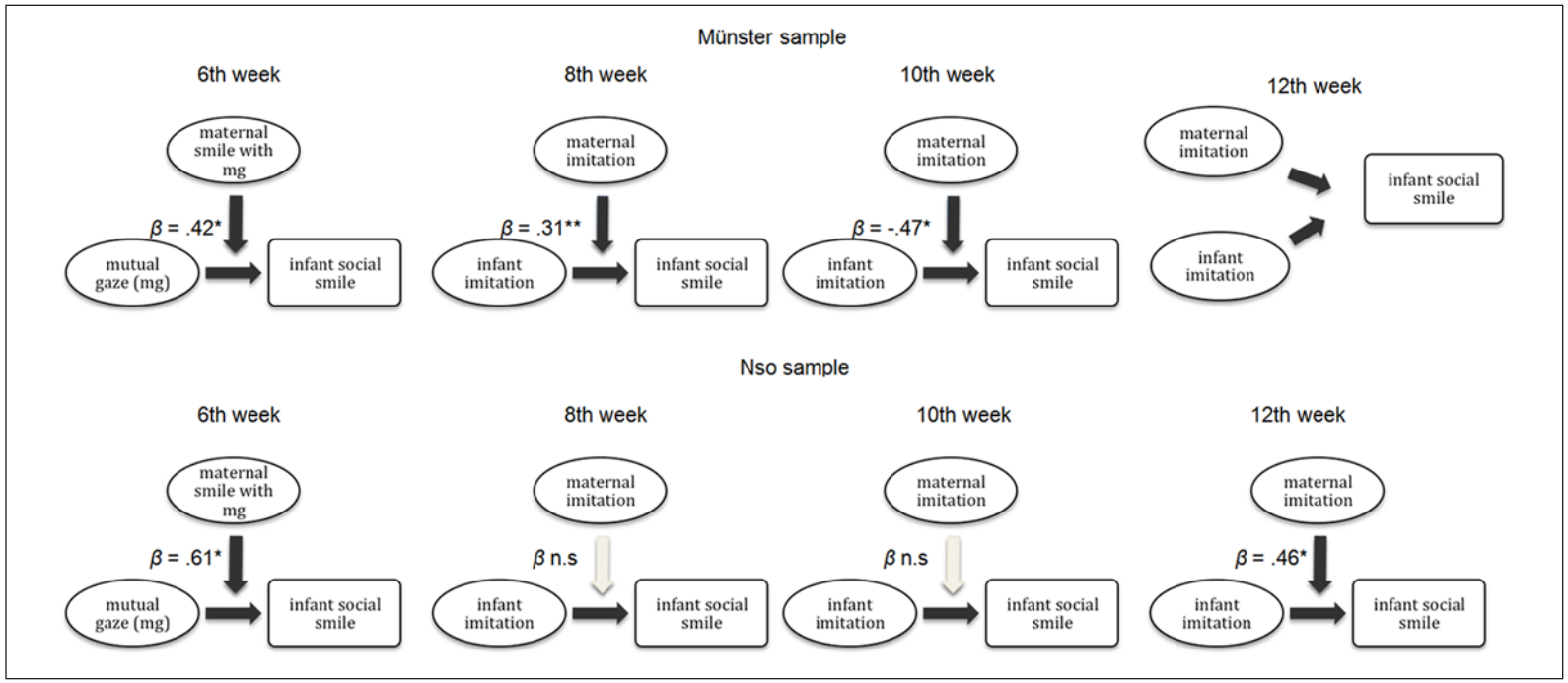

Figure 5. The timeline of interplay models of maternal and infant imitations in both sociocultural contexts.
*$p < .05$. **$p < .01$.

corroborated for the Münster sample because of the reversal (negative) moderator effect of maternal imitation here, but it was confirmed for the Nso sample because of the absence of moderator effect of maternal imitation here as expected.

Finally, during the 12th week of age, we no longer found a moderator effect of maternal imitation of infants' smiling in the Münster sample. Now, both mechanisms, infants' imitation of maternal smile and maternal imitation of infants smiling, represent independent predictors, which contribute to the duration of infants' social smile in the Münster sample. However, we first found a moderator effect of maternal imitation on the relation between infants' smiling imitation and duration of infants' social smile in the Nso sample. Simple slope analysis showed that only infants of those mothers, who have a high level of imitation of their infants' smiling, have a stronger connection between imitation of their mothers' smiling and duration of social smile. This is contrary to our hypothesis because we expected to find this effect in Münster sample and not in Nso sample. Thus, our hypothesis for the 12th week of age was not confirmed at all.

Summing up the results of our analysis, both sociocultural samples of our study have a similar emergence of the social smile at the sixth week of age. The first social smile of infants appears during mother–infant mutual gazing across different sociocultural contexts. Maternal smile during such interactions plays a reinforcing role for the infants smiling at this age. Note that the duration of infants' social smile at this age is very small.

The picture is changing during the 2-month shift. From the eighth week upward, there are culturally differential developmental pathways of infants' social smile (see Figure 5). Infants' imitation in the Nso sample seems to be the only observed mechanism that is related to the duration of social smile at the age of 8 and 10 weeks. In spite of the absence of the moderator effect of maternal imitation in Nso sample, Nso infants showed the social smile as well but much shorter than the same-aged infants from Münster (a proportion of ca. 1:4; see Table 1). This result is consistent with previous research with regard to infant imitation as one of the most essential forms of social learning in infancy, which can be found all over the world. It provides a basis not only for sociocommunicative development such as a foundation for understanding the mind of others (Meltzoff, & Williamson, 2010) but infant imitation also represents an essential feature of emotional development (Hess, Philippot, & Blairy, 1999; Holodynski & Friedlmeier, 2006). Even so, the continuous low duration of infants smiling during mutual gazing in the Nso sample implies that infants' imitation alone is not enough for the further increase of social smile that can be observed in many cultures and also in our Münster sample.

In the Münster sample, in turn, maternal imitation has a reinforcing effect on the relation between infant imitation and duration of infant social smile during the eighth week of age. It supports the assumption of the internalization model of emotional development (Holodynski & Friedlmeier, 2006), which is that maternal imitation is the second mechanism, after infant imitation, needed for an increase of positive emotions in early infancy. The process of mutual amplification, described in Lavelli and Fogel (2005), could maintain the possible explanation for this result. They showed that during the second month, a significant increase in maternal positive expression of emotions, such as maternal talk and smile, parallel developmental changes in the infants' patterns of attention and emotion during face-to-face interactions. The infants experience a positive feedback by the

> tension produced by intense looking and, at the same time, by the pleasure of getting emotional information from the mother's face. This sequence reveals a process of mutual amplification between receptive (effortful attention) and approaching (smile and cooing expression) patterns of attention and emotion, each supporting and enhancing the other through cyclical iteration. (p. 276)

The question, however, remains why there is a reversal moderator effect of maternal imitation at the 10th week of age in the Münster sample. Perhaps such results could be explained in line

with the idea of infants' contingency perception and still-face paradigm (Tronick, Als, Adamson, Wise, & Brazelton, 1978): The infants begin to socially bid for the mothers' smiles by smiling more, especially when mothers imitate less their infants' smiling (e.g., low imitative smiling mothers), like is seen in the still-face task when mothers are unresponsive during the still-face phase. For example, Ekas, Haltigan, and Messinger (2013) found that infants showed gazing and smiling behaviors at their parent (at least more at the beginning) of the still-face phase.

Another argument for a negative moderator effect of maternal smiling imitation in this population might indicate that infants in Münster sample exhibit the first signs of coyness already at this age, which is linked up with *smiling gaze aversion* (Reddy, Hay, Murray, & Trevarthen, 1997). Such smiling gaze aversion has been found from about 10 weeks of age and has a function of a briefly controlling the strong positive affect aroused in the infant by the familiar others during face-to-face interactions, mutual gazing, and positive emotionality of others toward the infants (Reddy, 2000; Reddy et al., 1997). It could also mean that the development of the early perceptual awareness of the other's attentiveness to the self emerges at this age (Reddy et al., 1997).

Further possible explanation regarding the reversal moderator effect of maternal imitation in these infants could be the findings of Lavelli and Fogel (2005). They found the copresence and overlapping of different patterns of infant and maternal attention and emotion over the second and third months of life. For example, the relation between "infant simple attention to the mother's face" and "infant neutral expression gazing elsewhere" could be found during the first month and, although much less, it could be still found during the second month as well. In addition, during the second month, there was a new relation, namely, between "infant simple attention to the mother's face" and "infant concentrated attention to the mother's face." These suggest that developmental changes, regarding the infant's attention and emotion, might be better explained by overlapping developmental patterns rather than by a sudden disappearance of old or simple and sudden appearance of new or more complex developmental patterns (Lavelli & Fogel, 2005). A possible explanation for the negative moderator effect in our Münster sample could be that infants are still used to imitate the maternal smiling with their "old tempo," but at the same time (with progressing cognitive development), they also start to smile before their mothers do, in order to induce maternal smiling. May be such overlapping leads to fewer infants' imitation of maternal smiling, however, causes more infants' smiling prior to their mothers' smile.

Finally, a developmental shift appears to occur at the 12th week in both contexts. The interplay of both imitation mechanisms is changing toward their independent influence on infant social smile in the Münster sample, and the maternal imitation of infant smiling assumed a moderating shape in Nso sample firstly at this age. Keller and Otto (2009) found that Nso mothers expect the emergence of joy in their infants approximately at six months of age. It could explain the later onset of maternal imitation of infants' smile in Nso mothers (with 3 months of age) comparing to the Münster mothers (with 2 months of age). Even so, the duration of infant social smile at the age of 12 weeks is still longer (and even increased) in the Münster sample than in the Nso sample. It seems like mother–infant interactions in Münster sample become more flexible (less rigidly organized) at this age, "mother and infant are more likely to overlap in their general affective state but are less likely to begin and end their behavior in relation to some specific state change in each other" (Fogel, 1982, pp. 60-61). Kaye and Fogel (1980) argued,

> as the infant's behavior becomes more highly organized—clusters develop and gazing and smiling grow functionally independent—the infant becomes less dependent on the mother's initiations. The mother's behavior seems to create a background or "frame" that affects the occurrence of the infant's behavior. (as cited in Fogel, 1982, p. 61)

It means that infants with the age of 6 months are able to take initiative in the social situation and to regulate internal arousal in that situation (Fogel, 1982). The authors spoke about the 6

month of life, whereas our results in Münster sample hints that this process could occur much earlier, at 3 months of age. Moreover, the age period in infancy around the third month is the transitional shift from attention to self and the perfect intersensory redundancy to a greater attention to social partners and the partially contingent, turn-taking structure of social interaction (Bahrick 2010, p. 142). It supports further findings that 12-week-olds discriminate different emotional expressions, attractiveness, and recognize familiar faces (Barrera & Maurer, 1981; Samuels & Ewy, 1985; Serrano et al., 1995).

In conclusion, we can say that results of the study demonstrated differential developmental pathways of infants' social smile during the first three months of life. Such differential development is associated with culture-specific mother–infant interactional patterns, which influence the maternal emotional behavior during face-to-face interactions toward their infants, and thus the emergence of infants' social smile. Further empirical studies should consider that the caregivers' affective behavior represents an essential moderating mechanism, which requires not only a contingent and repetitive "succinct" presentations of the infant's rudimentary and unfocused affect-expressive displays but is also crucially embedded in the eco-cultural environment and its care-giving processes. Thus, culture-specific caregivers' interpretations of and expectations concerning infants' expressive behavior lead to culture-specific infant-caregiver interactions, which, in turn, influence the infants' socioemotional development.

Limitations of the Study

There are several ongoing questions, which we could not answer in the present study. First, the present study represents time-repeated observations and the analyses require large samples. Our sample sizes were relatively small so that the results should be interpreted with caution. First of all, we used larger time windows for the contingent reactions of mothers and infants as those that are usually used in the literature (1 s). Further studies with larger sample sizes should be conducted in order to prove, on one hand, the distribution of both maternal and infant contingent reaction times in different sociocultural contexts and, on the other hand, if the effects would be the same with the smaller time windows. Furthermore, we did not examine the exact developmental trajectories in each sample. For the further studies, it would be useful with the aim of the bigger sample sizes to determine the dyads' subgroups with regard to the peak of social smile and prove the influence of both maternal and infant imitations on the emergence of social smile at the peak longitudinally and cross-culturally.

Second, we examined only maternal smile and maternal smile imitation as precursor mechanisms, which essentially contribute to the emergence of infant smiling in both sociocultural contexts. But exact mechanisms underlying infant smiling in Nso sample apart from infants' imitation remain still unknown. According to Sroufe's (1996) Tension Modulation Hypothesis, the emergence of infants smiling could be triggered by contingency experiences not only in face-to-face contexts but also in the contexts of other modalities such as body contact, body stimulation, vocalizations, and so on. For example, there are evidences that special type of intersensory redundancy, namely, human faces together with human voices and movement tend to be a powerful elicitor of infants' attention and information processing at this developmental stage (Bahrick & Lickliter, 2002; Vaughan van Hecke, & Mundy, 2010). Further cross-cultural analysis of the influence of such contingencies and their combinations, on the emergence of infant smiling, could be useful in order to examine their relations. Such analysis would be informative particularly in such cultural contexts, where face-to-face interactions do not take the main role of mother–infant interaction patterns. Besides this, it would be worthwhile to find out, which socialization role the infant social smile plays in such contexts, especially because in further child development, the smile becomes a common form of expression in all cultures.

Finally, the question arises as to whether infant smiling in Nso sample takes the similar developmental pathway after the third month of age and shows the same interplay of both maternal and infant imitations as in Münster sample. However, it seems to be just delayed by around one month.

In conclusion, we want to point out that the results of the present study are based on prototypical samples of independent and interdependent sociocultural contexts with different models of early child care. Hence a replication of these results is necessary in order to be able to generalize them to similar sociocultural contexts. Further studies in other sociocultural contexts, such as those that represent a sociocultural model of autonomy-relatedness (e.g., urban societies of China, India, Mexico, Costa Rica) (Keller et al., 2006) would complement our knowledge regarding the emergence process of social smile and culture-specific mechanisms of it.

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Declaration of Conflicting Interests

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Note

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