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The Regulation of Infant Negative Emotions: The Role of Maternal Sensitivity and Infant-Directed Speech Prosody

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This study explored the role of maternal sensitivity and infant-directed speech (IDS) prosody in infants' expression and regulation of negative emotion. Seventy mothers and their 3-month-old infants were observed during the Still-Face Paradigm (SFP). Maternal sensitivity and IDS prosody were assessed at baseline and infant negative affect in the baseline, still-face, and reunion episodes. Results showed that prototypical IDS prosody characterized by high fundamental frequency (F0) variability was related to decreases in infant's negative affect, but only if accompanied by maternal sensitivity. Infants of sensitive mothers who spoke with more prototypical IDS prosody showed better abilities to regulate negative affect during the SFP. When prototypical IDS prosody was accompanied by low maternal sensitivity, infants showed lower regulation of negative emotions. In conclusion, infant negative affect regulation in a dyadic setting is facilitated by an optimal combination of both more prototypical maternal IDS prosody and maternal sensitive responsiveness. Implications for the study of mother–infant interaction are discussed.

The successful regulation of distress is an important developmental goal in early childhood because it fosters adaptive socio-emotional development throughout childhood (Belsky, Fish, & Isabella, 1991; Braungart-Rieker, Garwood, Powers, & Wang, 2001; Stifter & Braungart, 1995). In infancy, emotion regulation is mostly dyadic in that mothers play a key role in facilitating and fostering infant regulation, which may then develop into self-regulation beyond infancy (Tronick, 1989). This means that the quality of maternal interactive behaviors with the infant is crucial to understanding the infant's abilities to regulate emotions. Indeed, research shows that infants of mothers

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who sensitively read and respond to infant cues are better able to express and regulate emotions (Ainsworth, Blehar, Waters, & Wall, 1978; Crockenberg & Leerkes, 2003; Leerkes, Blankson, & O'Brien, 2009). In addition, a mother's use of infant-directed speech (IDS) is considered an important vehicle of emotion communication and is supposed to be associated with the development of infant emotion regulation processes (Fernald & Simon, 1984; Spinelli, Fasolo, & Mesman, 2017; Stern, Spieker, & MacKain, 1982). Interestingly, sensitivity and IDS have never been examined conjointly to understand their separate and interactive effects on infant emotion regulation. In this study, we investigate the role of maternal sensitivity and the prosody of IDS in infants' abilities to regulate negative emotions as observed during the Still-Face Paradigm (SFP; Tronick & Gianino, 1986; Tronick, Als, Adamson, Wise, & Brazelton, 1978), an observational method known to increase infant negative affect (Mesman, van Ijzendoorn, & Bakermans-Kranenburg, 2009).

An infant's interactive experience with his/her mother plays an important role in the development of distress regulation. From the first moments of life, infants need and search for their mother's support to regulate emotional distress (Trevarthen, 1977). Moreover, the many mismatch moments that naturally occur between infants' interactive expectations and their mother's behaviors can generate negative emotions. The experiences of repairing these mismatches with the reestablishment of positive interactive moments create infants expectations about their mother's availability to respond to their affective signals, which has positive effects on the infants' sense of self-efficacy (Tronick & Gianino, 1986). When infants experience failure of repair within the interaction, they may become unable to regulate negative emotions.

One of the factors that plays a fundamental role in this process is the quality of the mother's interactive abilities, such as the ability to read and respond appropriately to her infant's interactive messages, commonly defined as maternal sensitivity (Ainsworth et al., 1978; Braungart-Rieker et al., 2001; Mesman & Emmen, 2013). The experience of having a sensitive mother is supposed to positively influence infants' perception of the expression and sharing of negative emotions as acceptable rather than problematic, and their sense of their mother as an effective helper in the regulation of emotions (Bell & Ainsworth, 1972). Indeed, several studies have shown that infants who have sensitive and responsive mothers are better able to regulate their emotions than those who do not (Crockenberg & Leerkes, 2003; Leerkes et al., 2009). Similarly, a lack of maternal sensitivity characterized by intrusive and hostile behaviors has been found to maximize the expression of unregulated negative affect, and in the long term to be associated with behavioral and emotional problems, because the infant becomes fearful or highly distressed due to prior experiences with maternal hostility (Eisenberg, Taylor, Widaman, & Spinrad, 2015; Kogan & Carter, 1996; Little & Carter, 2005; Papoušek, 2007). However, insensitive behaviors such as rejecting, dismissing, or ignoring negative emotions may lead to minimizing the expression of negative affect even in very distressful moments because the infant no longer expects to receive a response (Field, 1994; Papoušek, 2007; Tronick, 1989; Weinberg & Tronick, 1998).

The macro-level constellation of a sensitive, responsive, coordinated interactive maternal style is composed of a multimodal communicative repertoire of single modalities such as tactile, visual, and vocal behaviors and facial expressions. Among these, the quality of IDS is considered a particularly important component of maternal communication (Saint-Georges et al., 2013; Spinelli et al., 2017); especially during interaction with preverbal infants, it is not so much the linguistic content of IDS but rather the prosody of the voice that is of interest (Fernald, 1989; Stern, Spieker, Barnett, & MacKain, 1983). Prototypical IDS, the pattern that has been observed in the majority of parents during interactions with their infants, is indeed characterized by specific prosodic features such as higher fundamental frequency (F0) mean values and wider F0 variations and excursions within and between utterances (F0 variability; Fernald & Simon, 1984; Fernald et al., 1989). These prosodic features are widely considered as a sign of an adult's emotional arousal, with a higher F0 mean and a higher F0 variability indicating highly aroused emotions, both negative and positive (such as anger and happiness; Laukka, Juslin, & Bresin, 2005). In contrast, medium pitch levels, more often observed in adult-directed speech, are considered to correspond to more neutral feelings and lower emotional activation (Pell, 2001; Scherer, 2003). Consequently, a common hypothesis is that mothers use such exaggerations to share and communicate emotions (Fernald & Kuhl, 1987; Stern et al., 1982; Trainor, Austin, & Desjardins, 2000), particularly positive emotions (Kitamura & Burnham, 2003), to infants and children. Thus, with the prosodic modulation of the voice mothers share positive emotions with the infant and attune to the infant's affective state and interactional expectations. The infant's perception of this sensitive attunement may contribute to the creation and maintenance of an emotional bond with his/her mother and to the development of his or her emotional development (Papoušek, 2007).

As an expression of maternal attunement with the infant's affective state, IDS prosody is expected to relate to the general quality of mother's responsiveness to her infant's needs. Nonetheless, very little research has been conducted on this topic. We know that a mother's emotional state influences the prosody of her voice. For example, a reduction in the mean and variability of F0 and a general lack of emotional expression were found in the voice of depressed mothers (Bettes, 1988; Porritt, Zinser, Bachorowski, & Kaplan, 2014), mothers who experienced highly controlling childrearing when they were children (Spinelli et al., 2016), and mothers with dismissing attachment histories (Milligan, Atkinson, Trehub, Benoit, & Poulton, 2003). To the best of our knowledge, only one study explored both sensitivity and IDS prosody (Kaplan, Burgess, Sliter, & Moreno, 2009). This study failed to find a relation between the two constructs. However, IDS prosody was coded from selected sentences pronounced by mothers asked to interest their infants in a stuffed toy using a given phrase, "pet the gorilla." Hence, this result may only be generalized to say that more or less sensitive mothers seem to use their voices in a similar way when their aim is to attract infant attention, but does not say much about IDS and maternal attunement with infant affective state during more spontaneous interactions.

Similarly, only a few studies explored the role of prototypical IDS, with its typical exaggerated prosodic features, in eliciting and regulating infant emotions (Fernald, 1993; Fernald & Simon, 1984). Infants responded with more positive affect to vocalizations characterized by an exaggerated F0 mean and variability than to low modulated vocalizations, to which they tend to respond with more negative affect (Fernald, 1993). Moreover, maternal speech characterized by more and wider F0 variations was associated with more infant smiling and gazing directed to the mother (Stern et al., 1982) and greater infant positive affect responses (Phillips, 1995). As the meta-analyses by Spinelli et al. (2017) suggested, more studies on the topic are needed, especially studies that explore the association between spontaneous (rather than pre-recorded) IDS prosody and infant expression and emotion regulation, taking into consideration general maternal sensitivity and responsiveness.

The Still-Face Paradigm and the regulation of negative affect

The SFP represents a simulation and exaggeration of the interruption of infant–parent interaction to better assess adults' and infants' behaviors that reflect the mutual organization of emotions in social interaction (Adamson & Frick, 2003; Tronick & Gianino, 1986; Tronick, Ricks, & Cohn, 1982). After a few minutes of face-to-face dyadic interaction (the baseline episode), the parent is asked to suddenly interrupt the interaction and to continue looking at the infant with an inexpressive and unresponsive face (the still-face episode). After 1–3 min (depending on the procedure applied), the social interaction resumes (the reunion episode). Mesman et al. (2009) reviewed and meta-analyzed the results of around 30 studies that applied the SFP. The overall pattern showed that infants significantly increased their negative affect from the baseline to the still-face episode (the still-face effect). The expected decrease in negative affect from the still-face episode to the reunion as a consequence of the restart of the interaction (the recovery effect) was not found. Indeed, the meta-analyses confirmed the carry-over effect of the still-face stressful experience, reporting significantly higher levels of negative affect in the reunion compared to the baseline, which signaled that restoration of the interaction is not per se sufficient to cancel out the effects of the stressful experience.

The quantity and quality of the negative affect expressed during the SFP can be considered an index of infant's ability to express and regulate negative arousal within the dyadic interaction with the mother (Cohn, 2003). In particular, the ability of the dyad to repair the disruption of the dyadic regulation and interactive system is a crucial aspect of the quality of infant–mother interaction (Kogan & Carter, 1996) and may provide essential information about individual and dyadic differences that predict future adaptation (Mesman, Linting, Joosen, Bakermans-Kranenburg, & van Ijzendoorn, 2013).

Consequently, several studies have explored the maternal interactive characteristics that are related to infant's responses to the SFP. Some studies reviewed in Mesman et al. (2009) reported that infants with sensitive mothers show more regulatory behaviors, more positive affect, less avoidance, and less negative affect during still-face and reunion episodes. However, the meta-analyses revealed a significant overall positive effect of sensitivity only on infant positive affect and not on negative affect during the SFP. More recent studies (not included in the meta-analyses) similarly showed an inconsistent pattern. While some studies found a general association of sensitivity with less negative affect during both the still-face episode and the reunion (Haltigan, Leerkes, Supple, & Calkins, 2014), others reported associations only with infant reactions in some episodes. For example, it was found that greater maternal sensitivity and affective matching during baseline were associated with lower negative expressions during the reunion, but not during the still-face episode, during which differences were more present at the level of infant positive affect and social signals (Coppola, Aureli, Grazia, & Ponzetti, 2016; Mastergeorge, Paschall, Loeb, & Dixon, 2014; Noe, Schluckwerder, & Reck, 2015). Other studies found that maternal sensitivity predicted infant physiological reactivity and regulation only during the reunion and not during the baseline episode (Conradt & Ablow, 2010). Moreover, the association between maternal sensitivity and infant negative affect seems to be moderated by maternal risk status; infants with low-risk sensitive mothers reacted less negatively to the still-face episode, and infants with high-risk sensitive mothers, such as adolescent mothers, reacted more negatively (Tarabulsy et al., 2003).

Thus, even if sensitivity has been hypothesized to be a crucial factor that plays a role in the development of infant regulatory capacities, studies using the SFP have shown that the ability to generally sensitively respond to infants' cues is a factor that does not fully explain the dyadic regulation process. Other aspects of this communication need to be explored. Tronick et al. (1982) found that infants with mothers who sensitively imitated and exaggerated infant's social signals showed a greater ability to cope with the still-face episode. The vocal aspect of such exaggerations is reflected in IDS, which may therefore represent a communication process that guides the regulatory function of the dyadic infant–mother system.

Some studies have looked specifically at maternal vocal communication in relation to infant affect during the SFP. However, they have mostly done so by modifying the procedure with the aim to explore the effects of the presence or absence of vocal stimulation. It was found, for example, that infants displayed fewer sad facial expressions, fewer negative vocalizations, and less gaze aversion when their mother wore a mask but continued to talk than when their mother was still-faced and silent; this demonstrates the role of maternal vocal communication as a cue for infant emotion regulation (Legerstee & Markova, 2007). Moreover, the contingency of vocal mother–infant nondistress productions, but not smiling contingency, during the baseline was associated with the infants' social bidding-like behaviors in the following still-face episode (Bigelow & Power, 2016). This suggests that when the quality of mothers' verbal communication is sensitively coordinated with infants' messages by contingently responding to infants' vocal behaviors, mothers enhance infants' involvement in social encounters and facilitate infants' sense that they are effective agents in instigating social interactions (Bigelow & Power, 2016). To date, we are unaware of any studies exploring the association between IDS prosody and maternal and infant behaviors and affect within the SFP. Exploring the interplay of these maternal behaviors in relation to infant regulation of negative affect can contribute to understanding contrasting findings in the current literature.

The present study

The main aim of the present study was to examine mothers' sensitivity and IDS prosody during the baseline face-to-face play episode of the SFP and to explore the associations between these maternal interactive aspects and infant regulation of negative emotions as assessed by the paradigm.

Based on the literature discussed above, we expected that

(1a) infants with more sensitive mothers are less affected by the stressful experience of the still-face episode and are more able to reestablish the interaction with the mother after it. They consequently present

- lower negative affect in the still-face and in the reunion episodes
- a greater ability to reestablish interaction with the mother after the still-face episode, reflected in: decrease in negative affect from the still-face episode to the reunion (a stronger recovery effect) and in similar levels of negative affect in the reunion as in the baseline interaction (a less pronounced carry-over effect).

(1b) infants with mothers using more prototypical IDS prosody (higher F0 mean and wider F0 variability) are less affected by the stressful experience of the still-face episode and are more able to reestablish the interaction with the mother after it. They consequently present

- a lower negative affect throughout the still-face and the reunion episodes
- a weaker carry-over effect
- a stronger recovery effect

(2) infants with mothers who show both high sensitivity and more prototypical IDS prosody show more effective emotion regulation in response to the still face and will therefore show

- the lowest negative affect throughout the still-face and the reunion episodes
- the weakest carry-over effect
- the strongest recovery effect

METHOD

Participants

This study included 70 mother–infant dyads. The dyads were selected from a larger study on parenting and infant development (Mesman et al., 2013), stratified by gender (35 F and 35 M). Mothers' mean age at the time of the visit was 31 years ($SD = 4.71$). All mothers lived with the father of the child, were born in the Netherlands, and spoke Dutch as their primary language. Concerning educational level, 43% had an elementary educational level, 23% middle and high school, and 34% university.

This study was conducted according to guidelines laid down in the Declaration of Helsinki, with written informed consent obtained from a parent or guardian for each child before any assessment or data collection. All procedures involving human subjects in this study were approved by the Ethics Committee of the Institute of Education and Child Studies at Leiden University, the Netherlands.

Instruments

The Still-Face Paradigm

The SFP was conducted at age of 3 months in the families' homes (Tronick et al., 1978). The SFP consisted of three steps: (1) a 2-min baseline normal interaction, (2) a 1-min still-face episode in which the adult became unresponsive while looking at the child with a neutral facial expression, and (3) a 2-min reunion in which normal interaction was resumed. During the baseline interaction and reunion, mothers were allowed to touch the infant and speak as they would normally do, but they were not allowed to touch the child or speak during the still-face segment. The SFP was conducted when infants were awake and alert. If the infant cried during the majority of the procedure, the SFP was conducted again during an extra home visit (in two cases). To increase the likelihood of "normal" interaction in the SFP, we conducted the procedure in the families' homes, using the infant personal seat, and started the SFP after an acclimatization period. A specially designed portable "wall" was placed around the infant seat to prevent distraction from the task.

Infant and maternal behaviors

Infant and maternal behaviors were coded with an adapted version of the 4-point global rating scales (0–3) of the Mother Infant Coding System (Miller, McDonough, Rosenblum, & Sameroff, 2002). The coding system is composed of several scales aimed to evaluate mother and infant behaviors during dyadic interaction; in this study, we included the Infant Negative Affect and the Mother Sensitivity scales.

The Infant Negative Affect scale evaluates the frequency and intensity of infant negative emotion displays (e.g., fussing, crying, screaming) with scores indicating 0 = no negative affect; 1 = few instances of low intensity fussy, whiny, or cry; 2 = one instance of highly negative display, or periods of medium intensity fussing and crying mixed with neutral or positive affect; and 3 = few periods without fussing or crying (infant is crying or upset to the point that he or she cannot seem to become well-regulated or pull self together to focus attention on mother or self). This scale was coded for all three episodes separately.

The Maternal Sensitivity scale evaluates the extent to which the mother follows infant cues in an appropriate manner (e.g., infant-focused behaviors, gently soothe, acknowledge infant state, use appropriate pacing) and it was coded during the baseline episode. Scores range from 0 to 3, indicating 0 = virtually no sensitivity, the mother does not make attempt to follow the infant's signal, is intrusive or disengaged, 1 = a few instances of sensitive behavior mixed with at least some unresponsiveness, intrusiveness, or misinterpretation of infant cues, 2 = mother is moderately sensitive, there appear to be too many lapses in her sensitive responses (there is an inconsistency), but she does have more sensitive responses than insensitive ones, to 3 = consistently child-centered in responding to infant cues with well-timed and appropriate responses.

The SFP and the Infant Negative Affect and Maternal Sensitivity scales were independently coded by a team of eight trained coders. The intercoder reliabilities (intraclass correlation, single rater, absolute agreement) were >.70 for all dyads on all scales. Episodes within one assessment and within target (infant or mother) were scored by independent raters blind to the study hypotheses and to maternal data. All tapes were double-coded for the Maternal Sensitivity scale as this scale was considered the more difficult one. When the two scores were not identical, a final consensus score was given by two expert coders after discussion of the video.

Two effects within the SFP are of interest: the recovery effect, which reflects the change in infant affect from still-face episode to reunion (a better recovery effect is indicated by a decrease in negative affect from the still face to the reunion), and the carry-over effect, which describes the difference in infant affect between baseline and reunion (a stronger carry-over effect is indicated by more negative affect in the reunion than in baseline, indicating that negative affect was "carried over" from the still face into the reunion; Mesman et al., 2009).

Infant-directed speech prosody

The audio recordings of the 2-min baseline normal interaction episode were separated from the videos to select and code all mothers' vocal productions (total = 4,363, mean per subject = 62, *SD* = 16.76). The prosodic coding was conducted using PRAAT speech software with a 50–800 Hz pitch setting range (Boersma & Weenink, 2005). A vocal production was defined as a sound with a vocalic content separated from the following sound by a silent moment longer than 0.3 s (Stern, Beebe, Jaffe, & Bennett, 1977). Guttural productions, laughs, and all sounds without vocalic content were excluded and not considered vocal productions. Some vocal productions were not codable because the audio was disturbed (e.g., it overlapped with infant sound, or with other noises) or the intensity was too low to produce a fundamental frequency line on the spectrogram (e.g., the mother whispered). These productions were excluded. The following prosodic measures were considered: (1) F0 mean: calculated automatically by PRAAT, in Hz. It represents the rate of vibrations of the vocal cords within the larynx and reflects pitch levels of the voice; (2) F0 variability (in semitones): the logarithmic difference between the maximum and the minimum pitches in an utterance, measured in semitones $[12/\log(2)]*[\log(\text{maximum F0}-\text{minimum F0})]$. This refers to the width of pitch changes over the entire utterance and reflects the modulation of the voice.

Infant-directed speech mean prosodic values for this sample (F0 mean: *M* = 274 Hz, range = 196–357; F0 variability: *M* = 7.91 semitones, range = 3.78–11.23) were similar to the prototypical IDS prosodic values found in previous studies (Fernald, 1989; Spinelli et al., 2016). The number of productions did not correlate with maternal sensitivity and slightly correlates with baseline IDS variability.

Plan of analysis

Analyses were run with the linear mixed model procedure of SPSS with REML as the method for estimation (West & Galecki, 2011). To explore the associations among IDS prosody, maternal sensitivity, and infant negative affect in the still-face and reunion episodes, we ran several linear mixed models. Baseline maternal sensitivity (ordinal score ranging from 0 to 3), each baseline IDS prosodic variable (F0 mean in Hz, and F0 variability in semitones), and their interaction were independent variables, and infant negative affect (ordinal score ranging from 0 to 3) during each episode was the dependent variable.

To assess the association between maternal sensitivity and IDS prosody with the changes in infant negative affect between episodes (carry-over effect and recovery effect), we ran linear mixed models with baseline maternal sensitivity (ordinal score ranging from 0 to 3), episode (still face and reunion; baseline and reunion), each baseline IDS prosodic variable (F0 mean in Hz and F0 variability in semitones), and their interactions as fixed effects on infant negative affect (ordinal score ranging from 0 to 3). All analyses were run with continuous scores. Dichotomization of variables was only applied for illustration purposes (i.e., the figures).

To represent variation that is due to individual differences, we entered intercepts and slopes for subjects as random effects, with a variance components covariance structure. Visual inspection of residual plots did not reveal any obvious deviation from homoscedasticity or normality.

RESULTS

Associations between maternal and infant variables

The correlations reported in Table 1 showed that mother's sensitivity and IDS prosodic variables (F0 mean and F0 variability) were not significantly associated, while, as expected, a positive association was present between F0 mean and F0 variability. The infant negative affect levels at each episode were correlated with one another.

Concerning the associations between maternal and infant variables, baseline maternal sensitivity was associated only with baseline infant negative affect with infants of more sensitive mothers showing lower negative affect. Moreover, IDS F0 mean and IDS F0 variability were not associated with infant negative affect at any episode of the SFP (see Table 1).

Maternal education was positively associated with maternal sensitivity, with higher educated mothers showing higher sensitivity scores. We controlled for this maternal variable in all the further analyses.

Baseline IDS prosody and maternal sensitivity in relation to infant negative affect

Four linear mixed effects models were conducted (see Table 2) to test the fixed effects of baseline maternal sensitivity score and IDS prosody (F0 mean and F0 variability) and their interaction on infant negative affect at the still-face and reunion episodes controlling for maternal education.

No significant effects were found for the models with regard to IDS F0 mean (see Table 2). Maternal sensitivity score, IDS F0 mean during baseline, and their interaction were not associated with infant negative affect during the still-face episode and during the reunion.

We did find a significant effect of the interaction between baseline maternal sensitivity score and baseline F0 variability on infant negative affect during the reunion, $F(1, 65) = 5.06$, $p = .03$. Higher baseline IDS F0 variability values were associated with less infant negative affect during the reunion when mothers showed higher sensitivity scores, whereas higher baseline IDS F0 variability values were related to *more* infant negative affect during the reunion when mothers showed lower sensitivity scores. To illustrate this effect, we dichotomized the sensitivity variable (low = scores 0

TABLE 1
Means, Standard Deviations, and Correlations

Variable	*M*	*SD*	*1*	*2*	*3*	*4*	*5*	*6*	*7*
1. Baseline maternal sensitivity	2.00	0.83	–						
2. Baseline infant negative affect	0.37	0.68	−.32**	–					
3. Still-face infant negative affect	0.64	1.01	−.17	.76**	–				
4. Reunion infant negative affect	0.83	1.06	−.07	.47**	.63**	–			
5. Baseline F0 mean	274	37	−.22	.08	−.11	−.04	–		
6. Baseline F0 variability	7.91	1.72	.20	.12	−.04	−.05	.23*	–	
7. Maternal education	–	–	.296*	−.187	−.068	.077	−.013	.043	–

Note. *$p < .05$; **$p < .01$.

TABLE 2
Linear Mixed Models Results. Effects of Baseline Maternal Sensitivity, Baseline IDS Prosody, and their Interaction on Infant Negative Affect (Controlling for Maternal Education)

	Still-face infant Negative affect		*Reunion infant Negative affect*	
	F(1, 65)	*p*	*F(1, 65)*	*p*
Intercept	1.17	.28	2.42	.12
Baseline maternal sensitivity	.25	.62	.169	.19
Baseline IDS F0 mean	.79	.37	1.87	.18
Maternal sensitivity × IDS F0 mean	.42	.52	1.84	.18
Maternal education	.923	.34	.10	.75
Intercept	.01	.92	2.39	.13
Baseline maternal sensitivity	.63	.43	5.37	.02*
Baseline IDS F0 variability	.04	.84	3.60	.06
Maternal sensitivity × IDS F0 variability	.24	.62	5.06	.03*
Maternal education	.75	.39	.56	.46

Note. $^{*}p < .05$.

and 1, high = scores 2 and 3) so the relation between IDS F0 variability and infant negative affect could be visualized in separate lines for these two groups of mothers (see Figure 1).

Baseline IDS prosody and maternal sensitivity in relation to infant changes in negative affect between the SFP episodes

Four mixed models were run to explore the effect of baseline maternal sensitivity score and baseline IDS prosody (F0 mean and F0 variability) on the changes in infant negative affect between the episodes (recovery effect and carry-over effect) controlling for maternal education.

To explore the recovery effect, we tested the relation of maternal variables (maternal sensitivity score and IDS F0 mean and F0 variability values during baseline) with infant changes in negative affect from the still-face episode to the reunion. No significant effects were found in the models that included baseline IDS F0 mean as a fixed effect. Concerning the model including IDS F0 variability, only a marginally significant effect of the interaction (maternal sensitivity × IDS F0 variability × episode) was found, $F(1, 66) = 3.52$, $p = .06$. The direction of the effect suggests a tendency for mothers with higher sensitivity scores and wider IDS F0 variability values and for mothers with lower sensitivity and lower IDS F0 variability at baseline to have infants who present a greater decrease in negative affect from the still-face episode to the reunion (a better recovery ability from the stressful still-face episode).

To explore the carry-over effect, we explored the relation of maternal variables (maternal sensitivity and IDS F0 mean and F0 variability during baseline) with infant differences in negative affect at baseline and at reunion. The results revealed a significant effect of the interaction between episode, baseline maternal sensitivity, and baseline IDS F0 variability, $F(1, 66) = 9.83$, $p < .01$. For infants of mothers with lower sensitivity scores (see Figure 2a, with dichotomized sensitivity scores for illustration purposes), a wider IDS F0 variability during baseline was associated with a greater negative affect

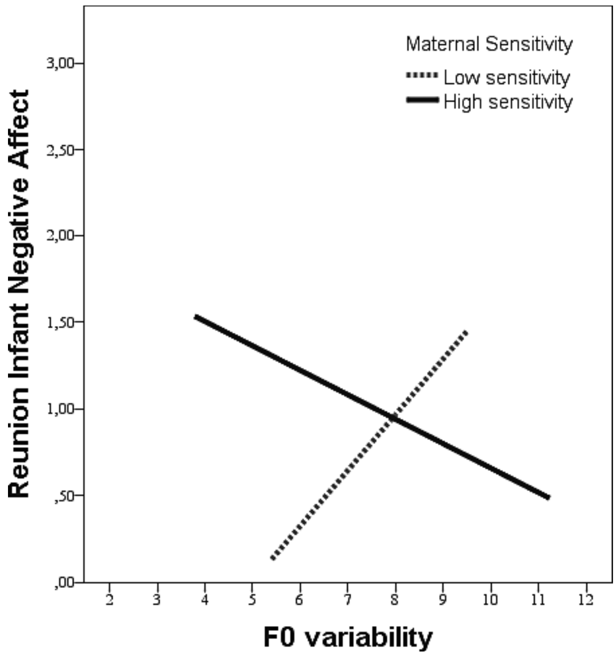

Figure 1 Interaction effect of baseline maternal sensitivity and infant-directed speech F0 variability on reunion infant negative affect (low sensitivity = 0 or 1; high sensitivity = 2 or 3).

in the reunion compared to the baseline (a sign of greater carry-over effect). On the contrary, for infants with mothers scoring higher in sensitivity (see Figure 2b, with dichotomized sensitivity scores for illustration purposes) a higher IDS F0 variability at baseline was associated with a lower carry-over effect on negative affect.

DISCUSSION

The present study explored maternal sensitivity and maternal IDS prosody in relation to infant negative affect regulation within the SFP. Our first hypothesis describing significant bivariate associations between higher maternal sensitivity, higher maternal IDS prosody and infant lower expression, and better regulation of negative affect was not confirmed. Neither maternal sensitivity nor IDS prosody alone were associated with lower negative affect in the still-face episode and in the reunion, or to changes in negative affect between episodes. Our second hypothesis was confirmed: The combination of higher maternal IDS prosody levels and higher maternal sensitivity during the baseline was related to less negative affect during the reunion and showed a lower carry-over effect in negative affect (i.e., showed similar negative affect in the reunion as in the baseline).

Prototypical IDS with its exaggerated prosodic features is considered a vehicle of positive affect and was expected to be associated with lower negative affect and with better regulation of negative emotions (Fernald, 1993). Further, mothers and infants form an integrated dyadic regulatory system responsible for regulating infants'

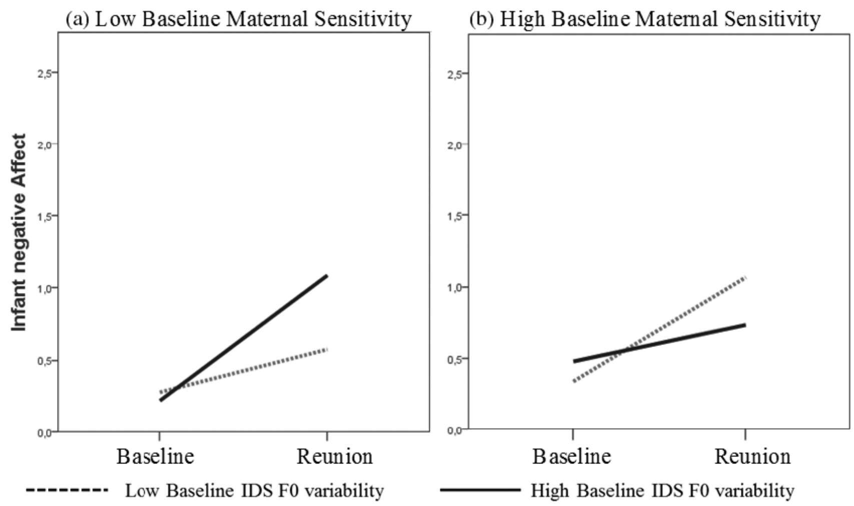

Figure 2 (a, b) The effect of baseline maternal sensitivity and baseline infant-directed speech (IDS) F0 variability on infant changes in negative affect from baseline to reunion (low baseline IDS F0 variability = under the mean F0 variability; high baseline IDS F0 variability = above the mean F0 variability).

emotions, such as negative emotions, and mothers' contingent and responsive responses are supposed to have the function to support and promote infants' regulation of emotions (Tronick, 1989; Tronick et al., 1982). Contrary to these hypotheses, neither IDS prosody nor sensitivity during the baseline of the SFP were directly associated with the expression of infant negative affect during the SFP. This indicates that maternal IDS prosody and sensitive responsiveness alone are not enough to explain infant capacities to regulate negative emotions in the SFP.

Consistent with our second hypothesis, when general maternal sensitivity was accompanied by a more modulated prototypical IDS, the infant showed a better ability to regulate negative emotions after the stressful experience of the interruption of the interaction during the still-face episode. The use of prototypical IDS in combination with more sensitive responses (rather than the presence of only sensitivity or only IDS, or of course neither of these) may reflect a more comprehensive attunement to infant emotional needs and affective expressions than either alone. Apparently, sensitive responses to distress are more effective when characterized by higher levels of IDS prosody that may have a more specific soothing and regulating effect. Similarly, IDS prosody acts like an affective regulator particularly when used in a way that fits with the infant's signals. In this situation, prototypical IDS becomes a communicative behavior used not only to express positive emotions, as already previously stated (Fernald, 1989), but also to reestablish a positive match after mismatched moments and after infant distress (Stern et al., 1982). Thus, based on the repetitions of the repair of interactive errors they experienced during normal dyadic interactions, infants of more sensitive mothers showing more prototypical IDS expand their affect regulatory capacities and internalize a representation of the dyadic interaction as effective in repairing the mismatched and uncoordinated interactive moments.

A different and less favorable picture emerged when mothers scoring higher in sensitivity speak to the infant with a less modulated IDS. Within these dyads, infants showed higher negative affect in the reunion and a larger carry-over effect (i.e., higher negative affect in the reunion compared to baseline). These results may explain the lack of significant associations reported by previous studies between maternal sensitivity per se and infant negative reactions in the SFP (Conradt & Ablow, 2010; Mesman et al., 2009, 2013).

The findings regarding less sensitive mothers represent the other side of this coin: infants with less sensitive mothers displaying less modulated IDS prosody showed very low negative affect during the reunion. Because low F0 variability values have been detected in depressed mothers and can be interpreted as an index of flat and unemotional interaction (Bettes, 1988; Porritt et al., 2014), it may be that these mothers' insensitive behaviors are characterized by a flat and withdrawn interactive style (Cohn & Tronick, 1988). As a consequence of this maternal disengagement from the interaction, the infant develops low expectations of maternal responses. This causes the infant to refrain from using other-directed regulatory behaviors, such as positive or negative affect, to engage the partner and to share and communicate his/her affective states (Gianino & Tronick, 1988). The still-face episode may be in some way less stressful for these infants as their expectations about social interactions may be based on maternal unavailability (Papoušek, 2007). This may parallel the lack of behavioral negative reactions of avoidant attached infants to the separation episode of the SSP hypothesized to be the result of a rejecting and unavailable mother (Ainsworth et al., 1978; Cohn, 2003). Moreover, it is consistent with previous studies reporting that low rates of maternal mirroring of infant emotional expressions failed to show an association with changes in infants' negative reactions throughout the SFP episodes, while infants of mothers who mirrored their behaviors showed more negative vocalizations in the still face and in the reunion (Bigelow & Walden, 2009).

Interestingly, when a less sensitive interactive style was accompanied by wider IDS F0 variability, infants presented higher negative affect after the still-face episode and a lower ability to recover from the still-face episode. When prototypical IDS co-occurs with insensitivity to infant cues, it may not represent adequate mirroring of infant affect, but rather reflect a more intrusive interaction style in which mothers force a hyper-interactive style that does not match with the infant's communicative signals. Thus, the predominance of unregulated infant negative affect is a result of experiencing obstacles in the interaction that cannot be overcome due to a mother who is unreliable as an external emotion regulator (Tronick, 1989). A similar pattern of dysregulated cry in the SFP was shown by infants of dyads characterized by cycles of overstimulating and noncontingent interactive style in the baseline (Papoušek, 2007). These findings reflect the detrimental effect of maternal overcontrol and intrusive behaviors on the development of infant regulation of negative emotions as revealed during the SFP (Kogan & Carter, 1996; Rosenblum, McDonough, Muzik, Miller, & Sameroff, 2002), which have also been found longitudinally at older ages (Eisenberg et al., 2015; Graziano, Keane, & Calkins, 2010; Little & Carter, 2005).

In sum, more prototypical IDS prosody must not be considered uniquely as an expression of positive affect and a way mothers imitate and exaggerate infant positive emotions. Indeed, even when expressed with a positive intention, prototypical IDS prosody may be considered affective mirroring behavior only if it is part of a sensitive and responsive interaction and as such, it may have a positive effect on dyadic emotion regulation processes (Bigelow & Walden, 2009). Otherwise, if incongruent with infant communication messages, prototypical IDS prosody may be interpreted by the infant as an intrusive exaggerated behavior.

An important additional finding of this study is that F0 variability, compared with F0 mean, is the IDS prosodic feature that better predicts not only infant prelinguistic and linguistic abilities, as stated in the Spinelli et al. (2017) meta-analysis, but also infant emotional abilities. We further confirmed Fernald and Kuhl (1987) hypothesis that of all the prosodic characteristics of IDS, the more salient aspects are related to the modulation of the voice, and not simply to average pitch levels. These variations of the F0 are probably a better cue for infants not only to attract their attention or to underline the linguistic aspects of communication as previously reported (Kaplan, Bachorowski, Smoski, & Zinser, 2001), but also to see their emotions mirrored and mutually recognized by the mother within the dyadic interactive process (Stern et al., 1982). The F0 mean is a variable that is more closely linked to the general height of pitch, and so to personal voice characteristics and to a general arousal of speech, and may less evidence the many changes and modifications that occur in social interactions (Fernald & Kuhl, 1987).

Some limitations of this study should be noted. First, the mother–infant dyads were from a homogenous population and from a Western European country. Studies in populations from different cultural and linguistic contexts would give a more complete picture of the phenomena under investigation. Second, the interaction period in which both maternal sensitivity and IDS prosody were measured was short, that is, the baseline interactive phase of the SFP. Longer mother–infant interactions may produce wider variations in both sensitivity and IDS prosody. However, the mothers and infants were involved in other assessments before the SFP procedure and thus had some time to get used to the home visitor and the observation setting. In addition, there is evidence that observations of sensitivity in the SFP are significantly related to sensitivity observations in other longer interaction settings (Joosen, Mesman, Bakermans-Kranenburg, & van IJzendoorn, 2012).

In conclusion, the present study provides important contributions to the research on the different roles of maternal IDS prosody in infant development. First, it demonstrated that considering the prototypical IDS prosody in general as beneficial for infant affective development is an inaccurate simplification of the process (Fernald, 1989; Stern et al., 1982). IDS is one communicative modality that may be very powerful and merits consideration, but it cannot be considered as disentangled from the other aspects of the complexity of the dyadic interaction (Spinelli et al., 2017).

At the same time, this study evidenced that IDS prosody may indeed be considered a crucial modality mothers use to attune to infant signals. Consequently, IDS prosody in concordance with infant behaviors and affective expressions should be taken into account in the evaluation of maternal sensitivity (Mesman & Emmen, 2013; Mesman, Minter, & Angnged, 2016). Furthermore, the growing attention in the micro-analyses of dyadic interactions suggests the importance of the contingency of maternal communicative modalities with infant signals as crucial for infant development (Beebe & Steele, 2013; Beebe et al., 2010). Thus, a microanalysis of infant behaviors and maternal IDS prosodic responses as well as the interplay of IDS prosody with other maternal communicative expressions (such as visual, facial, and touch) will help to more fully understand the quality of the dyadic communication system and its impact on infant affective development (Beebe & Steele, 2013).

Further attention could also be given to IDS prosody in interventions aimed at promoting sensitive parenting and secure attachment (e.g., Bakermans-Kranenburg, Van Ijzendoorn, & Juffer, 2003), by teaching mothers about the important role of their voice as a potential external regulator for their infants' emotions. Future research could further examine whether this positive interactive effect of sensitivity and IDS prosody is also confirmed at different ages and in different (more naturalistic) interaction settings. Longitudinal studies are also needed to explore the potential longer-term effects of IDS and sensitivity on emotion regulation in later childhood and its related outcomes in the broader domain of psychosocial functioning.

CONFLICT OF INTEREST

Both authors declare no conflict of interest.

REFERENCES

Adamson, L. B., & Frick, J. E. (2003). The still face: A history of a shared experimental paradigm. *Infancy*, *4*, 451–473.

Ainsworth, M. D. S., Blehar, M., Waters, E., & Wall, S. (1978). *Patterns of attachment: A psychological study of the strange situation*. Hillsdale, NJ: Erlbaum.

Bakermans-Kranenburg, M. J., Van Ijzendoorn, M. H., & Juffer, F. (2003). Less is more: Meta-analyses of sensitivity and attachment interventions in early childhood. *Psychological Bulletin*, *129*, 195–215.

Beebe, B., Jaffe, J., Markese, S., Buck, K., Chen, H., Cohen, P., & Feldstein, S. (2010). The origins of 12-month attachment: A microanalysis of 4-month mother-infant interaction. *Attachment & Human Development*, *12*(1–2), 3–141.

Beebe, B., & Steele, M. (2013). How does microanalysis of mother–infant communication inform maternal sensitivity and infant attachment? *Attachment & Human Development*, *15*, 583–602.

Bell, S. M., & Ainsworth, M. D. S. (1972). Infant crying and maternal responsiveness. *Child Development*, *43*, 1171–1190.

Belsky, J., Fish, M., & Isabella, R. A. (1991). Continuity and discontinuity in infant negative and positive emotionality: Family antecedents and attachment consequences. *Developmental Psychology*, *27*, 421–431.

Bettes, B. A. (1988). Maternal depression and motherese: Temporal and intonational features. *Child Development*, *59*, 1089–1096.

Bigelow, A. E., & Power, M. (2016). Effect of maternal responsiveness on young infants' social bidding-like behavior during the still face task. *Infant and Child Development*, *25*, 256–276.

Bigelow, A. E., & Walden, L. M. (2009). Infants' response to maternal mirroring in the still face and replay tasks. *Infancy*, *14*, 526–549.

Boersma, P., & Weenink, D. (2005). *Praat (version 4.3. 31)*. Amsterdam, The Netherlands: University of Amsterdam. http://www.fon.hum.uva.nl/praat

Braungart-Rieker, J. M., Garwood, M. M., Powers, B. P., & Wang, X. (2001). Parental sensitivity, infant affect, and affect regulation: Predictors of later attachment. *Child Development*, *72*, 252–270.

Cohn, J. F. (2003). Additional components of the still-face effect: Commentary on Adamson and Frick. *Infancy*, *4*, 493–497.

Cohn, J. E., & Tronick, E. Z. (1988). Mother-infant face-to-face interaction: Influence is bidirectional and unrelated to periodic cycles in either partner's behavior. *Developmental Psychology*, *24*, 386–392.

Conradt, E., & Ablow, J. (2010). Infant physiological response to the Still-Face Paradigm: Contributions of maternal sensitivity and infants' early regulatory behavior. *Infant Behavior and Development*, *33*, 251–265.

Coppola, G., Aureli, T., Grazia, A., & Ponzetti, S. (2016). Reunion patterns in the Still-Face Paradigm as predicted by maternal sensitivity and dyadic coordination. *Infancy*, *21*, 453–477.

Crockenberg, S., & Leerkes, E. (2003). Infant negative emotionality, caregiving, and family relationships. In A. Booth, & A. C. Crouter (Eds.), *Children's influence on family dynamics: The neglected side of family relationships* (pp. 57–78). Mahwah, NJ: Lawrence Erlbaum Associates.

Eisenberg, N., Taylor, Z. E., Widaman, K. F., & Spinrad, T. L. (2015). Externalizing symptoms, effortful control, and intrusive parenting: A test of bidirectional longitudinal relations during early childhood. *Development and Psychopathology*, *27*(4 pt 1), 953–968.
Fernald, A. (1989). Intonation and communicative intent in mothers' speech to infants: Is the melody the message? *Child Development*, *60*, 1497–1510.
Fernald, A. (1993). Approval and disapproval: Infant responsiveness to vocal affect in familiar and unfamiliar languages. *Child Development*, *64*, 657–674.
Fernald, A., & Kuhl, P. K. (1987). Acoustic determinants of infant preference for motherese speech. *Infant Behavior and Development*, *10*, 279–293.
Fernald, A., & Simon, T. (1984). Expanded intonation contours in mothers' speech to newborns. *Developmental Psychology*, *20*(1), 104–113.
Fernald, A., Taeschner, T., Dunn, J., Papousek, M., de Boysson-Bardies, B., & Fukui, I. (1989). A cross-language study of prosodic modifications in mothers' and fathers' speech to preverbal infants. *Journal of Child Language*, *16*, 477–501.
Field, T. (1994). The effects of mother's physical and emotional unavailability on emotion regulation. *Monographs of the Society for Research in Child Development*, *59*, 208–227.
Gianino, A., & Tronick, E. Z. (1988). The mutual regulation model: The infant's self and interactive regulation, coping and defensive capacities. In T. Field, P. McCabe, & N. Schneiderman (Eds.), *Stress and coping across development* (pp. 47–68). New York, NY: Psychology Press.
Graziano, P. A., Keane, S. P., & Calkins, S. D. (2010). Maternal behaviour and children's early emotion regulation skills differentially predict development of children's reactive control and later effortful control. *Infant and Child Development*, *19*, 333–353.
Haltigan, J. D., Leerkes, E. M., Supple, A. J., & Calkins, S. D. (2014). Infant negative affect and maternal interactive behavior during the still-face procedure: The moderating role of adult attachment states of mind. *Attachment & Human Development*, *16*, 149–173.
Joosen, K. J., Mesman, J., Bakermans-Kranenburg, M. J., & van IJzendoorn, M. H. (2012). Maternal sensitivity to infants in various settings predicts harsh discipline in toddlerhood. *Attachment & Human Development*, *14*, 101–117.
Kaplan, P. S., Bachorowski, J. A., Smoski, M. J., & Zinser, M. (2001). Role of clinical diagnosis and medication use in effects of maternal depression on infant-directed speech. *Infancy*, *2*, 537–548.
Kaplan, P. S., Burgess, A. P., Sliter, J. K., & Moreno, A. J. (2009). Maternal sensitivity and the learning-promoting effects of depressed and nondepressed mothers' infant-directed speech. *Infancy*, *14*, 143–161.
Kitamura, C., & Burnham, D. (2003). Pitch and communicative intent in mother's speech: Adjustments for age and sex in the first year. *Infancy*, *4*(1), 85–110.
Kogan, N., & Carter, A. S. (1996). Mother-infant reengagement following the Still-Face: The role of maternal emotional availability in infant affect regulation. *Infant Behavior and Development*, *19*, 359–370.
Laukka, P., Juslin, P., & Bresin, R. (2005). A dimensional approach to vocal expression of emotion. *Cognition & Emotion*, *19*, 633–653.
Leerkes, E. M., Blankson, A. N., & O'Brien, M. (2009). Differential effects of maternal sensitivity to infant distress and non-distress on social-emotional functioning. *Child Development*, *80*, 762–775.
Legerstee, M., & Markova, G. (2007). Intentions make a difference: Infant responses to still-face and modified still-face conditions. *Infant Behavior and Development*, *30*, 232–250.
Little, C., & Carter, A. S. (2005). Negative emotional reactivity and regulation in 12-month-olds following emotional challenge: Contributions of maternal–infant emotional availability in a low-income sample. *Infant Mental Health Journal*, *26*, 354–368.
Lyons-Ruth, K., Bronfman, E., & Parsons, E. (1999). Maternal frightened, frightening, or atypical behavior and disorganized infant attachment patterns. *Monographs of the Society for Research in Child Development*, *64*(3), 67–96.
Mastergeorge, A. M., Paschall, K., Loeb, S. R., & Dixon, A. (2014). The Still-Face Paradigm and bidirectionality: Associations with maternal sensitivity, self-esteem and infant emotional reactivity. *Infant Behavior and Development*, *37*, 387–397.
Mesman, J., & Emmen, R. A. (2013). Mary Ainsworth's legacy: A systematic review of observational instruments measuring parental sensitivity. *Attachment & Human Development*, *15*, 485–506.
Mesman, J., Linting, M., Joosen, K. J., Bakermans-Kranenburg, M. J., & van Ijzendoorn, M. H. (2013). Robust patterns and individual variations: Stability and predictors of infant behavior in the Still-Face Paradigm. *Infant Behavior and Development*, *36*, 587–598.

Mesman, J., Minter, T., & Angnged, A. (2016). Received sensitivity: Adapting Ainsworth's scale to capture sensitivity in a multiple-caregiver context. *Attachment & Human Development*, *18*, 101–114.

Mesman, J., van Ijzendoorn, M. H., & Bakermans-Kranenburg, M. J. (2009). The many faces of the Still-Face Paradigm: A review and meta-analysis. *Developmental Review*, *29*, 120–162.

Miller, A. L., McDonough, S. C., Rosenblum, K. L., & Sameroff, A. J. (2002). Emotion regulation in context: Situational effects on infant and caregiver behavior. *Infancy*, *3*, 403–433.

Milligan, K., Atkinson, L., Trehub, S. E., Benoit, D., & Poulton, L. (2003). Maternal attachment and the communication of emotion through song. *Infant Behavior and Development*, *26*(1), 1–13.

Noe, D., Schluckwerder, S., & Reck, C. (2015). Influence of dyadic matching of affect on infant self-regulation. *Psychopathology*, *48*, 173–183.

Papoušek, M. (2007). Communication in early infancy: An arena of intersubjective learning. *Infant Behavior and Development*, *30*, 258–266.

Pell, M. D. (2001). Influence of emotion and focus location on prosody in matched statements and questions. *The Journal of the Acoustical Society of America*, *109*, 1668–1680.

Phillips, R. (1995). *Infant-directed speech in African American mothers*. Doctoral dissertation. Available from EBSCOhost psyh database.

Porritt, L. L., Zinser, M. C., Bachorowski, J.-A., & Kaplan, P. S. (2014). Depression diagnoses and fundamental frequency-based acoustic cues in maternal infant-directed speech. *Language Learning and Development*, *10*(1), 51–67.

Radloff, L. S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement*, *1*, 385–401. 5

Rosenblum, K. L., McDonough, S., Muzik, M., Miller, A., & Sameroff, A. (2002). Maternal representations of the infant: Associations with infant response to the still face. *Child Development*, *73*, 999–1015.

Saint-Georges, C., Chetouani, M., Cassel, R., Apicella, F., Mahdhaoui, A., Muratori, F., & Cohen, D. (2013). Motherese in interaction: At the cross-road of emotion and cognition? (A systematic review). *PLoS One*, *8*(10), e78103.

Scherer, K. R. (2003). Vocal communication of emotion: A review of research paradigms. *Speech Communication*, *40*(1–2), 227–256.

Spinelli, M., Fasolo, M., & Mesman, J. (2017). Does prosody make the difference? A meta-analysis on relations between prosodic aspects of infant-directed speech and infant outcomes. *Developmental Review*, *44*, 1–18.

Spinelli, M., Fasolo, M., Tagini, A., Zampini, L., Suttora, C., Zanchi, P., & Salerni, N. (2016). Linguistic and prosodic aspects of child-directed speech: The role of maternal child-rearing experiences. *European Journal of Developmental Psychology*, *13*, 183–196.

Stern, D. N., Beebe, B., Jaffe, J., & Bennett, S. L. (1977). The infant's stimulus world during social interaction: A study of caregiver behaviors with particular reference to repetition and timing. In H. R. Schaffer (Ed.), *Studies in mother-infant interaction* (pp. 177–202). New York, NY: Academic Press.

Stern, D. N., Spieker, S., Barnett, R., & MacKain, K. (1983). The prosody of maternal speech: Infant age and context related changes. *Journal of Child Language*, *10*(01), 1–15.

Stern, D. N., Spieker, S., & MacKain, K. (1982). Intonation contours as signals in maternal speech to prelinguistic infants. *Developmental Psychology*, *18*(5), 727.

Stifter, C. A., & Braungart, J. M. (1995). The regulation of negative reactivity in infancy: Function and development. *Developmental Psychology*, *31*, 448–455.

Tarabulsy, G. M., Provost, M. A., Deslandes, J., St-Laurent, D., Moss, E., Lemelin, J. P., … Dassylva, J. F. (2003). Individual differences in infant still-face response at 6 months. *Infant Behavior and Development*, *26*, 421–438.

Trainor, L. J., Austin, C. M., & Desjardins, R. N. (2000). Is infant-directed speech prosody a result of the vocal expression of emotion? *Psychological Science*, *11*, 188–195.

Trevarthen, C. (1977). Descriptive analyses of infant communicative behaviour. In R. Schaffer (Ed.), *Studies in mother-infant interaction* (pp. 227–269). London, UK: Academy Press.

Tronick, E. Z. (1989). Emotions and emotional communication in infants. *American Psychologist*, *44*(2), 112.

Tronick, E., Als, H., Adamson, L., Wise, S., & Brazelton, T. B. (1978). The infant's response to entrapment between contradictory messages in face-to-face interaction. *Journal of the American Academy of Child and Adolescent Psychiatry*, *17*, 1–13.

Tronick, E. Z., & Gianino, A. (1986). Interactive mismatch and repair: Challenges to the coping infant. *Zero-to-Three*, *6*, 1–6.

Tronick, E. Z., Ricks, M., & Cohn, J. F. (1982). Maternal and infant affective exchange: Patterns of adaptation. In T. Field, & A. Fogel (Eds.), *Emotion and early interaction* (pp. 83–98). Mahwah, NJ: Lawrence Erlbaum Associates.
Weinberg, M. K., & Tronick, E. Z. (1998). Emotional characteristics of infants associated with maternal depression and anxiety. *Pediatrics*, *102*(5 Suppl E), 1298–1304.
West, B. T., & Galecki, A. T. (2011). An overview of current software procedures for fitting linear mixed models. *The American Statistician*, *65*, 274–282.