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ARTICLE

Silence matters: The role of pauses during dyadic maternal and paternal vocal interactions with preterm and full-term infants

Eliza KIEPURA[1], Alicja NIEDŹWIECKA[2], and Grażyna KMITA[1,2]

[1]Institute of Mother and Child, Warsaw, Poland and [2]Faculty of Psychology, University of Warsaw, Warsaw, Poland
Address for correspondence: Eliza Kiepura Institute of Mother and Child, Warsaw, Poland
E-mail: eliza.kiepura@imid.med.pl

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Abstract

This study examined the characteristics of the vocal behaviors of parents and preterm infants, as compared to their term-born peers, at three months of age. Potential links between specific features of parental IDS and infants' vocal activity were also sought. We analyzed the frequencies and durations of vocalizations and pauses during the dyadic interactions of 19 preterm and 19 full-term infants with their mothers and fathers. The results showed that the duration of the vocalizations was shorter for the preterm than for the full-term infants, regardless of the interactive partner. Mothers vocalized more frequently and for a longer time than fathers, regardless of the group, but only the frequency of paternal utterances was significantly and positively correlated with the frequency and duration of infant vocalizations. Frequent conversational pauses of a relatively short total duration seemed to be related to more active infants' vocal participation, regardless of prematurity and parent gender.

Keywords: preterm infant; vocal interactions; pauses in vocal interactions

Introduction

Infants' vocal development and interactional competencies

Infants are born with a progressive capacity to co-construct social interactions (Beebe, Alson, Jaffe, Feldstein & Crown, 1988; Delafield-Butt & Trevarthen, 2015). An extensive literature details human-specific early communication as being based on a turn-taking structure and the ability to alternate speaker-listener roles in a mutually matched and rhythmically timed manner (Delafield-Butt & Trevarthen, 2015; Jaffe, Beebe, Feldstein, Crown & Jasnow, 2001; Levinson, 2006). Interactive exchanges in which partners' vocal behaviors are coordinated with gaze, body movements, touch, hand gestures, and facial expressions indicating emotion have been broadly described as conversation-like and regarded as a building block for communicative development

(Bateson, 1975; Delafield-Butt & Trevarthen, 2015; Hilbrink, Gattis & Levinson, 2015; Levinson, 2006; Gratier, 2003). The ability to take part in interpersonally synchronized interactions can be observed as early as the neonatal period (Bateson, 1975; Gratier, Devouche, Guellai, Infanti, Yilmaz & Parlato-Oliveira, 2015; Papoušek, 1992).

From a developmental, as well as a clinical, perspective, infants' vocal activity during protoconversations with caregivers is viewed as a significant aspect of healthy development (Hilbrink et al., 2015; Hsu, Fogel & Cooper, 2000; Papoušek, 1992). Infants express themselves vocally from very early on. Oller and colleagues (Oller, Caskey, Yoo, Bene, Jhang, Lee, Bowman, Long, Buder & Vohr, 2019) documented that flexible production of vocants, squeals, and grunts occurs in preterm infants as soon as they are able to breath independently. At three months of age, infants continue to explore their vocal capabilities and start to produce more vowel-like vocalizations (Oller, Eilers & Basinger, 2001).

Early vocal development is associated with speech and language acquisition (Hilbrink et al., 2015; Hsu et al., 2000; Oller et al., 2001; Oller et al., 2019). Infants' vocalizations, which are precursors to speech, occur in both interactive and non-interactive circumstances. However, infants produce more speech-like vocalizations in the presence of an interactive partner, especially a responsive one (Hsu, Fogel & Messinger, 2001; Masataka, 1993).

Parental scaffolding of infant vocal communication

Parents and infants actively co-construct their exchanges from the earliest stages of a child's life. According to transactional and multilevel dynamic system theories (Fogel, 1982; Sameroff, 2010), the structure of parent-infant vocal interactions depends on both partners' input. However, early in life, there is a greater need for parental support and scaffolding for the infant's interactive behaviors (Sameroff, 2010). Parents intuitively support the early conversational competencies of their infants and facilitate an infant's vocal participation in early vocal interactions (Hilbrink et al., 2015; Hsu, Fogel & Messinger, 2001; Papoušek, 1992). According to Papoušek and Bornstein (1992, p. 210), parent-infant "interactional dialogues include innumerable episodes in which caregivers make themselves predictable, controllable, and contingent, initiate instrumental learning, and affectively reward successful learning. Communicative development and acquisition of speech represent the main targets of most naturalistic lessons."

One of the most powerful tools that caregivers use in their intuitive didactics is infant-directed speech (IDS): a structurally, prosodically, and semantically unique way of speaking while talking to preverbal children (Papoušek, 1992). In fact, IDS differs from the adult-directed speech (ADS) in syntax (more parallels, repetitive and simplified sentence structures), prosody (slower rate of speech, higher overall pitch, wider pitch contours) and lexis (shorter and simplified utterances) (Fernald, 1992; Papoušek, 1992).

Another characteristic feature of IDS concerns conversational pauses. Protoconversations consist of mutually coordinated periods of parental IDS, infant vocalizations, and pauses, which partly overlap. The temporal characteristics of culture-specific parent-infant communicative and expressive behaviors have been described as based on universally shared biobehavioral organization (Delafield-Butt & Trevarthen, 2015; Trevarthen, 2016). Some cross-cultural similarities have been found in the time structure of early mother-infant vocal exchanges, in which contingent vocal behaviors of mothers and infants are centered around 1–2 s within 1.5–5 s temporal

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units (3 s on average) and separated by longer pauses (Gratier, 2003; Keller, Lohaus, Völker, Cappenberg & Chasiotis, 1999). Parents intuitively adjust the duration of pauses to their children's ages: the older the infant, the shorter the pauses and the more complex the utterances (Marklund, Marklund, Lacerda & Schwarz, 2015).

Many researchers distinguish between intrapersonal and switching pauses. Intrapersonal pauses are instances of silence between an interlocutor's consecutive utterances. Switching pauses are instances of silence between one interlocutor's utterance and the other interlocutor's response (Beebe et al., 1988; Gratier et al., 2015; Jaffe et al., 2001). Both types of pauses were proven to be longer in IDS than in ADS (Beebe et al., 1988).

Frequent pauses, potentially aimed at giving an infant time to vocalize, might favor an alternating sequence of vocal communicative behaviors. An infant's active participation in vocal exchanges, together with parental language input (Soderstrom, 2007), lays the basis for child speech and conversational development (Oller et al., 2019; Golinkoff, Can, Soderstrom & Hirsh-Pasek, 2015).

Prematurity as the context of early vocal interactions between parents and preterm infants

Despite considerable improvements in neonatal care, prematurity is still considered a major risk factor for neurodevelopmental and mental health disorders. Neonates born very preterm are at an increased risk of neurocognitive, emotional, and behavioral disorders in childhood, adolescence, and adulthood (Aarnoudse-Moens, Weisglas-Kuperus, van Goudoever & Oosterlaan, 2009; Joseph et al., 2016; Wolke, Johnson & Mendonça, 2019). Even children who were born moderately to late preterm are not completely free from the risk of the above-mentioned developmental problems (Dotinga, de Winter, Bocca-Tjeertes, Kerstjens, Reijneveld & Bos, 2019).

Preterm birth may lead to compromised language development in the first years of life (Vandormael, Schoenhals, Hüppi, Filippa & Borradori Tolsa, 2019). As compared to children born at term, those born preterm (especially the extremely and very preterm) have weaker grammatical skills, comprehension, vocabulary, and phonological processing from early childhood into the school age years (Vandormael et al., 2019; Joseph et al., 2016). It is still a question of debate whether these difficulties are, in fact, specific language impairments or a result of atypical cognitive functioning. Furthermore, complex mechanisms are potentially implied in the atypical language development of preterm infants, including altered brain development and functional brain organization, structural abnormalities (white matter volume loss, delayed myelination, thinning of corpus callosum), exposure to specific environmental hazards in the NICU (exposure to noise and auditory stimuli inappropriate for the developing central nervous system), non-optimal and misattuned patterns of social interactions with parents, and their respective interrelations (see a review in Vandormael et al., 2019).

Preterm birth can have negative consequences for the quality of parent-infant communication (Feldman, 2007; Hall, Hoffenkamp, Tooten, Braeken, Vingerhoets & van Bakel, 2015). Preterm infants are often regarded difficult interaction partners because they may be more passive and less attentive and responsive while communicating with their parents in comparison with full-term infants (Montirosso, Borgatti, Trojan, Zanini & Tronick, 2010).

The parents of preterm infants are often described as more intrusive and less attuned to their children's cues as compared with parents of full-term infants (Agostini, Neri,

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Dellabartola, Biasini & Monti, 2014). However, the concept of intrusiveness is still under theoretical and methodological discussion (Fantasia, Galbusera, Reck & Fasulo, 2019). The specificity of interactions between preterm infants and their caregivers remains understudied, and existing results are inconclusive. In a prospective study by Poehlmann and Fiese (2001), low- and very low birthweight infants with a high level of perinatal health risks experienced more problematic interactions with parents at 6 months and obtained lower cognitive scores at the age of 12 months. Furthermore, intrusive and less cooperative patterns of mother-preterm infant interactions at 6 months were also significantly associated with compromised behavioral outcomes at 18 months (Forcada-Guex, Pierrehumbert, Borghini, Moessinger & Muller-Nix, 2006). However, in a systematic review of mother-preterm infant interactions and attachment, Korja, Latva, and Lehtonen (2012) cited studies in which the quality of mother-preterm infant interactions was at least as high as in full-term infants.

There is also a lack of data exploring the vocal interactions between preterm infants and their parents. Although it is known that both mothers and fathers use infant-directed speech while talking to preverbal children, regardless of the child's prematurity (Butler, O'Sullivan, Shah & Berthier, 2014), studies comparing the qualitative and quantitative characteristics of maternal and paternal IDS were conducted mainly with the parents of full-term infants. Furthermore, the results are inconclusive (see, e.g., Leech, Salo, Rowe & Cabrera, 2013). Research on gender differences in parental interactive behaviors is also insufficient. According to certain research projects (e.g., Johnson, Caskey, Rand, Tucker & Vohr, 2014; Kokkinaki, 2019), fathers tend to speak less to their infants than mothers. However, no such differences were found in the study of Papoušek, Papoušek, and Haekel (1987). Fathers were described as less verbally responsive than mothers in the study of Neri, Agostini, Perricone, Morales, Biasini, Monti, and Polizzi (2017), but the micro-analysis of parental speech directed at infants aged two to six months conducted by Kokkinaki (2019) showed no interparental differences in their tendency to refer to infants' emotions during spontaneous interactions.

Various forms of early vocal contact with parents have beneficial effects for language and communication development in preterm infants (Filippa & Kuhn, 2017). Parental responsiveness – namely, the contiguity and contingency of verbal input – is considered to play a crucial role in active language learning by infants (Tamis-LeMonda, Kuchirko & Song, 2014). Moreover, the rate of early vocalizations is predictive of later language performance in very-low-birth-weight children (Stolt, Lehtonen, Haataja & Lapinleimu, 2012). Therefore, enhancing vocal behaviors in preterm infants may be a port of entry for early intervention. This raises the questions of the specificity of preterm infants' vocalizations during protoconversations with their mothers and fathers.

In our study, we aimed to 1) examine the characteristics of vocal behaviors in preterm infants in comparison with full-term infants and in mothers as compared with fathers and 2) determine which characteristics of parental vocal behaviors promote the active vocal participation of the infant in protoconversations. To this end, we analyzed the frequencies and durations of vocal behaviors during maternal and paternal interactions with infants at the age of three months (corrected age in the case of preterm infants). On the basis of current knowledge, we assumed that preterm infants are less vocally active during vocal interactions and that both rich parental verbal input, as well as the ability to pause while talking to an infant are supportive of the infant's vocal activity during protoconversations. Thus, we hypothesized that preterm infants would vocalize less than full-term infants (H.1) and that a greater number of parental utterances, as well as pauses, would be related to a greater number of infant

vocalizations (H.2). Although we expected some differences between mothers and fathers' IDS use, no specific hypothesis was formulated, due to the limited extant evidence in the literature. Therefore, those analyses were exploratory.

Method

Study design

This study was part of a longitudinal project on the relational and biological predictors of self-regulatory processes in preterm children. The project followed the developmental trajectories of preterm children over the first year of life. The data were collected between 2008 and 2010.

Participants

Participants were recruited from two tertiary care hospitals. The exclusion criteria were multiple pregnancies and metabolic disease or genetic disorder. The sample included two groups of families with preterm infants, who were born extremely, very and moderately preterm, as well as the control group of families with full-term infants. Both parents were asked to take part in the study and provided written informed consent. The study was approved by the local institution's ethics committee and conformed to the Declaration of Helsinki.

Here, we present the data collected from the very and moderately preterm infants (28 to 34 weeks) (G1, n = 30) and the full-term (38 weeks or more) controls (G2, n = 30). The data were collected when infants were three months old (+/- 15 days), and in the case of preterm infants, the corrected age was calculated. Eleven families needed to be excluded from the analyses due to technical problems during recording or a violation of the study procedure: five families from the preterm group (G1) and six from the full-term group (G2). No significant differences were found between excluded and included participants with regard to the parents' age and completed years of formal education (all $ps > .05$). The final sample included 38 infants with their mothers and fathers: 19 preterm infants (nine girls) and 19 full-term infants (nine girls). The characteristics of the sample are presented in Table 1. All enrolled families were middle-class Caucasian inhabitants of a metropolitan area of a city with a population of more than 1.5 million. In all families, both parents were actively involved in caregiving. No statistically significant differences were found between mothers and fathers of preterm vs. full-term infants in terms of their age and completed years of formal education (all $ps > .05$).

All mothers and fathers were screened for postpartum depression (PPD) using the Edinburgh Postnatal Depression Scale (EPDS) (Cox, Holden & Sagovsky, 1987). A score of $\geqslant$13 on the EPDS was interpreted as a risk for PPD (Matthey, 2004). In the preterm group, four mothers and one father scored above the cut-off point of 12 on the EPDS, whereas none of the parents in the full-term group scored higher than 10 points. An independent-samples t-test demonstrated that mothers of preterm infants scored significantly higher on the EPDS than mothers of full-term infants, $t[36] = 2.767$, $p = .01$, 95% CIs [.212, .144]. No significant differences were found between fathers of preterm and full-term infants (all $ps > .05$).

Procedure

All families enrolled in the project were visited at their homes when the infants were three months old (corrected age in the case of preterm infants). No specific

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Table 1. Demographic characteristics of the sample

Variable	Group	*M*	*SD*	*Min*	*Max*
Gestational age at birth (weeks)	Preterm infants	31.26	1.66	29	34
	Full-term infants	39.58	1.26	38	43
Birth weight (grams)	Preterm infants	1657	370	770	2440
	Full-term infants	3418	523	2700	4900
Mother's age	Preterm infants	31.16	3.87	20	41
	Full-term infants	29.9	2.71	25	35
Father's age	Preterm infants	34.58	6.25	27	52
	Full-term infants	31.95	4.74	25	46
Mother's education (years)	Preterm infants	15.90	2.00	12	17
	Full-term infants	16.90	.99	15	20
Father's education (years)	Preterm infants	14.79	2.92	11	20
	Full-term infants	15.84	1.92	12	17
Mother's depression scores	Preterm infants	7.74	5.48	1	19
	Full-term infants	4.67	3.76	0	14
Father's depression scores	Preterm infants	3.89	2.58	1	10
	Full-term infants	4.95	3.05	1	10

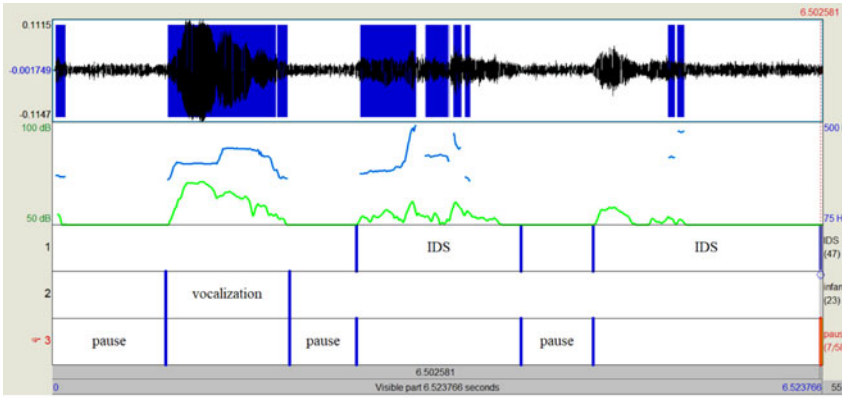

Figure 1. An exemplary illustration of the annotation of parental IDS, infant's vocalizations, and pauses

instruction was given to parents regarding what to do. Mothers and fathers were only asked to play with their infants "as they usually would." Parent-child protoconversations were recorded with a camcorder by the researcher, who was present in the room. The video camera was turned on once the parent was seated with the infant in a comfortable position. Five-minute-long video recordings were made separately for mothers and fathers. While one of the parents was interacting with the infant, the other parent was asked to stay away, far enough so as not to interfere. For the purpose of this study one-minute episodes (of parent-infant vocal interactions) were analyzed. We used the first minute without any disturbing sounds and with minimal interactive disruption attributable to the infant's condition (e.g., crying, hiccupping, or spitting) for the analysis. The video files were then converted into audio ones. Acoustic segments were subsequently presented in the form of spectrograms with the application of the PRAAT software (Boersma & Weenink, 2020). The TextGrid function was used to segment and label all the vocal behaviors and pauses. Three separate TIRES were created in the TextGrid to annotate all parental utterances, infant vocalizations, and pauses (see Figure 1).

All utterances, as well as phonetically distinguishable sounds, including sounds like whistling, tongue clicking, or sighing, were coded as IDS if they were directed toward the infant. Only non-distress and non-vegetative infant sounds were coded as vocalizations. Based on Hsu and colleagues (2000; 2001), effort sounds, whimpers, fusses, and cries were classified and marked on the spectrogram as negative vocalizations, and wheezes, sneezes, coughs, and hiccups were classified and annotated as vegetative sounds. Unlike in the mentioned works, infant laughs were included as non-distress vocalizations. Both negative vocalizations and vegetative sounds were excluded from the analysis; i.e., they did not add to either the number or the duration of infants' vocalizations. However, negative and vegetative infant vocalizations were considered infant sounds, which could delimitate the incidence of a pause. A pause was defined as a perceivable, at least 0.5 s, silence between any two vocal sounds (Gratier, 2003), regardless of whether the silence occurred between two consecutive infant vocalizations, two consecutive parent utterances, a parent's utterance and an infant's vocalization, or an infant's vocalization and a parent's utterance.

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In order to control the precision and reliability of extracting the parent and child vocal behaviors, thirty seconds from six randomly chosen recordings were double-coded by the first author and a trained coder. The obtained kappa values were .820 for infant vocalizations and .855 for parental utterances (see Supplementary Materials).

Analyses

We used a z-score scaling to standardize the data because some of the variables had different units (i.e., duration and number). Zero-order correlations were run between infant gestational age at birth and birth weight, parental EPDS scores, and the vocal behaviors of parents and infants, *i.e.,* the frequency of vocalizations, the total duration of vocalizations, the frequency of pauses, and the total duration of pauses. Mixed-design analyses of variance (2×2 ANOVAs) with "group" (preterm vs. full-term) as a between-subject factor and "parent" (mother vs. father) as a within-subjects factor were run to determine whether there were any significant differences between preterm and full-term infants and between mothers and fathers of preterm and full-term infants with regard to vocal behaviors. Partial correlations were used to examine whether, after controlling for infant gestational age, the number and duration of parental vocalizations and pauses were significantly correlated with the number and duration of vocalizations produced by the infant.

Results

Preliminary correlations

Mothers' EPDS scores were significantly and negatively correlated with infants' gestational age at birth and birth weight ($r = -.457$, $p = .004$ and $r = -.478$, $p = .002$, respectively): the lower the gestational age and birth weight, the higher the EPDS score. These correlations were non-significant for fathers ($ps > .05$). Of all infant vocal behaviors, only the total duration of vocalizations was significantly and positively correlated with infants' gestational age at birth, $r = .427$, $p = .008$: the higher the gestational age, the longer the total duration of vocalizations. None of the other characteristics of vocal behaviors in infants were significantly correlated with gestational age or birth weight. In mother-infant dyads, EPDS scores were not significantly correlated with any characteristics of maternal or infant vocal behaviors. Similarly, in father-infant dyads, the characteristics of vocal behaviors were not significantly correlated with EPDS scores. Therefore, depression scores were not included in subsequent analyses. A full matrix of zero-order correlations is presented in Table S1 (Supplementary Materials).

Frequencies and durations of vocal behaviors

Analyses revealed that preterm and full-term infants differed with regard to their vocal behaviors. First, regarding the number of vocalizations, there was a trend approaching significance for the main effect of "group", $F(1, 36) = 3.867$, $p = .057$, $\eta_p^2 = .097$. Preterm infants vocalized relatively less frequently with mothers ($M = 5.95$, $SD = 6.468$) and with fathers ($M = 4.79$, $SD = 5.006$) than full-term infants with mothers ($M = 9.26$, $SD = 4.931$) and with fathers ($M = 7.21$, $SD = 7.627$). The main effects of the "parent" and the "parent" x "group" interactions were non-significant (= 240, $\eta_p^2 = .038$ and $p = .741$, $\eta_p^2 = .003$, respectively). Second, for the total

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duration of vocalizations, there was a significant main effect on the part of "group", $F(1, 36) = 7.892$, $p = .008$, $\eta_p^2 = .18$. The total duration of vocalizations was shorter in the preterm group with mothers ($M = 2.547$ s, $SD = 2.305$ s) and with fathers ($M = 2.689$ s, $SD = 3.586$) than in the full-term group with mothers ($M = 5.884$ s, $SD = 4.718$ s) and with fathers ($M = 5.084$ s, $SD = 5.877$ s). The main effects of the "parent" and the "parent" x "group" interactions were non-significant ($p = 735$, $\eta_p^2 = .003$ and $p = .629$, $\eta_p^2 = .007$, respectively).

With regard to the number of vocalizations uttered by parents, there was no significant main effect on the part of "group" ($p = 377$, $\eta_p^2 = .022$). There was, however, a significant main effect on the part of "parent", $F(1, 36) = 23.267$, $p < .001$, $\eta_p^2 = .393$. Mothers ($M = 25.74$, $SD = 5.802$) vocalized more frequently than fathers ($M = 19.84$, $SD = 5.916$). There was not any significant "group" x "parent" interaction ($p = 701$, $\eta_p^2 = .004$). Similarly, with regard to the duration of parents' vocalizations, there was not any significant main effect on the part of the "group" ($p = .516$, $\eta_p^2 = .012$) or "group" x "parent" interactions ($ps = 361$, $\eta_p^2 = .023$). There was, however, a significant main effect on the part of "parent", $F(1, 36) = 16.721$, $p < .001$, $\eta_p^2 = .317$. The total duration of vocalizations was longer in mothers ($M = 32.839$ s, $SD = 7.726$ s) than in fathers ($M = 25.126$ s, $SD = 9.414$ s).

Regarding the number of pauses, there was not any significant main effect on the part of "group" ($p = .274$, $\eta_p^2 = .033$), but there was a significant main effect on the part of "parent", $F(1, 36) = 16.062$, $p < .001$, $\eta_p^2 = .309$. Mothers ($M = 27.95$, $SD = 6.195$) made more pauses than fathers ($M = 22.5$, $SD = 7.738$). There was not any significant "group" x "parent" interaction ($p = .455$, $\eta_p^2 = .016$). Similarly, with regard to the duration of pauses, there was not any significant main effect on the part of "group" or "group" x "parent" interaction ($ps = .885$, $\eta_p^2 = .001$ and $p = .464$, $\eta_p^2 = .015$, respectively) but there was a significant main effect on the part of "parent", $F(1, 36) = 8.904$, $p = .005$, $\eta_p^2 = .198$. The total duration of pauses was shorter in mother-infant interactions ($M = 24.484$ s, $SD = 8.672$ s) than in father-infant interactions ($M = 30.718$ s, $SD = 10.525$ s).

Relationships between parents' and infants' vocal behaviors

In order to test our hypothesis that, after controlling for infant gestational age at birth, the number and total duration of parental vocalizations and pauses would be significantly related to the number and total duration of infant vocalizations, we used partial correlations with gestational age as a controlled variable. A full matrix of partial correlations is presented in Table S2 (Supplementary Materials).

In mother-infant dyads, the number and duration of maternal utterances were not significantly correlated with the number and duration of infant vocalizations (all $ps > .05$). The number of pauses in maternal speech was significantly and positively correlated with the number of infant vocalizations, $r = .496$, $p = .002$ (see Figure 2.), while the duration of pauses was significantly and negatively correlated with the duration of infant vocalizations, $r = -.393$, $p = .016$ (see Figure 3). Furthermore, the duration of pauses was significantly and negatively correlated with the number of infant vocalizations, $r = -.462$, $p = .004$.

In father-infant dyads, the frequency of paternal utterances was significantly and positively correlated with both the frequency and the duration of infant vocalizations ($r = .522$, $p = .001$ and $r = .426$, $p = .008$) (see Figure 4). The duration of paternal vocalizations was not significantly correlated with infant vocal behaviors. The number

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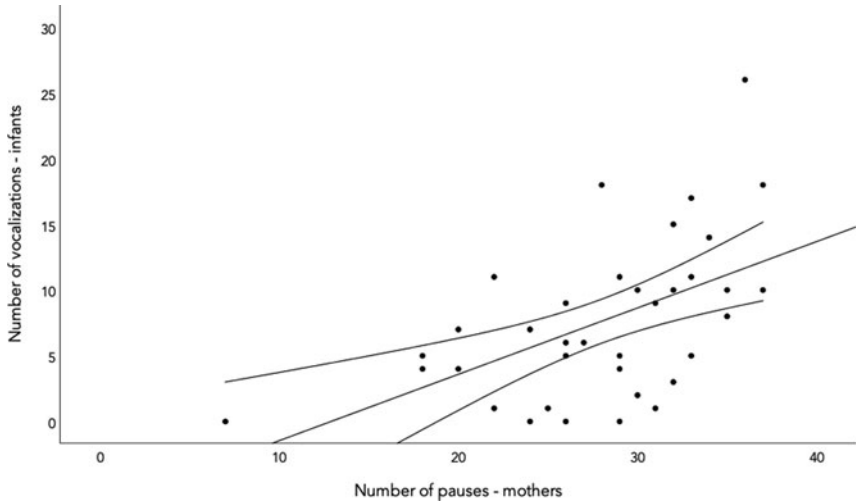

Figure 2. Correlation between the number of pauses in maternal speech and the number of infant vocalizations: individual cases (dots) with a regression line and 95% confidence intervals.

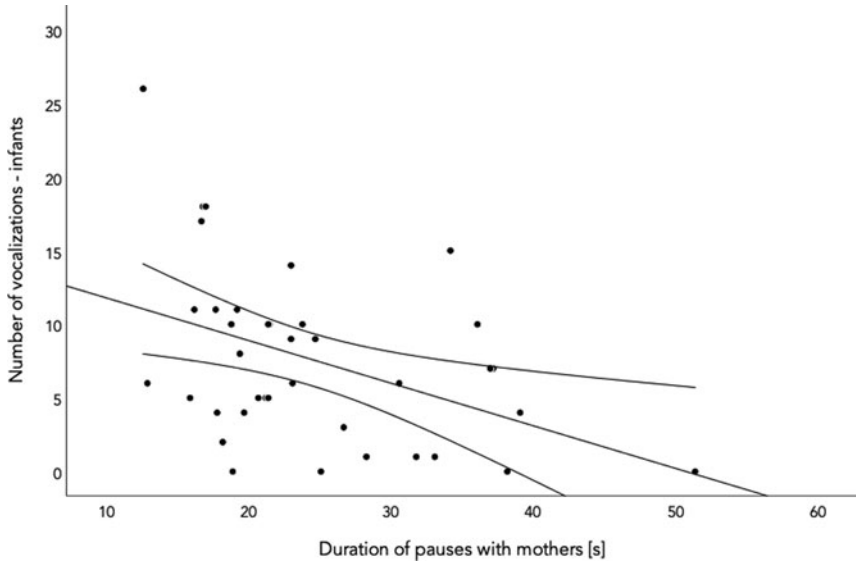

Figure 3. Correlation between the duration of pauses in maternal speech and the duration of infant vocalizations: individual cases (dots) with a regression line and 95% confidence intervals.

of pauses in paternal speech was significantly and positively correlated with the frequency and duration of infant vocalizations ($r = .711$, $p < .001$ and $r = .556$, $p < .001$, respectively). On the other hand, the duration of pauses was significantly and negatively correlated with the frequency and duration of infant vocalizations ($r = -.354$, $p = .031$ and $r = -.4$, $p = .014$, respectively) (see Figure 5).

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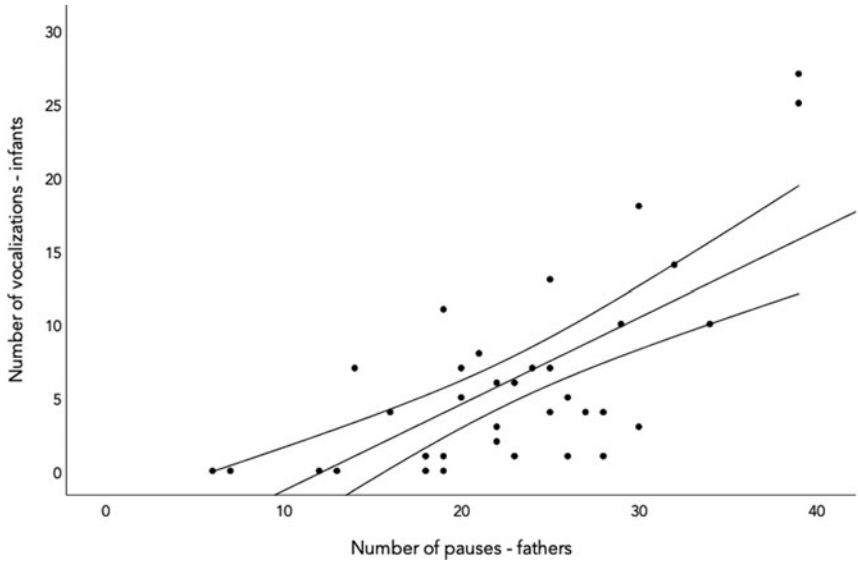

Figure 4. Correlation between the number of pauses in paternal speech and the number of infant vocalizations: individual cases (dots) with a regression line and 95% confidence intervals.

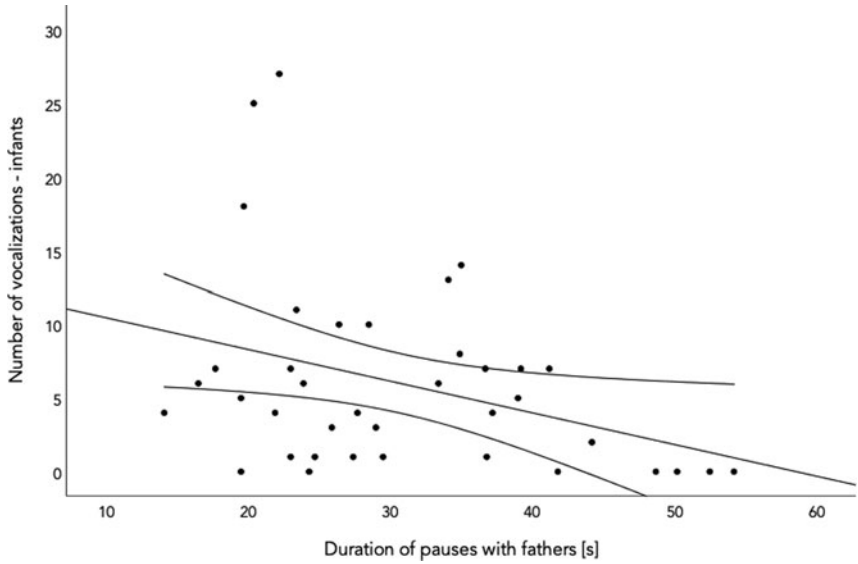

Figure 5. Correlation between the duration of pauses in paternal speech and the duration of infant vocalizations: individual cases (dots) with a regression line and 95% confidence intervals.

Discussion

In this study, we investigated the vocal interactions of preterm and full-term infants at the age of three months with their parents. Specifically, we examined how mother-infant and father-infant dyads with preterm infants differed from dyads with

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full-term infants, as well as whether parental IDS was related to the frequency and duration of child vocalizations.

The comparison of full-term and preterm infant protoconversations with mothers and fathers showed that preterm birth significantly affected the frequency and duration of infant vocalizations. As we hypothesized, preterm infants vocalized significantly less than full-term ones. Moreover, certain features of parental IDS may support the infant's vocal activity. Specifically, the conversational pauses in both maternal and paternal vocal interactions with infants, as well as the vocal behaviors of fathers, were associated with the frequency and duration of preverbal infants' vocalizations.

We found that frequent pauses in vocal interactions with both parents were significantly correlated with the infant's vocal behaviors regardless of the infant's preterm birth. This result highlights the significance of conversational pauses for infant vocalic behavior. Although, as we hypothesized, preterm infants vocalized less than full-term ones, they were more prone to vocalize during interactions intertwined with frequent pauses. Additionally, a longer total duration of pauses characterized dyads with infants who vocalized less frequently and for shorter periods of time. Thus, while frequent pauses of a relatively short total duration may enhance the infant's participation in vocal exchanges, lengthy pauses may be regarded as interactional disruptions. We cannot, however, rule out the possibility that frequent pauses may also be a byproduct of infants' vocalizing more often.

Although the results of our study confirmed the hypothesis regarding the relationship between the frequency of infant vocalizations and the parental tendency to pause, they do not answer the question of the direction of this relationship. Modifications to the dynamics of conversational pauses are well-documented intuitive adjustments of the speech parents direct toward their preverbal infants (Fernald, 1992; Marklund et al., 2015). According to Sameroff's dynamic model of development (2010), at the earliest stages of the child's life, the pattern of co-constructed parent-infant interactions is strongly shaped by the caregivers' input. This theoretical assumption indicates that it is the parental ability to stimulate infants verbally and pause that enhances infants' vocal activity during vocal interactions. On the other hand, parental IDS and conversational pauses might be seen as intuitive reactions to infants' vocalizations (Papoušek, 1992). Three-month-old infants spontaneously produce non-distressed vocalizations in the context of face-to-face interaction with caregivers (Bateson, 1975; Hilbrink et al., 2015; Masataka, 1993; Papoušek, 1992), which is true also for preterm infants (Oller et al., 2019). Parents, in turn, intuitively enhance infants' vocal signals via contingent verbal and non-verbal responses (Bornstein, Putnick, Cote, Haynes & Suwalsky, 2015; Hsu et al., 2000; Oller et al., 2001; Papoušek, 1992). From this perspective, frequent parental pauses that follow verbal or non-verbal maternal and paternal reactions to infants' vocal behaviors may be seen as behaviors aimed at giving the infant time to vocalize. A more detailed analysis of pauses (including a differentiation between the pauses that precede and those that follow infants' vocalizations, as well as their functions) is needed to better understand our results.

We did not find any significant differences in the frequency and duration of speech directed toward infants between parents of full-term and preterm infants. This stands in contrast with studies that reported mothers of preterm infants to be more prone to follow their infant's vocal behaviors in comparison with mothers of full-term infants (Crnic, Ragozin, Greenberg, Robinson & Basham, 1983; Reissland & Stephenson,

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1999; Suttora & Salerni, 2011). Firstly, our inability to confirm the significance of differences in both the frequency and duration of parental speech directed toward preterm versus full term infants does not mean that such differences do not exist. Furthermore, more well-designed studies are needed to disentangle this problem. Secondly, the similarities between parents with regard to the quantitative characteristics of their vocal interactions with infants found in this study may be related to the characteristics of the sample.

Our study focused on very and moderately preterm and relatively healthy infants, whereas a vast body of research indicates that the specificity of both parents' and infants' interactional behaviors is significantly stronger among very and extremely preterm infants (Agostini et al., 2014; Neri et al., 2017). It is possible that parents of very and moderately preterm infants without serious health issues do not differ from parents of full-term infants in the way they perceive children as communicative partners, despite the lower vocal activity of preterm infants. Perhaps, mothers and fathers see their preterm infants as just as capable of taking part in vocal exchanges as full-term infants.

Another possible explanation for our results might be related to the study's design. The present study focused solely on the vocal aspects of parent-infant interactions. Protoconversations are highly complex and multimodal. Vocalizations are intertwined with kinetic and tactile behaviors, as well as facial expressions of emotion (Bateson, 1975; Delafield-Butt & Trevarthen, 2015; Gratier, 2003). It is possible that both mothers and fathers responded verbally to some non-verbal but communicatively oriented signals from their preterm infants, which were not measured in this study. This may represent a compensatory mechanism of intuitive parenting.

Our results add to the understanding of the gender specificity of maternal and paternal vocal interactions with preverbal infants. Some researchers highlight certain similarities between mothers and fathers in global interaction characteristics: synchrony and co-regulation (Feldman, 2007), sensitivity (Bilgin & Wolke, 2015), and prosodic and syntactic modifications of IDS or intuitive didactics (Papoušek et al., 1987). These global similarities, which are especially observable in the earliest stages of a child's life (Laflamme, Pomerleau & Malcuit, 2002), co-occur with the gender-related specificity of parental behaviors.

Our results are consistent with previous works in showing some significant differences in maternal and paternal IDS. Overall, a body of research (Laflamme et al., 2002) has demonstrated that mothers speak more to their infants than fathers. For instance, Johnson and colleagues (2014) found, in a longitudinal study, that mothers provided approximately three times as much language input to their infants from birth through seven months of age as fathers. Moreover, fathers were also found to differ from mothers in the functional use of IDS (Niwano, 2003) and to ascribe less beneficial value to talking to infants (Kennison & Byrd-Craven, 2015). Finally, gender-specific parental differences were found in the duration of utterances (longer in mothers), pitch range of IDS (smaller in fathers), tempo of speech (a bit faster in fathers), and functions of IDS (Leech et al., 2013; Papoušek et al., 1987). During interactions with preterm infants, interactive disturbances were observed in both maternal and paternal interactions, but while mothers were found to be more controlling, fathers were more unresponsive (Neri et al., 2017).

Our results are in line with these studies in pointing to gender-specific differences in the quantity of maternal and paternal IDS. Mothers, in the present study, were found to

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be more verbally active than fathers during vocal interactions with infants. However, no statistically significant association could be found between the amount of maternal IDS and the frequency or the duration of infants' vocalizations. Both the frequency and total duration of full-term and preterm infants' vocalizations were related to the frequency of paternal IDS, however. Our results demonstrate that various characteristics of maternal and paternal IDS may be associated with infants' vocal behaviors. In mothers, who tend to speak a great deal during protoconversations, brief but repeated pauses may encourage the infant to participate in the vocal exchanges, rather than the amount of the verbal input itself. In fathers, however, frequent utterances were related to a higher frequency of infant vocalizations. Perhaps, as fathers tend to speak less than mothers, their verbal behaviors are more salient and thus even more effective in eliciting infants' vocalizations.

Moreover, paternal interactions are known to be more playful and characterized by more peaks of arousal and excitement as compared with maternal ones (Feldman, 2007; Neri et al., 2017). Such playful episodes of sharing joy and excitement were found to facilitate child vocalizations (Hsu et al., 2001; Kokkinaki, 2008). Therefore, it is possible that in the present study, paternal IDS was related to infant vocalizations due to certain qualitative characteristics of protoconversations.

In conclusion, our study suggests that the saliency of fathers' verbal input, in terms of the number of instances of IDS, may enhance infants' active vocal participation in protodialogues. This may be of special developmental and clinical importance. In light of the recent studies (Golinkoff et al., 2015), the processes of language acquisition and speech development not only require exposure to parental speech but also the child's active participation in vocal turn-taking. Thus, our results may have some significant clinical implications for early intervention, especially for preterm infants, who are at risk of having delays in speech and language development (Vandormael et al., 2019; Crnic et al., 1983; Foster-Cohen, Edgin, Champion & Woodward, 2007).

Limitations

The main limitations of our study are related to the characteristics of our sample and to the restricted length of the analyzed episodes of parent-infant interactions.

The subjects were moderately and very preterm infants without severe medical complications or developmental impairments. Therefore, the results cannot be generalized to extremely preterm infants or those with health or developmental issues. Moreover, the results may have been biased by the characteristics of the parents. The mothers and fathers enrolled in the project were relatively well-educated inhabitants of a metropolitan area. In all families, both parents lived with the child and were highly engaged in caregiving. Previous research revealed strong associations between socioeconomic status, parenting, and child developmental outcomes (see, e.g., Miser & Hupp, 2012; Pungello, Iruka, Dotterer, Mills-Koonce & Reznick, 2009). Our findings may only be pertinent to middle-class families with relatively minor socioeconomic burdens. Furthermore, the sample size was modest. A larger-scale study with a more socio-economically diversified sample could provide more in-depth results.

The episodes analyzed in this study were relatively short and limited to one recording session. Data collected in a wider range of interactional contexts would be more informative.

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Future directions

More studies are needed to better understand the function and dynamics of pauses in parent-infant communication and their developmental course. Including analyses of pause sequences and types of pauses in future research may deepen our knowledge of the role of pauses during parent-infant vocal interactions. Longitudinal studies would be of particular value because they could trace developmental trajectories, as well as stability and change in the characteristics and functions of pauses during parent-infant communication. Longitudinal data could shed light on the relationships between the patterns of preverbal parent-infant communication and children's language development.

The present analyses were limited to quantitative data. Only the frequencies of vocal behaviors and pauses were coded. Exploring interconnections between child vocalizations, parental IDS, other modalities of interactive behaviors (mimic expressions, touch, and body movement), and the semantic characteristics and linguistic functions of parental IDS could help in understanding the structure of participation in parent-child protoconversations, especially in clinical groups.

Although we found significant differences in the frequency and duration of maternal and paternal IDS, we were not able to confirm the differences in the frequency of infants' vocalizations with mothers and fathers. Combining qualitative and quantitative data in the analysis of parent-infant vocal interactions would be beneficial in better understanding the specificity of infants' vocalizations during interactions with mothers and fathers.

Conclusions

The results of the present study add to our growing knowledge of early maternal and paternal vocal interactions with moderately and very preterm infants. Frequent conversational pauses of a relatively short total duration may be beneficial for the infant's participation in vocal exchanges, regardless of parent gender and child prematurity. Additionally, the verbal activity of fathers was found to be significantly advantageous in increasing the frequency of infants' vocalizations. This result may have significant clinical implications for early intervention, especially for preterm infants, because active vocal participation in protodialogues serves as the basis for language acquisition and speech development.

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