Cultura, lenguaje y representación / *Culture, Language and Representation* Universitat Jaume I

Carvalho, Maria Eduarda Salgado, João Justo, Raul Rincón, Helena Rodrigues (2023): Communicative and affectionate features of motherese and preterm infants' vocalizations during kangaroo care: A microanalytical study. *Cultura, Lenguaje y Representación,* Vol. XXX, 243–264
ISSN 1697-7750 · E-ISSN 2340-4981
DOI: http://dx.doi.org/10.6035/clr.6950

Communicative and affectionate features of motherese and preterm infants' vocalizations during kangaroo care: A microanalytical study

Características lingüísticas y prosódicas del motherese y las vocalizaciones de los bebés prematuros durante el método canguro

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Artículo recibido el / *Article received*: 2022-10-28
Artículo aceptado el / *Article accepted*: 2023-04-15

ABSTRACT: Motherese has been studied particularly in its prosodic features. The scientific literature has underlined the importance of this type of communication on the infants' vocal responsiveness. However, we still know little about the role of motherese on preterm infants' vocal responsiveness. We intend to know the prosodic and communicative characteristics of motherese in preterm dyads

[1] The contributions made by each of the authors in this paper are: Maria Eduarda Salgado Carvalho: study design, participants recruitment, data collection and codification, statistical analysis and paper writing; João Justo: statistical analysis and paper writing; Raul Rincón: accoustic codification, accoustic data analysis, and paper writing; Helena Rodrigues: paper review.

DOI: http://dx.doi.org/10.6035/clr.6950

and particularly to understand its relationship with the preterm infant's vocal responsiveness. At NICU, mothers (N = 38) were asked to speak and to sing without words (humming) to their preterm infants in kangaroo care during five periods of three minutes alternating voice and silence, controlling the order effect (silence – speech or humming – silence – humming or speech – silence). A microanalytical study about prosodic and communicative/affectionate features of motherese was performed using ELAN, MAXQDA, and PRAAT software. According to results, tonal contours (sinusoidal, U-shaped and falling) and infants' vocalizations seem to contribute for preterm dyads' vocal modulation. A high use of phatic and conative functions, interrogative utterances, infants' positive aspects, infants designated by affectionate words, and utterances connected with infants' needs were observed. This study contributed to explore the role of the communicative/affectionate and prosodic features of the motherese on preterm infants' vocal responsiveness during the kangaroo care in NICU. Still, more studies are needed to deepen these preliminary results.

Key words: preterm infants, maternal speech, communicative and affectionate features, prosodic features, infant's vocalizations, kangaroo care.

RESUMEN: *Motherese* ha sido estudiado especialmente en características prosódicas. La literatura científica ha destacado la importancia de este tipo de comunicación en la capacidad de respuesta vocal de los bebés. Sin embargo, todavía sabemos poco sobre el papel de *motherese* en la capacidad de respuesta vocal de los bebés prematuros. Nos proponemos conocer las características prosódicas y comunicativas del motherese en díadas de prematuros y comprender su relación con la responsividad vocal del prematuro. En la UCIN, se les pidió a las madres (N = 38) para que hablen y canten sin palabras (*humming*) a sus bebés prematuros en cuidado canguro (*kangaroo care*) durante cinco períodos de tres minutos alternando voz y silencio controlando el efecto de la secuencia (silencio – habla o *humming* – silencio – *humming* o habla – silencio). Se realizó un estudio microanalítico sobre las características prosódicas y lingüísticas del *motherese* utilizando los softwares ELAN, MAXQDA y PRAAT. Según los resultados, los contornos tonales (sinusoidales, en forma de U y descendentes) y las vocalizaciones de los bebés parecen contribuir a la modulación vocal de las díadas prematuras. Se observó un alto uso de funciones fáticas y conativas, enunciados interrogativos, aspectos positivos de los bebés, bebés designados por palabras afectivas y enunciados relacionados con las necesidades de los bebés. Este estudio contribuyó a explorar el papel de las características comunicativas/afectivas y prosódicas del *motherese*, en las vocalizaciones del bebé prematuro durante el método canguro en la UCIN. Todavía, se necesitan más estudios para profundizar estos resultados preliminares.

Palabras clave: prematuros, habla materna, características comunicativas y afectivas, características prosódicas, vocalizaciones del bebé, cuidado canguro.

1. INTRODUCTION

As a primordial human experience, maternal voice seems to play a crucial role on human early interaction since prenatal life (Carvalho *et al*., 2019a). Fetal auditory development depends on brain maturation (Kisilevsky *et al*., 2011). At the beginning of gestation, the fetus is particularly sensitive to low-frequency sounds while at the end of gestation he will be able to react to high-frequency sounds (Spence *et al*., 1987) as well as to processing phonemes of language (Lecanuet *et al*., 1987). The mother's voice is also perceived by the fetus from the 32nd week of gestation on (Kisilevsky *et al*., 2009, 2011).

Preterm infants are at higher risk for language deficits, with phonological neural discrimination being strongly compromised due to neurological immaturity (Kisilevsky *et al*., 2014; Pena *et al*., 2012). Auditory speech discrimination deficits in preterm infants at term-equivalent age may predict language developmental disturbances (Bartha-Doering *et al*., 2019) and difficulties in speech processing capacity during the first year of life (Fellman *et al*., 2004). However, no significant differences were found between healthy preterm infants and infants born at term regarding the auditory processing of speech sounds (Kostilainen *et al*., 2020).

Although preterm birth is associated with psychological risk for maternal anxiety and depression (Keren *et al*., 2003) impacting the mother-infant relationship (Zelkowitz *et al*., 2007), inconsistent results about early relationships point to the need for more research in this field. The prosodic characteristics of motherese seem to be affected by maternal emotional states, namely depression (Bettes, 1988; Lam-Cassettari *et al*., 2020). When addressing their infants, depressed mothers use less motherese style, lower mean pitch, smaller pitch range, slower verbal responsiveness, and express less positive affect than non-depressed mothers (Lam-Cassettari *et al*., 2020). Before birth, the frequency of motherese addressed to the unborn infant appears to be negatively affected by maternal depression (Parlato-Oliveira *et al*., 2021).

Maternal behaviors predict the development of preterm infants' abilities during the first years of life (Landry *et al*., 1997). This underlines the importance of enforcing intervention programs of neonatal care centered on the family and on the neurodevelopment of the infant, improving the contingent interaction of preterm dyads in NICU. In this way, as a multimodal experience, kangaroo care is a current method in NICUs, with positive effects at promoting contingent interaction and self-regulation of preterm infants (Fluharty *et al*., 2021). Comparatively with the usual kangaroo care, more vocal contingent interactions of preterm dyads were found when preterm infants were positioned diagonally in skin-to-skin contact allowing gaze contact. This positioning is designated "kangaroo supported flexion diagonal positioning" (Buil *et al*., 2016).

The use of live parental voice (speech, singing or humming) directed to preterm infants in NICU has been encouraged, emphasizing the neonatal care centered on the family and on the infant neurodevelopment (Filippa *et al*., 2021; Shoemark *et al*., 2021). Live parental speech directed to preterm infants in NICU increases infants' vocalizations (Caskey *et al*., 2011) improving the pre-linguistic and cognitive development of preterm infants (Caskey *et al*., 2014). However, questions remain about how these infants are able to process the communicative and phonological aspects of speech. The deepening of this knowledge may contribute to a more effective intervention about the way we should vocally interact with the preterm infant.

From birth, mothers use a melodic and affectionate intonation when talking to their newborns contributing to the early development of communicative musicality (Malloch & Trevarthen, 2009). This specific form of speech used by mothers to address their infants has been designated by motherese or infant directed speech (Fernald, 1989;

 DOI: http://dx.doi.org/10.6035/clr.6950

Grieser & Kuhl, 1988; Cooper *et al*., 1997). Pragmatic and communicative aspects of motherese have been less analyzed than prosodic aspects. The literature about characteristics of motherese directed to newborns is scarce and, particularly the motherese directed to preterm infants has been understudied, both in its prosodic and pragmatic aspects.

Literature underlines four components of language prosodic function: 1) "affect" – liking versus disliking, 2) "turn-end" – understanding questions versus statements, 3) "chunking" –prosodic phrasing, and 4) "focus"– central emphasis on a specific word (Filipe *et al*., 2017). The first function of motherese is to engage and maintain the newborn's attention (Bozzette, 2008; Eckerman *et al*.,1994), providing auditory stimuli to which the newborn can respond (Dunbar, 1993; Fernald, 1991). Specific features of motherese are well documented in literature (Fernald & Kuhl, 1987; Cooper *et al*., 1997; Fernald, 1991; Macwhinney & Snow, 1985; Snow, 1972, 1977). Comparatively to adult-directed speech, motherese is typically characterized by exaggerated intonation (high pitch level) and positive affect playing a key role in the infant's vocal responsiveness. Motherese also presents longer pauses, slower tempo, more prosodic repetitions, and better clarification of vowel space as well as vowel duration (Hartman *et al*., 2017). Its exaggerated prosodic properties assist infants in segmenting the speech sequence and detecting regularities (Hartman *et al*., 2017). Boundary cues of intonational phrases are processed early in children's language development (Frota, 2016). Also, the early discrimination between phonetic units of native and non-native language is enhanced by social interaction (Kuhl *et al*., 2003; García-Sierra *et al*., 2021).

Regarding the prosodic features of motherese, tonal contours play important functions for communicative intentionality and may be modulated in a contingent way encouraging the infants' vocal responsiveness (Falk, 2011; Fernald, 1989; Papousek *et al*., 1991). Tonal contours of motherese were classified in order to identify distinct communicative functions during early vocal interactions (Fernald, 1989; Papousek, 1996): 1) falling and bell-shaped utterances allow a decrease in infants' state of arousal, helping to conclude a turn or to express approval; 2) rising and U-shaped utterances improve infants' attention, increasing their arousal level and helping them to take a turn; 3) sinusoidal utterances sustain infants' attention, ensuring a moderate level of arousal, and 4) linear utterances support the maintenance of a minimum level of arousal, keeping infants in a calm condition. Previous studies showed that, in tonal (Thai) and non-tonal (Australian English) languages, prosodic aspects of motherese change (pitch average, pitch range and tonal contours) according to infants' age as well as to infants' gender (Kitamura *et al*., 2001). A higher pitch average, a higher pitch range and more rising utterances were found in Australian English motherese directed to female than to male infants. Also, a lower average pitch and more frequent falling utterances were observed in Thai motherese directed to female than to male infants (Kitamura *et al*., 2001). When mothers address their infants, rising utterances are used to initiate eye contact with the infant, while sinusoidal and bell-shaped utterances are used to maintain the infants' gaze and positive affect (Stern *et al*., 1982).

Regarding turn-taking during motherese, the latency time of full-term newborns' contingent vocalizations is 1000 milliseconds in average (Dominguez *et al*., 2016). In a similar way, the contingent vocal responses of preterm infants to motherese occur within a latency time of 800 milliseconds in average (Carvalho *et al*., 2019b). Contingent maternal behavior (like imitation) increases the infants' vocal responsiveness (Goldstein & Schwade, 2008; Pelaez *et al*., 2011). Also, infants' vocalizations play a crucial role for vocal interaction with their mothers, eliciting more maternal vocalizations than what infants' gaze contact or smile can do (Van Egeren *et al*., 2001). Prosodic changes of

motherese directed to preterm infants (an increase in pitch) were found after infants' positive signals, like vocalizations and facial expressions (Filippa *et al*., 2018). This suggests that early vocal interaction is reciprocal and modulated by both partners (Lavelli & Fogel, 2013). A microanalytical study observed that preterm infants vocalize less frequently while their mothers talk and hum to them than during silent baseline; in addition, turn-taking is more frequent during the speech condition while overlapping vocalizations are more frequent during the humming condition (Carvalho *et al*., 2019b). This suggests an early ability of the preterm infant to process the temporal structure of the addressed maternal speech.

About multimodal communication, motherese elicits preterm infants' responsiveness increasing eye opening and behavioral attention state (Eckerman *et al*., 1994), decreasing motor activity, increasing wakefulness, and presenting eye widening as well as facial tone (Bozzette *et al*., 2008). Self-exploration behavior (self-touch), as a marker of infant's self-regulation, and eye-opening has been found in preterm infants when mothers speak or sing to them in NICU (Filippa *et al*., 2020).

Concerning the pragmatic features of motherese, a previous study (Pessoa & Seidl de Moura, 2008) based in Jakobson's Model (1961) considered four communicative functions: 1) emotive function (message centered on the mother, involving attribution of meanings, adjectives and complements); 2) referential function (context-centered message, involving descriptions of actions, objects, people, etc.); 3) conative function (message centered on the infant, involving imperatives, requests, request for a response), and 4) phatic function (message to maintain the communication, non-propositional utterances, onomatopoeic sounds and monosyllabic interrogative contractions).

Motherese is simplified pragmatically, grammatically and semantically with a simplified and redundant structure of the utterances (repeating a small number of words), a high use of vowels and suppression of some consonants, along with whispers and onomatopoeia (Snow *et al*., 1972). Narrative content is often focused on the present time with a frequent use of interrogative and imperative utterances and often using first names (Paavola *et al*., 2005). Several authors highlighted the role of infants' feedback relative to motherese development (Pêcheux *et al*., 1993; Trevarthen, 1993). When addressing newborns, mothers engage in conversations playing the role of the infant and simulating him to be the one that speaks (Rheingold & Adams, 1980). This means that newborns are considered as partners in the exchange being able to capture their mothers' intentions and emotions. Mothers express a wide range of communicative intentions (Snow *et al*., 1996) which are crucial for children language acquisition. These communicative intentions also help us to understand the cross-cultural variations and the individual variations of the infants' development (Pan *et al*., 1996). Changes in the expression of mothers' communicative intentions are related to children's communicative and linguistic development. Mothers' acknowledgement of developmental changes in their children's communicative skills induces changes in maternal communicative intentions during interaction (Rivero, 2010). Regarding to communicative and affectionate features, the positive affect of motherese undergoes intention variations according to infants' age. At three months of age, the mother's positive affect is primarily intended to provide comfort while at six months, it usually serves to express affection. At nine months, the positive affect of motherese is used to capture the infants' attention and engagement, inciting the infants' responsiveness during the turn-taking (Kitamura *et al*., 2003).

A study with full-term dyads underlined a change of linguistic contents of motherese according to the infants' behavioral state; when addressing their newborns while drowsy, mothers use more verbs to refer to physiological issues, volition, or communication (Dominguez *et al*., 2017). Nevertheless, we didn't find any studies about

 DOI: http://dx.doi.org/10.6035/clr.6950

motherese linguistic contents directed to preterm infants. Studies in this field are based on maternal reports during psychological support sessions without the presence of the preterm infant (Correia *et al*., 2008). Among the contents of these maternal reports, the maternal representation of the preterm infant seems to be a useful indicator for the understanding of the early relationship. When mothers address their preterm infants, probably the verbal contents of the motherese express the maternal representations about the infants and about the relationship with them. This way, one of the goals of our study will be to identify the communicative and affectionate features of motherese that can be associated with the maternal representation of the preterm infant during kangaroo care in NICU.

Studies about the pragmatic features of motherese offer relevant contributions for the understanding of language development processes which are compromised in preterm infants. The state of the art highlighted an important role of parental voice on the responsive behavior of preterm infants (Bozzette, 2008; Dunbar, 1993; Eckerman *et al*.,1994; Fernald, 1991; Filippa *et al*., 2020), and particularly on their vocal responsiveness (Caskey *et al*., 2011), as well as in their pre-linguistic development (Caskey *et al*., 2014). However, it is unclear whether preterm infants are able to extract linguistic regularities of speech. Therefore, it is important to clarify which prosodic characteristics of motherese in preterm dyads can influence the infants' vocal responsiveness. Considering that preterm infants' behavior can increase the pitch level of motherese (Filippa *et al*., 2018) it is expected that preterm infants' vocalizations can influence the prosodic features of motherese. However, we didn't identify any studies that have been carried out for this purpose.

Microanalytical studies have been developed to clarify the temporal organization of mother-infant vocal interaction in NICU (Carvalho *et al*., 2019b; Filippa *et al*., 2018; 2020; 2021; Palazzi *et al*., 2021). Likewise, we intend to develop a microanalytical study to explore the role of motherese in preterm dyads during kangaroo care in NICU. In this study we intended to know: 1) the communicative and affectionate features of motherese in preterm dyads; 2) the impact of the prosodic features of motherese on infants' vocal responsiveness; and 3) the effect of infants' vocalizations on prosodic features of motherese.

2. METHODS

2.1. DESIGN

Participants were mothers of preterm infants being cared for at the NICU of a Portuguese maternity hospital recruited for a previous study about vocal interactions in preterm dyads (Carvalho *et al*., 2019b). After admission in NICU, participants were selected according to inclusion and exclusion criteria followed by an invitation addressed by the first author. All mothers signed informed consent and agreed to be videotaped for microanalytical analysis. Mothers and their preterm infants were in skin-to-skin contact, using the method of "kangaroo supported flexion diagonal positioning". Preterm infants were in a state of quiet alertness or drowsiness (Brazelton & Nugent, 2011) at the beginning of the observation.

Mothers were asked to hum (improvising a melody without words) or to speak (in a motherese style) to their infants using a 15-minute protocol. This protocol was composed of 5 consecutive stages, lasting for 3 minutes each: 1) silent baseline, 2) speech or humming, 3) silence, 4) humming or speech, and 5) silence. The order effect was controlled. During the three periods of silence, mothers were asked to remain silent

although without interrupting visual or tactile contact with their infants. During the observed sequence, the first author of this study was always present signaling, for the mothers, the change of condition in each of the 5 periods.

Participants were excluded from the study based on the following criteria: 1) mother being younger than 19 years old, 2) difficulties understanding and speaking the Portuguese language, 3) mother or infant having an auditory deficit, 4) pregnancy without medical supervision, 5) previous or current psychiatric pathology, and 6) addictive behaviors. Dyads were also excluded if during observation infants had any of the following conditions: 1) post-menstrual age lower than 32 weeks or higher than 37 weeks, 2) unstable vital parameters, 3) Continuous Positive Airway Pressure support, 4) intraventricular hemorrhages, 5) congenital neurological anomalies of the auditory cortex, 6) nasogastric tube, and 7) breathing support. Dyads were also excluded if skin-to-skin kangaroo care had not been practiced at least once.

2.2. PARTICIPANTS

Fifty dyads were initially recruited and there were no refusals. Due to hospital routines and personal issues, 10 dyads were not able to participate in the study. Due to sound interference incompatible with the study protocol during the recording process, two dyads were excluded. The final sample included 38 dyads; because they had twins, 3 mothers were observed interacting with 2 infants one at a time. Mothers (N = 38) were mostly of Portuguese nationality (n = 26) and the remaining participants (n = 12) were Brazilian nationals or from African countries where Portuguese is the official language. All mothers were fluent in Portuguese language and had lived in Portugal for more than 7 years. Ages ranged from 21 to 48 years (M = 34.21, SD = 6.57), education was of university level (number of successful years of education: M = 15.21, SD = 3.64). Based on the educational level, socioeconomic status was considered of medium-high level.

Regarding preterm infants, the gender ratio (21 males vs. 17 females) reflected the vulnerability of male infants to prematurity. Gestational age at birth was around 30 weeks (days, M = 212.21, SD = 18.11, min. = 173, max. = 241) and birth weight was 1273.47 g on average (SD = 348.19, min. = 590 g, max. = 2165 g). At observation, the average of infants' gestational age was 240 days (SD = 9.77, min. = 224, max. = 262), the average weight was 1560.39 g (SD = 254.96, min. = 1060 g, max. = 2185 g). The average chronological age at the observation moment was 27.79 days (SD = 22.07, min. = 4, max. = 89).

2.3. MATERIAL AND EQUIPMENT

A Sociodemographic and Clinical Questionnaire was used in order to collect basic information about participating dyads and their obstetric and pediatric background. A video recording (MP4) and an audio recording (WAV) were made for each dyad. One camera (Panasonic 4K HC-VX870) was oriented toward the mother and the infant, and an expanded image was captured of both mother and infant faces (see Figure 1). The camera was connected to an external microphone placed near the dyad. The mother was provided with a large scarf for holding the infant in skin-to-skin contact during kangaroo care. According to "kangaroo supported flexion diagonal positioning", an additional strap was provided to support the infant's neck, enabling the mother to see the infant's face.

ELAN software (EUDICO Linguistic Annotator, version 4.9.4) was used to code the vocalizations of the mother-infant dyads. PRAAT software was used to analyze acoustic parameters of motherese, namely pitch/F0 (Hz), intensity (dB) and tonal

 DOI: http://dx.doi.org/10.6035/clr.6950

contours (linear, bell-shaped, U-shaped, sinusoidal, rising and falling) before and after infant's contingent vocalizations. Regarding the communicative and affectionate features of motherese we used the MAXQDA software to analyze all maternal utterances.

Figure 1. Kangaroo care with supported flexion diagonal positioning

2.4. CODING CRITERIA OF MATERNAL AND INFANTS' VOCALIZATIONS

To estimate the latency time of infants' vocal responses to motherese, it was considered the time between the end of maternal utterance and the beginning of the infants' vocalizations. Similarly, regarding the latency of maternal utterances of motherese it was considered the time from the end of the infants' vocalizations until the beginning of the maternal utterances.

The codification of motherese was based on temporal segmentation criteria according to temporal criteria established by Gratier *et al*. (2015); each utterance was temporally codified from the start to the end of the vocal emission before a breathing break or an intentional break, and these intentional breaks were codified when the utterance was interrupted for more than 300 milliseconds (ms). According to temporal criteria indicated by previous studies (Dominguez *et al*., 2016; Carvalho *et al*., 2019b), it was considered as an infant's contingent vocalization the one that occurs in the latency time between 300 ms and 3000 ms.

Regarding the acoustic analysis, we considered as parameters the pitch/F0 (Hz), the intensity (dB) and the tonal contours (linear, bell-shaped, U-shaped, sinusoidal, rising and falling) of all maternal utterances before and after the infants' contingent vocalizations (latency time between 300 ms – 3000 ms).

Taking maternal utterances as a temporal unit, acoustic variations of maternal utterances before and after infants' vocalizations were compared. For this, at first, we selected all contingent infants' vocalizations. Secondly, we selected maternal utterances that preceded and those that followed the infants' vocalizations. After segmenting these vocal episodes using Elan software, audio files were imported in PRAAT software. Each maternal utterance, as a unit, was analyzed regarding F0 (Hz), intensity (dB) and tonal contours to compare averages of F0, intensity and tonal contours before and after infants' vocalizations. The criteria for acoustic analysis in PRAAT was based on the study about the pitch of the puerperal women's voice (Pisanski *et al*., 2018).

Regarding communicative and affectionate features of motherese, each maternal utterance could be coded according to one or several of the seven categories and subcategories created for this study (see Table 1). These categories were created according to features of motherese referenced in literature, such as elements of expressiveness (onomatopoeias, repetitions, anaphors), type of utterances (declarative, interrogative, exclamatory, imperative) and communicative functions (vocative, conative,

emotional, referential, and phatic). Reading the global verbal contents of motherese we identified aspects related to maternal representation about the infant, like infant's designation, his physical and temperamental characteristics, and care centered on the infant's needs or on the mother's needs.

Table 1. Communicative and affectionate categories and subcategories of motherese

Categories	Subcategories	Definitions	Examples
speech intentionality	interrogative	when mothers appeal to the infants to answer a question	What happened?
	exclamatory	when mothers address the infants expressing an emotion about them	My dear!
	declarative	when mothers describe an event about themselves, about the infants or about others	You are here at the mommy's lap.
	vocative	when mothers call or appeal to the infants	Hello.
	imperative	when mothers state a command, prohibition or advise the infants	Look at Mom.
forms of expressiveness	anaphors	when the first element of a segment is repeated in two or more consecutive segments	Hello baby. Hello my love.
	variations	when the sequence of the elements is changed in two or more consecutive segments	Baby is beautiful, beautiful is my baby.
	repetitions	when several elements of each segment are repeated in the same sequence in two or more consecutive segments	Hello. Hello.
communicative function	conative	when mothers engage the infants directly, appealing to the infants' participation	What happened?
	phatic	when mothers address and sustain communication with the infants	Hello baby!
	emotive	when mothers speak on behalf of the infants or address the infants in an affectionate way	I am a little princess!
	referential	when maternal speech refers to the environment or events in the present moment	The baby is sleepy!
speech connected with infants' or maternal needs	infants' needs	when mothers convey their speech according to the infants' needs	I am so sleepy!
	maternal needs	when mothers convey their speech according to their own needs	You don't care about me!
infants' designation	baby	when mothers address the infants using the word "baby"	Hello baby!
	little boy/girl	when mothers address the infants using the words "little boy" or "little girl"	My little boy is hungry!
	son/daughter	when mothers address the infants using the words "son" or "daughter"	Hello my son!

 DOI: http://dx.doi.org/10.6035/clr.6950

	first name	when mothers address the infants using the infants' first names	David.
	diminutive	when mothers address the infants using the diminutive of the infants' first names	Little Peter.
	affectionate words	when mothers designate the infants using affectionate words	My little princess!
infants' physical features	positive	when mothers address the infants using the infants' positive physical features	You have grown fingers.
	negative	when mothers address the infants using the infants' negative physical features	I am very little.
infants' temperamental features	positive	when mothers address the infants using the infants' positive mental features	You are mommy's strong warrior.
	negative	when mothers address the infants using the infants' negative mental features	Lazy!

2.5. RELIABILITY

Two researchers performed an independent coding of the data for 30% of the maternal utterances in two aspects: speech temporal segmentation (ELAN) and speech linguistic features (MAXQDA). Inter-observer reliability was estimated via intraclass correlation coefficients (ICC). High agreement coefficients were found for the frequency of vocalizations and pauses in maternal speech: speech vocalizations (ICC = .991, p = .000); 2) pauses in speech (ICC = .985, p = .000). Agreement coefficients for frequencies of communicative and affectionate features of maternal speech varied between .862 (p = .004) and 1.

3. RESULTS

3.1. DESCRIPTIVE ANALYSIS OF MATERNAL UTTERANCES AND INFANTS' VOCALIZATIONS

A total of 2270 maternal utterances (M = 60.72, SD = 10.37, 45-83) was observed on 38 dyads. Only 30 mothers had their infants vocalizing at least once. Within these mothers, we identified 1791 maternal utterances (M = 59.70, SD = 10.20, 44-81) and 243 infants' vocalizations (M = 8.10, SD = 6.89, 1-26) were found during motherese.

To identify the episodes of contingent vocal interactions of preterm dyads, we selected the total maternal utterances preceding or following the infants' vocalizations, in a latency time between 300 ms and 3000 ms according to temporal criteria by Gratier and team (2015). Based on these criteria, we found 158 maternal utterances that occurred, in a contingent response, after the end of an infant vocalization. Among the total of infants' vocalizations (N = 243), we identified 161 (66.25%) infants' contingent vocalizations that occurred after the end of a maternal utterance.

Latency time of infants' vocal responses to motherese, as well as the latency time of maternal utterances to infants' vocalizations were estimated. According to results, latency time average (ms) of the infants' vocal responses to maternal utterances (M = 917, SD = 422, min. = 13, max. = 1890) was similar to the latency time average of maternal utterances after the infants' vocalizations (M = 977, SD = 711, min. = 12, max. = 3400).

Only infants' vocalizations with a latency time equal or shorter than 3000 ms were considered to analyze the infants' vocal contingency.

3.2. COMPARATIVE ANALYSIS OF COMMUNICATIVE AND AFFECTIONATE FEATURES OF MOTHERESE

The proportion of each of the seven categories created for this study regarding the communicative and affectionate features (Table 1) was estimated according to the total of maternal utterances (N = 2270) produced by the 38 mothers. Regarding the first aim of study, the proportion in each subcategory was estimated according to the total of segments in each category. The individual proportions of maternal utterances in each category and subcategory were also estimated relative to the total number of maternal utterances of each mother. Table 2 displays the descriptive analysis of categories and subcategories of communicative and affectionate features of motherese.

Table 2. Descriptive analysis of categories and subcategories about communicative and affectionate features on maternal utterances (N = 2270)

Categories	Subcategories	number	% * N = 2270	M (%) ** N = 38	SD	Min.-Max.
speech intentionality	total	2248	99	86.81	2.64	86.44-100.00
	interrogative	903	40	38.96	14.14	11.11-69.74
	exclamatory	607	27	27.80	15.81	3.64-74.00
	declarative	324	14.41	15.35	14.68	.00-56.36
	vocative	296	13.16	12.78	11.40	.00-44.07
	imperative	118	5.24	5.29	6.12	.00-24.44
forms of expressiveness	total	382	16.82	16.62	7.34	.00-32.20
	anaphors	149	39	6.47	5.65	.00-23.53
	variations	142	37.17	6.16	4.09	.00-16.67
	repetitions	91	23.82	3.98	3.28	.00-14.81
communicative function	total	2205	97.13	97.25	4.93	78.13-102.27
	conative	736	33.37	32.38	16.39	3.92-89.09
	phatic	642	29.11	27.99	10.36	1.82-45.28
	emotive	543	24.62	23.82	16.51	1.67-76.47
	referential	284	12.87	13.05	9.87	.00-47.83
speech connected with infants' or maternal needs	total	2270	100	100	.00	100-100
	infants' needs	1915	84.36	84.35	21.86	7.27-100.00
	maternal needs	355	15.63	15.64	21.86	.00-92.73
infants' designation	total	547	24.09	23.91	13.29	3.77-50.98
	baby	79	14.44	3.73	5.69	.00-22.00
	son/daughter	35	6.39	1.72	3.35	.00-15.91
	first name	109	19.92	4.78	4.78	.00-16.00
	diminutive	16	2.92	.58	1.86	.00-9.72
	affectionate words	291	53.19	12.43	9.95	.00-45.10
infants' physical features	total	147	6.47	6.70	6.77	.00-23.46
	positive	110	74.82	5.04	5.93	.00-21.57
	negative	37	25.17	1.66	3.12	.00-11.36
infants' temperamental features	total	110	4.84	4.77	6.56	.00-34.00
	positive	77	70	3.45	6.07	.00-34.00
	negative	33	30	1.32	2.15	.00-9.88

* Proportion relative to the total of utterances (N = 2270).
** Proportion relative to the total of dyads (N = 38).

 DOI: http://dx.doi.org/10.6035/clr.6950

A comparative statistical analysis (t-Student with Bonferroni correction) between the different subcategories of communicative and affectionate features in maternal speech was carried out. According to results, a higher proportion of interrogative segments was found when compared with declarative ($t = 6.207$, $df = 37$, $p < .000$), with imperative ($t = 12.844$, $df = 37$, $p < .000$) as well as with vocative segments ($t = 8.571$, $df = 37$, $p < .000$).

In the category "communicative function", there were more utterances of the conative function than of the referential function ($t = 5.792$, $df = 37$, $p < .000$); there were fewer utterances of the referential than of the phatic function ($t = 6.420$, $df = 37$, $p < .000$) or than of the emotive function ($t = 2.918$, $df = 37$, $p = .006$). There were more utterances in the subcategory "speech connected with the infants' needs" than in "speech connected with maternal needs" ($t = 9.686$, $df = 37$, $p < .000$).

In the category "infant designation", there was a higher proportion of the subcategory "affectionate words" than: "baby" ($t = -4.905$, $df = 37$, $p < .000$), "little boy/little girl" ($t = -7.413$, $df = 37$, $p < .000$), "son/daughter" ($t = -6.377$, $df = 37$, $p < .000$), "first name" ($t = -4.340$, $df = 37$, $p < .000$), and "diminutive of the first name" ($t = -7.119$, $df = 37$, $p < .000$). Regarding infants' physical features there were more utterances relating to positive features than negative features ($t = 3.136$, $df = 37$, $p = .003$). Regarding the maternal mental representation about the infant, there were also more utterances related to positive features than negative features ($t = 2.073$, $df = 37$, $p = .045$).

3.3. Prosodic features of maternal speech and infants' vocalizations

To explore the relationship between infants' vocalizations and tonal contours of mothers' speech, maternal utterances that were preceded and followed by infants' vocalizations were compared in terms of their tonal contours. Table 3 shows the results of descriptive statistical analysis of maternal tonal contours before and after infants' vocalizations.

Table 3. Descriptive analysis of tonal contours of maternal utterances before and after infants' vocalizations

Tonal Contours	Number	M	SD	Min.-Max.
		before infants' vocalizations		
Linear	11	.4231	.7027	.00–2.00
Bell-shaped	8	.3077	.6176	.00–2.00
U-shaped	0	.000	.000	.00–.00
Sinusoidal	74	2.846	2.693	.00–9.00
Rising	21	.8077	1.132	.00–4.00
Falling	47	1.807	1.876	.00–8.00
Total	161			
		after infants' vocalizations		
Linear	6	.2308	.6516	.00–3.00
Bell-shaped	5	.1923	.4019	.00–1.00
U-shaped	4	.1538	.3679	.00–1.00
Sinusoidal	75	2.884	2.454	.00–9.00
Rising	17	.6538	1.129	.00–4.00
Falling	51	1.961	1.886	.00–8.00
Total	158			

A comparative statistical analysis was performed between the number of each maternal tonal contour before and after infants' vocalizations. Results show a

significantly higher number of U-shaped utterances after infants' vocalizations (t = -2.132, df = 25, p = .043). This suggests that infants' vocalizations induce an increase of U-shaped utterances.

To explore the relationship between infants' vocalizations and acoustic features of motherese such as pitch, and intensity, maternal utterances before and after infants' vocalizations were analyzed. Table 4 displays descriptive data.

Table 4. Descriptive analysis of acoustic variables of motherese before and after infants' vocalizations

Acoustic Variables	M	Min. – Max.	SD
before infants' vocalizations			
Pitch (Hz)	242.67	178.57 – 314.29	33.17
Intensity (dB)	66.14	59.81 – 71.92	3.67
after infants' vocalizations			
Pitch (Hz)	238.02	160.25 – 289.52	32.31
Intensity (dB)	65.47	59.73 – 71.71	3.77

Comparative statistical analysis were performed between the average pitch as well as between the average intensity of maternal utterances before and after infants' vocalizations. Results show a significant decrease in the average intensity of maternal utterances after infants' vocalizations (t = 2.268, df = 25, p = .032). This suggests that infants' vocalizations influenced the intensity of maternal utterances. No significant differences were found between the average maternal pitch before and after infants' vocalizations.

Multiple hierarchical linear regression analyzes (see Table 5) were performed to understand the impact of the acoustic features (pitch, intensity, tonal contour) of maternal utterances (independent variables) on infants' vocalizations (dependent variable). Maternal age, education, and nationality as well as infants' gestational age at birth were controlled.

Table 5. Multiple hierarchical linear regression, concerning infants' vocalizations as dependent variable (DV) and prosodic features of motherese (utterances intensity average, falling utterances duration average, and sinusoidal utterances duration average) as independent variables (IV)

Models	R	R^2	Adjusted R^2	St. error of the estimate	R^2 change	F change	df1	df2	Sig. of F change
infants' vocalizations (DV) / utterances intensity average (IV)									
Model 1	.355	.126	.007	6.24800	.126	1.056	3	22	.388
Model 2	.389	.151	-.011	6.30228	.025	.623	1	21	.439
Model 3*	.695	.483	.354	5.03970	.332	12.840	1	20	.002
infants' vocalizations (DV) / falling utterances (IV)									
Model 1	.355	.126	.007	6.24800	.126	1.056	3	22	.388
Model 2	.389	.151	-.011	6.30228	.025	.623	1	21	.439
Model 3**	.732	.536	.420	4.77246	.385	16.621	1	20	.001
infants' vocalizations (DV) / sinusoidal utterances (IV)									
Model 1	.355	.126	.007	6.24800	.126	1.056	3	22	.388
Model 2	.389	.151	-.011	6.30228	.025	.623	1	21	.439
Model 3***	.558	.311	.139	5.81826	.160	4.639	1	20	.044

Model 3*(maternal age, education, and nationality as well as infants' gestational age at birth and utterances intensity average); Model 3**(maternal age, education, and nationality as well as infants' gestational age at birth and falling utterances); Model 3***(maternal age, education, and nationality as well as infants' gestational age at birth and sinusoidal utterances).

 DOI: http://dx.doi.org/10.6035/clr.6950

According to results (see Table 5), the intensity average of maternal utterances (before the infants' vocalizations) was a good predictor of infants' vocalizations (*b* = 581 [.414, 1.568], p = .002). This suggests that the average intensity of maternal utterance (as unit) may help to explain the production of infants' vocalizations. Also, both the sinusoidal utterances (*b* = .407 [.030, 1.866], p = .044) and the falling utterances of motherese (*b* = .652 [1.064, 3.292], p = .001) were good predictors of infants' vocalizations produced after these contours. This suggests that these tonal contours seem to explain the infants' vocal responsiveness.

Multiple hierarchical linear regression analyzes were performed to test whether infants' vocalizations (independent variable) influenced the prosodic features of motherese such as pitch, intensity, and tonal contour (dependent variables). Table 6 displays the significant results regarding prosodic features of motherese like intensity average, U-shaped utterances, and sinusoidal utterances (dependent variables) and infants' vocalizations (independent variable). Maternal age, education, and nationality, as also the infants' gestational age at birth were controlled.

Table 6. Multiple hierarchical linear regression, concerning prosodic features of motherese (utterances intensity average, U-shaped utterances, and sinusoidal utterances) as dependent variables (DV) and infants' vocalizations as independent variable (IV)

Models	R	R^2	Adjusted R^2	St. error of the estimate	R^2 change	F change	df1	df2	Sig. of F change
utterances intensity average (DV) / infant's vocalizations (IV)									
Model 1	.192	.037	-.095	3.94346	.037	.279	3	22	.840
Model 2	.192	.037	-.147	4.03624	.000	.000	1	21	.991
Model 3*	.655	.429	.287	3.18335	.393	13.760	1	20	.001
U-shaped utterances (DV) / infants' vocalizations (IV)									
Model 1	.150	.022	-.063	.37929	.022	.264	2	23	.771
Model 2	.194	.038	-.146	.39385	.015	.165	2	21	.849
Model 3**	.462	.213	.016	.36492	.176	4.461	1	20	.047
sinusoidal utterances (DV) / infants' vocalizations (IV)									
Model 1	.114	.013	-.073	2.54276	.013	.150	2	23	.861
Model 2	.234	.055	-.125	2.60407	.042	.465	2	21	.634
Model 3***	.504	.254	.068	2.37034	.199	5.346	1	20	.032

Model 3*(maternal age, education, maternal nationality, infants' gestational age at birth, and infants' vocalizations); Model 3**(maternal nationality, education, infants' gestational age at birth, infants' weight at birth, and infants' vocalizations); Model 3***(maternal nationality, education, infants' gestational age at birth, infants' weight at birth, and infants' vocalizations)

Results suggest (see Table 6) that infants' vocalizations are good predictors of the intensity of maternal utterances after infants' vocalizations (*b* = 680 [.179, .639], p = .001). Also, the infants' vocalizations (independent variable) are good predictors of two tonal contours (dependent variables): after infants' vocalizations, U-shaped utterances (*b* = .450 [.000, .052], p = .047) and also sinusoidal utterances (*b* = .479 [.018, .357], p = .032). Maternal nationality, education, infants' gestational age at birth and infants' weight at birth, were controlled. This suggests that infants' vocalizations explain the change in the intensity of maternal utterances, and also the number of U-shaped and of sinusoidal utterances.

4. DISCUSSION AND LIMITATIONS

4.1. DISCUSSION

The aims of this study encompassed the communicative and affectionate features of motherese in preterm dyads, the impact of maternal prosodic features on infants' vocal responsiveness, and the effect of infants' vocalizations on maternal prosodic features. These aims were based on previous studies reporting that: a) parental speech in NICU plays an important role for preterm infants' vocalizations (Caskey *et al*., 2011), and for the turn-taking happening in the preterm dyad (Carvalho *et al*., 2019b); b) preterm infants' positive behaviors (including infants' vocalizations) increase maternal pitch level (Filippa *et al*., 2018); c) in full-term dyads linguistic features of motherese are related with infants' behavioral states (Dominguez *et al*., 2017), and d) motherese seems to play an important role for infants' language development (Hartman *et al*., 2017; Kuhl *et al*., 2003; García-Sierra *et al*., 2021).

Our results showed that the average latency time of both mothers' and infants' vocal responses during the turn-taking have similar values (nearly one second). Also, previous studies with full-term newborns observed contingent vocal interactions with a latency time around one second (Dominguez *et al*., 2016). Our study underlined the important role of maternal tonal utterances as well as of the infants' vocalizations for the vocal modulation during the dyadic turn-taking. The intensity of maternal utterances directed to the infant is associated with the infant's vocal responsiveness. There was a significant decrease in maternal vocal intensity after the infants' vocalizations. Possibly this decrease is a response of mothers to support their infants' regulation, leading to a decrease in their state of arousal.

Contrary to a previous study with preterm dyads (Filippa *et al*., 2018), in our study infants' vocalizations did not induce an increase in the pitch (F0) of maternal speech. However, pitch variations in motherese tonal contours seem to play an important role for vocal interactions in preterm dyads. Sinusoidal, U-shaped, and falling maternal utterances can play a function of communicative intentionality in preterm dyads. Sinusoidal and falling contours are particularly effective for infants' vocalizations, while infants' vocalizations seem to induce an increase of U-shaped maternal utterances. Considering that the U-shaped tonal contour signals a question, the increase of this type of tonal contour after the infants' vocalizations suggests that mothers' intend to keep the infants' attention. According to literature, falling utterances signal the end of a turn (Fernald, 1989; Papousek, 1996), possibly helping infants to increase their vocal responsiveness. Probably, the boundary cues of the phonological utterance are recognized by preterm infants. Our results suggest an early ability to understand "turn-end" (Filipe *et al*., 2017), as well as to recognize maternal tonal utterances that precede pauses (Frota *et al*., 2016).

Despite the vulnerable context present in preterm dyads, similar communicative and affectionate aspects of motherese were found. Regarding the communicative features of motherese, the conative function is the most prevalent. This suggests that when mothers address infants, most of the time they intend to connect appealing for infants' attention, as underlined in literature (Paavola *et al*., 2005). Also, when addressing their infants, mothers often used repetitions and variations of utterances (for example, "Baby is beautiful, is beautiful my baby") as referenced in literature (Paavola *et al*., 2005; Snow *et al*., 1972). There was a predominant number of interrogative utterances (for example, "What happened?") which are related whit U-shaped contours possibly to redirect the infant to the mother appealing to the infants' attention.

 DOI: http://dx.doi.org/10.6035/clr.6950

Regarding to affectionate features of motherese, when mothers addressed their infants, they used predominantly affectionate words (for example, “My little princess”) more than infants’ first name, suggesting an idealized representation of the infant. They also expressed more positive than negative features about infants whether physical (for example, “You are growing”) whether mental representations (for example, “You are mommy’s strong warrior”). These maternal positive infants’ representations, possibly have the intention to repair the infants’ vulnerable condition. In addition, the positive representations about the infants seem to repair the maternal self, with the infant being represented as a part of the maternal self (“You are mommy’s strong warrior”).

Maternal speech is mainly aimed at meeting the infants’ needs, rather than expressing maternal needs and feelings. When mothers addressed their infants, they expressed themselves in the present tense, reading the infant’s behavioral state according to their signs of comfort (for example, “It's warm in mommy's arms”) or discomfort (for example, “My baby is hungry”, “My baby is sleepy”, “My baby is cold”) and sometimes having the infant as the subject of the sentence (“Oh! I'm so sleepy, mommy!”). This relationship between the linguistic features of motherese and infants’ behavioral state is also present in full-term dyads (Dominguez *et al*., 2017). This suggests that maternal concerns regarding the infants’ needs are especially related to infants’ self-regulation, health, and physical development. These expressions of positive affectivity by mothers are probably intended to provide comfort and self-regulation to the infant, expressing affection and protection, more than triggering the infants’ response. This aspects regarding mothers’ positive affect were also underlined in literature (Kitamura *et al*., 2003).

4.2. LIMITATIONS

Regarding to the first aim of our study, results do not allow to conclude about the exclusive communicative features of motherese directed to preterm infants in NICU. For this, comparative studies between preterm and full-term dyads are necessary. The fact that we chose a microanalytical methodology analyzing data from a global and quantitative point of view, the individual aspects of each dyad were not highlighted, which is one of the several limitations of this study. This way, it would be important to understand the communicative intentionality of each mother, correlating verbal and prosodic maternal features. Future research based on multiple cases studies would be highly recommended to explore this field of research. Also, longitudinal studies would allow to describe the linguistic evolution of preterm infants after the first weeks of life. Although our sample consisted of dyads with preterm infants between 25 and 37 gestational weeks at birth, infants with severe neurological disturbances were excluded. This constitutes one of the limitations of this study since neurological maturation interferes with the infants’ vocal development.

Literature underlined benefits in preterm infants’ self-regulation due to early vocal interaction in NICU. Moreover, positive infants’ vocalizations can be considered as a self-regulating behavior when emerging during a moderate attention state. However, our study did not analyze the infant behavioral state. Future studies should find out the relationship between vocal responsiveness and the infants’ behavioral status, as well as with the infants’ vital signs.

The mothers’ psychological state plays a crucial role in preterm dyads’ interactions, and particularly, in its prosodic characteristics of motherese. The hypothesis that communicative and affectionate features of motherese could be affected by the

condition of maternal emotional vulnerability cannot be analyzed in our study. So, in the future, it will be important to consider the maternal psychological variables.

Despite the multimodal nature of mother-infant interactions, this study focused only on the microanalysis of mother-infant vocal interactions. In the future, it will be necessary to consider other variables such as affective touch, gaze, and facial expression (smiles).

5. CONCLUSION

This study shows that communicative and affectionate features of motherese are present in preterm dyads. To confirm this, in future studies, it will be important to compare preterm dyads and full-term dyads regarding features of motherese. Our study points to a very early ability of preterm infants to understand the prosodic characteristics of mothers' speech. Tonal contours of motherese play important functions connecting the mother with her preterm infant and improving her vocal responsiveness. These aspects can facilitate the maternal positive affect during the earliest interactions. Also, maternal perception about the infant as an active partner during the early dyadic turn-taking can be improved. More studies are needed to deepen these preliminary results, in order to support mothers to address their preterm infants in NICU. Also, longitudinal and individualized studies are required to understand the role of motherese in preterm dyads in what respects to infants' language development.

Conflict of interest

The authors declare no conflict of interest, financial or otherwise.

Ethical considerations

This study follows the principles of the Declaration of Helsinki.

REFERENCES

Bartha-Doering, Lisa, Johanna Alexopoulos, Vito Giordano, Lisa Stelzer, Theresa Kainz, Silvia Benavides-Varela, Isabell Wartenburger, Katrin Klebermass-Schrehof, Monika Olischar, Rainer Seidl, and Angelika Berger. 2019. "Absence of neural speech discrimination in preterm infants at term-equivalent age". *Developmental Cognitive Neuroscience,* 39. https://doi.org/10.1016/j.dcn.2019.100679

Bettes, Barbara. 1988. "Maternal Depression and Motherese: Temporal and Intonational Features". *Child Development,* 59 (4): 1089–1096. https://doi.org/10.2307/1130275

Bozzette, Maryann. 2008. "Healthy Preterm Infant Responses to Taped Maternal Voice". *Journal of Perinatal and Neonatal Nursing,* 22 (4): 307–316. https://nursing.ceconnection.com/ovidfiles/00005237-200810000-00013.pdf

Brazelton, Thomas Berry, and Kevin Nugent. 2011. *The Neonatal Behavioral Assessment Scale*, 4th Edition. London: Mac Keith Press.

Buil, Aude, Isabelle Carchon, Giselle Apter, François Xavier Laborne, Maya Gratier, and Emmanuel Devouche. 2016. "Kangaroo supported diagonal flexion positioning: New insights into skin-to-skin contact for communication between mothers and very preterm infants". *Archives de Pédiatrie,* 23 (9): 913–920. https://doi.org/10.1016/j.arcped.2016.04.023

Carvalho, Maria Eduarda, João Manuel Justo, Maya Gratier, and Helena Maria Rodrigues. 2019a. "The impact of maternal voice on the fetus: A systematic

 DOI: http://dx.doi.org/10.6035/clr.6950

review". *Current Women's Health Reviews,* 15 (3): 196–206. https://doi.org/10.2174/15734048

Carvalho, Maria Eduarda, João Manuel Justo, Maya Gratier, Teresa Tomé, Esmeralda Pereira and Helena Rodrigues. 2019b. "Vocal responsiveness of preterm infants to maternal infant-directed speaking and singing during skin-to-skin contact (Kangaroo Care) in the NICU". *Infant Behavior and Development,* 57. https://doi.org/10.1016/j.infbeh.2019.101332

Caskey, Melinda, Bonnie Stephens, Richard Tucker, and Betty Vohr. 2011. "Importance of parent talk on the development of preterm infant vocalizations". *Pediatrics,* 128 (5): 910–916. https://doi.org/10.1542/peds.2011-0609

Caskey, Melinda, Bonnie Stephens, Richard Tucker, and Betty Vohr. 2014. "Adult talk in the NICU with preterm infants and developmental outcomes". *Pediatrics,* 133 (3): e578–e584. https://doi.org/10.1542/peds.2013-0104

Cooper, Robin Panneton, Jane Abraham, Sheryl Berman and Margaret. 1997. "The Development of infants' preference for motherese". *Infant Behavior and Development,* 20 (4): 477–488. https://www.sciencedirect.com/science/article/pii/S0163638397900370

Correia, Luciana Leonetti, Ana Emília Vita Carvalho, and Maria Beatriz Martins Linhares. 2008. "Verbal contents expressed by mothers of preterm infants with clinical emotional symptoms". *Revista Latino-Americana de Enfermagem,* 16 (1): 64–70. https://doi.org/10.1590/S0104-11692008000100011

Dominguez, Sarah., Emmanuel Devouche, Giselle Apter, and Maya Gratier. 2016. "The roots of turn-taking in the neonatal period". *Infant and Child Development,* 25: 240–255. https://doi.org/10.1002/icd.1976

Dominguez, Sarah, Maya Gratier, Karine Martel, Aude Buil, Giselle Apter and Emmanuel Devouche. 2017. "Le nouveau-né, un partenaire pour sa mère: Analyse du discours maternel". *Neuropsychiatrie de l'Enfance et de l'Adolescence,* 65 (4): 201–210. http://dx.doi.org/10.1016/j.neurenf.2017.03.005

Dunbar, Robin. 1993. "Coevolution of neocortical size, group size and language in humans". *Behavioral and Brain Sciences,* 16 (4): 681-735. https://www.uvm.edu/pdodds/files/papers/others/1993/dunbar1993a.pdf

Eckerman, Carol, Jerri Oehler, Mandy Medvin, and Thomas Hannan. 1994. "Premature newborns as social partners before term age". *Infant Behavior and Development,* 17 (1): 55–70. https://doi.org/10.1016/0163-6383(94)90022-1

Falk, Simone. 2011. Melodic versus intonational coding of communicative functions: A comparison of tonal contours in infant-directed song and speech. *Psychomusicology: Music, Mind and Brain,* 21 (1-2): 54–68. https://doi.org/10.1037/h0094004

Fellman, Vineta, Elena Kushnerenko, Kaija Mikkola, Rita Ceponiené, Jaana Leipälä, and Risto Näätänen. 2004. "Atypical auditory event-related potentials in preterm infants during the first year of life: a possible sign of cognitive dysfunction?" *Pediatric Research,* 56: 291–297. https://doi.org/10.1203/01.PDR.0000132750.97066.B9

Fernald, Anne. 1989. "Intonation and communicative intent in mothers' speech to infants: Is the melody the message?". *Child Development,* 60 (6): 1497–1510. https://doi.org/10.2307/1130938

Fernald, Anne. 1991. "Prosody in speech to children: Prelinguistic and linguistic functions". *Annals of Child Development*, 8: 43–80.

Fernald, Anne, and Patricia Kuhl. 1987. "Acoustic Determinants of Infant Preference for Motherese Speech". *Infant Behavior and Development*, 10, 279–293. http://dx.doi.org/10.1016/0163-6383(87)90017-8

Filipe, Marisa, Sue Peppé, Sónia Frota, and Selene Vicente. 2017. "Prosodic development in European Portuguese from childhood to adulthood". *Applied Psycholinguistics*, 38 (5): 1045–1070. DOI:10.1017/S0142716417000030

Filippa, Manuela, Maya Gratier, Emmanuel Devouche, and Didier Grandjean. 2018. "Changes in infant-directed speech and song are related to preterm infant facial expression in the neonatal intensive care unit". *Interaction Studies*, 19 (3): 427–444. https://doi.org/10.1075/is.16019.fil

Filippa, Manuela, Constantino Panza, Fabrizio Ferrari, Rossella Frassoldati, Pierre Kuhn, Sara Balduzzi, and Roberto D'Amico. 2017. "Systematic review of maternal voice interventions demonstrates increased stability in preterm infants". *Acta Paediatrica*, 106 (8): 1220–1229. https://doi.org/10.1111/apa.13832

Filippa, Manuela, Damiano Menin, Roberta Panebianco, Maria Grazia Monaci, Marco Dondi, and Didier Grandjean. 2020. "Live maternal speech and singing increase self-touch and eye-opening in preterm newborns: A preliminary study". *Journal of Nonverbal Behavior*, 44 (4): 453–473. https://doi.org/10.1007/s10919-020-00336-0

Filippa, Manuela, Elisa Della Casa, Roberto D'Amico, Odoardo Picciolini, Clara Lunardi, Alessandra Sansavini, and Fabrizio Ferrari. 2021. "Effects of early vocal contact in the neonatal intensive care unit: Study protocol for a multi-centre, randomised clinical trial". *International Journal of Environmental Research and Public Health*, 18 (8): Article 3915. https://doi.org/10.3390/ijerph18083915

Fluharty, Melissa, Lynne S. Nemeth, Ayaba Logan and Michelle Nichols. 2021. "What do neonatal intensive care unit policies tell us about kangaroo care implementation? A Realist Review". *Advances in Neonatal Care*, 21(4): E76–E85. https://doi.org/10.1097/ANC.0000000000000808

Frota, Sónia, Marisa Cruz, Nuno Matos, and Marina Vigário. 2016. "Early Prosodic Development: Emerging intonation and phrasing in European Portuguese". In M. Armstrong, N. C. Henriksen, & M. M. Vanrell (Eds.), *Intonational Grammar in Ibero-Romance: Approaches across linguistic subfields* (pp. 295–324). Philadelphia, USA: John Benjamins. DOI: 10.1075/ihll.6.14fro

García-Sierra, Adrián, Nairán Ramírez-Esparza, Noelle Wig, and Dylan Robertson. 2021. "Language learning as a function of infant directed speech (IDS)", in *Spanish: Testing neural commitment using the positive-MMR, Brain and Language*, 212: 104890. https://doi.org/10.1016/j.bandl.2020.104890

Goldstein, Michael, and Jennifer Schwade. 2008. "Social feedback to infants' babbling facilitates rapid phonological learning". *Psychological Science*, 19 (5): 515–523. https://doi.org/10.1111/j.1467-9280.2008.02117.x

Gratier, Maya, Emmanuel Devouche, Bahia Guellai, Rubia Infanti, Ebru Yilmaz, and Erika Parlato-Oliveira. 2015. "Early development of turn-taking in vocal interaction between mothers and infants". *Frontiers in Psychology,* 6: 1167. https://doi.org/10.3389/fpsyg.2015.01167

Grieser, Dianne, and Patricia Kuhl. 1988. "Maternal speech to infants in a tonal language: Support for universal prosodic features in motherese". *Developmental Psychology*, 24 (1): 14–20. http://ilabs.uw.edu/sites/default/files/1988%20Grieser%20_%20Kuhl.pdf

 DOI: http://dx.doi.org/10.6035/clr.6950

Hartman, Kelly, Nan Bernstein Ratner, and Rochelle Suzanne Newman. 2017. "Infant directed speech (IDS), vowel clarity and child language outcomes". *Journal Child Language,* 44 (5): 1140–1162. DOI: 10.1017/S0305000916000520

Jakobson, Roman. 1961. *Linguistics and Communication Theory*. Providence: American Mathematical Society.

Keren Miri, Ruth Feldman, Arthur Eidelman, Leah Sirota, and Barry Lester. 2003. "Clinical Interview for high-risk parents of premature infants (CLIP) as a predictor of early disruptions in the mother-infant relationship at the nursery". *Infant Mental Health Journal*, 24: 93–110. DOI: 10.1002/imhj.10049

Kisilevsky, Barbara, Sylvia Hains, Cecilia Ann Brown, Charlotte Tsz Sum Lee, B. Cowperthwaite, Sherri Schmidt Stutzman, Melissa L. Swansburg, Lee Kang, Xing Xie, Hefeng Huang, Haihui Ye, Ke Zhang, and Zengping Wang. 2009. "Fetal sensitivity to properties of maternal speech and language". *Infant Behavior and Development*, 32 (1): 59–71. DOI: 10.1016/j.infbeh.2008.10.002

Kisilevsky, Barbara, and Sylvia Hains. 2011. "Onset and maturation of fetal heart rate response to the mother's voice over late gestation". *Developmental Science*, 14 (2): 214–223. https://doi.org/10.1111/j.1467-7687.2010.00970.x

Kisilevsky, Barbara, Beverly Chambers, Kevin Parker, and Gregory Davies. 2014. "Auditory processing in growth-restricted fetuses and newborns and later language development". *Clinical Psychology Sciences,* 2 (4): 495–513. https://journals.sagepub.com/doi/10.1177/2167702613509371

Kitamura, Christine, and Denis Burnham (2003). "Pitch and communicative intent in mother's speech: adjustments for age and sex in the first year". *Infancy*, 4 (1): 85–110. https://onlinelibrary.wiley.com/doi/pdf/10.1207/S15327078IN0401_5

Kitamura, Christine, C. Thanavishuth, Denis K. Burnham, and Sudaporn Luksaneeyanawin. 2001. "Universality and specificity in infant-directed speech: Pitch modifications as a function of infant age and sex in a tonal and non-tonal language". *Infant Behavior and Development*, 24 (4): 372–392. https://doi.org/10.1016/S0163-6383(02)00086-3

Kostilainen, Kaisamari, Eino Partanen, Kaija Mikkola, Valtteri Wikström, Satu Pakarinen, Vineta Fellman, and Minna Huotilainen. 2020. "Neural processing of changes in phonetic and emotional speech sounds and tones in preterm infants at term age". *International Journal of Psychophysiology*, 148: 111–118. DOI: 10.1016/j.ijpsycho.2019.10.009

Kuhl, Patricia, Feng-Ming Tsao, and Huei-Mei Liu. 2003. "Foreign-language experience in infancy: effects of short-term exposure and social interaction on phonetic learning". *Proceedings of the National Academy of Sciences*, 100 (15): 9096–9101. DOI: 10.1073/pnas.1532872100.

Lam-Cassettari, Christa, and Jane Kohlhoff. 2020. "Effect of maternal depression on infant-directed speech to prelinguistic infants: Implications for language development". *PloS one*, 15 (7): e0236787. https://doi.org/10.1371/journal.pone.0236787

Landry, Susan, Karen Smith, Cynthia Miller-Loncar, and Paul Swank. 1997. "Predicting cognitive-language and social growth curves from early maternal behaviors in children at varied degrees of biological risk". *Developmental Psychology*, 33 (6): 1040–1053. DOI: 10.1037//0012-1649.33.6.1040

Lavelli, Manuela, and Alan Fogel. 2013. "Interdyad differences in early mother–infant face-to-face communication: Real-time dynamics and developmental pathways". *Developmental Psychology*, 49 (12): 2257–2271. https://doi.org/10.1037/a0032268

Lecanuet Jean-Pierre, Carolyn Granier-Deferre, Anthony DeCasper, Rosalyne Maugeais, André Jacques Andrieu, and Marie-Claire Busnel. 1987. "Fetal perception and discrimination of speech stimuli; demonstration by cardiac reactivity; preliminary results". *Comptes Rendus de l'Academie des Sciences. Série **III**, Sciences de la vie*, 305 (5): 161–1644.

Macwhinney, Brian, and Catherine Snow. 1985. "The child language data exchange system". *Journal of Child Language*, 12: 271–296. DOI: 10.1017/S0305000900013866

Malloch, Stephen, and Colwyn Trevarthen (Eds.). 2009. *Communicative musicality: Exploring the basis of human companionship*. Oxford: Oxford University Press.

Paavola, Leila, Sari Kunnari, Irma Moilanen, and Matti Lehtihalmes. 2005. "The functions of maternal verbal responses to prelinguistic infants as predictors of early communicative and linguistic development". *First Language*, 25 (2): 173–195. https://journals.sagepub.com/doi/pdf/10.1177/0142723705050341

Palazzi Ambra, Manuela Filippa, Rita Meschini, and Cesar Augusto Piccinini. 2021. "Music therapy enhances preterm infant's signs of engagement and sustains maternal singing in the NICU". *Infant Behavior and Development,* 64: 101596. DOI: 10.1016/j.infbeh.2021.101596

Pan, Barbara Alexander, Alison Imbens-Bailey, Kendra Winner, and Catherine Snow. 1996. "Communicative intents expressed by parents in interaction with young children". *Merrill-Palmer Quarterly*, 42: 248–266. https://www.jstor.org/stable/23087879

Papousek, Mechthild 1996. "Intuitive parenting: a hidden source of musical stimulation in infancy". In I. Deliege, & J. Sloboda (Eds.), Musical beginnings. Origins and development of musical competence (pp. 88–112). Oxford: Oxford University Press.

Papousek, Mechthild, Hanuš Papousek, and David Symmes. 1991. "The meanings of melodies in motherese in tone and stress languages". *Infant Behavior and Development*, 14 (4): 415–440. https://doi.org/10.1016/0163-6383(91)90031-M

Parlato-Oliveira, Erika, Catherine Saint-Georges, David Cohen, Hugues Pellerin, Isabella Marques Pereira, Catherine Fouillet, Mohamed Chetouani, Marc Dommergues, and Sylvie Viaux-Savelon. 2021. "*Motherese* Prosody in Fetal-Directed Speech: An Exploratory Study Using Automatic Social Signal Processing". *Frontiers in Psychology,* 12: 646170. https://doi.org/10.3389/fpsyg.2021.646170

Pêcheux, Marie-Germaine, Florence Labrell, F., and Marc Pistorio. 1993. "What do parents talk about to infants?". *Early Developmental Parent*, 2 (2): 89–97.

Pelaez, Martha, Javier Virués-Ortega, and Jacob L. Gewirtz. 2011. "Contingent and non-contingent reinforcement with maternal vocal imitation and motherese speech: Effects on infant vocalizations". *European Journal of Behavior Analysis*, 12: 277–287. https://doi.org/10.1080/15021149.2011.11434370

Peña, Marcela, Janet Werker, and Ghislaine Dehaene-Lambertz. 2012. "Earlier speech exposure does not accelerate speech acquisition". *Journal of Neuroscience,* 32 (33): 11159–11163. DOI: 10.1523/JNEUROSCI.6516-11.2012.

Pessoa, Luciana, and Maria Lucia Seidl de Moura. 2008. "Pragmatic characteristics of maternal speech in mother-child dyads (five and twenty months old)". *Arquivos Brasileiros de Psicologia*, 60 (1): 82–95. https://pepsic.bvsalud.org/pdf/arbp/v60n1/v60n1a08.pdf

Pisanski, Katarzyna, Kavya Bhardwaj, and David Reby. 2018. "Women's voice pitch lowers after pregnancy". *Evolution and Human Behavior*, 39 (4): 457–463. https://doi.org/10.1016/j.evolhumbehav.2018.04.002s

 DOI: http://dx.doi.org/10.6035/clr.6950

Rheingold, Harriet, and Judith Adams. 1980. “The significance of speech to newborns”. *Developmental Psychology*, 16 (5): 397–403.

Seidl de Moura, Maria Lucia, Adriana Ferreira Paes Ribas, Karla da Costa Seabra, Luciana Fontes Pessôa, Rodolfo de Castro Ribas Jr., and Susana Engelhard Nogueira. 2004. “Interações iniciais mãe-bebê”. *Psicologia: Reflexão e Crítica*, 17 (3): 295–302. https://www.scielo.br/j/prc/a/BxBdxRTQjSW5tq94xcJbRNQ/?lang=pt&format=pdf

Rivero, Magda. 2010. “Maternal expression of communicative intentions and pragmatic fine tuning in early infancy”. *Infant Behavior & Development*, 33 (4): 373–386. DOI: 10.1016/j.infbeh.2010.04.002

Shoemark, Helen, Marie Dahlstrøm, Oscar Bedford, and Lauren Stewart. 2021. “The Effect of a Voice-Centered Psycho-Educational Program on Maternal Self-Efficacy: A Feasibility Study”. *International Journal of Environmental Research and Public Health*, 18 (5): 2537. https://doi.org/10.3390/ijerph18052537

Snow, Catherine. 1972. “Mothers’ speech to children learning language”. *Child Development*, 43, 549–565.

Snow, Catherine. 1977. “Development of conversation between mothers and babies”. *Journal of Child Language*, 4: 1–22.

Snow, Catherine, Barbara Alexander Pan, Alison Imbens-Bailey, and Jane Herman. 1996. “Learning how to say what one means: a longitudinal study of children’s speech act use”. *Social Development*, 5: 56–84.

Spence, Melanie, and Anthony DeCasper. 1987. “Prenatal experience with low-frequency maternal-voice sounds influence neonatal perception of maternal voice samples”. *Infant Behavior and Development*, 10 (2): 133–142.

Stern, Daniel, Susan Spieker, and Kristine MacKain. 1982. “Intonation contours as signals in maternal speech to prelinguistic infants”. *Developmental Psychology*, 18 (5): 727–735. https://doi.org/10.1037/0012-1649.18.5.727

Trevarthen, Colwyn. 1993. “The self-born in intersubjectivity: The psychology of an infant communicating”. In U. Neisser (Ed.), *The perceived self: Ecological and interpersonal sources of self-knowledge* (pp.121–173). Cambridge University. https://doi.org/10.1017/CBO9780511664007.009

Van Egeren, Laurie, Marguerite Barratt, and Mary Roach. 2001. “Mother–infant responsiveness: Timing, mutual regulation, and interactional context”. *Developmental Psychology*, 37 (5): 684–697. https://doi.org/10.1037//0012-1649.37.5.684

Zelkowitz, Phyllis, Claudette Bardin, and Apostolos Papageorgiou. 2007. “Anxiety affects the relationship between parents and their very low birth weight infants”. *Infant Mental Health Journal,* 28: 296–313. DOI:10.1002/imhj.20137