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Vocal emotion expressions in infant-directed singing: The impact of war trauma and maternal mental health and the consequences on infant development

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Abstract

Maternal singing is considered vital to infant well-being. This study focuses on vocal emotion expressions in infant-directed singing among mothers in war conditions. It examines the questions: 1) how traumatic war events and mental health problems are associated with the content and valence of vocal emotion expressions and 2) how these emotion expressions are associated with infant development. The vocal material consists of songs sung by 50 Palestinian mothers, who participated at delivery (T1) as well as when their infants were 6 (T2) and 18 (T3) months of age. These mothers reported traumatic war events (T1), depressive and posttraumatic stress disorder (PTSD) symptoms (T2–T3), and infants' emotional, sensorimotor, and cognitive development (T2–T3). Student judges evaluated the valence and content of vocal emotion expressions in maternal infant-directed singing (playfulness-vivacity, fear, joy, sadness, love-tenderness, anger, and tension). Severe traumatic war events and depressive symptoms were associated with low positive and high negative vocal emotion expressions. High levels of playfulness and joy, as well as low levels of fear and tension, were associated with infant positive affectivity, while low levels of fear, anger, and tension were associated with advanced infant language skills. Discussion focuses on the vocal markers of maternal mental health and infant development.

Keywords: vocal emotion expression, infant-directed singing, maternal depression, maternal PTSD, infant development

Introduction

Caregivers have sung lullabies to their babies since the time of pre-literate, hunting-gathering societies (Trehub & Trainor, 1998) and contemporary research has recognized parental vocal communication to be a core aspect of interaction with an infant (Filippa, Devouche, Arioni, Imberty, & Gratier, 2013; Trehub, Plantinga, & Russo, 2016). Thus, infant-directed singing contains compressed, encapsulated interaction ingredients of the mother–infant dyad. There is evidence that maternal mental health problems, such as depression, negatively impact this dyadic interaction (Brummelte & Galea, 2016; Lefkovic, Baji, & Rigó, 2014), while some research also suggests that the singing of depressive mothers communicates negative affect in a flat tone (Bettes, 1988). Palestinian mothers were the participants of the present study, who sang to their infants in conditions of war and military violence. In such context, soothing and stimulating the infant is highly demanding—yet the empirical evidence on the impact of traumatic war events on the mother–infant interaction remains scarce (Isosävi et al., 2019) and is non-existent in relation to maternal infant-directed singing. Hence, we analyze how maternal exposure to war trauma and mental health are associated with the valence and content of vocal emotion expressions in singing and whether the vocal emotion expressions are further associated with infant development. Valence refers to the positive and negative tone of vocal emotions and content to basic emotions, such as joy, fear, and anger, as well as the emotions that are salient for the quality of dyadic interaction, such as playfulness-vivacity or tension.

Maternal Infant-Directed Singing

Infant-directed speech and singing differ distinctively from adult-directed speech and singing by being more rhythmic and higher in pitch, as well by exhibiting slower tempo, exaggerated pitch contours, and repeated sounds (Bergeson & Trehub, 1999; Trainor, 1996; Trainor et al., 1997). Ignorant listeners (not having professional vocal- or audio-related education) can easily distinguish infant-directed speech and singing from those directed to adults (Bergeson & Trehub, 1999; Rock, Trainor, & Addison, 1999). Infant-directed songs

can be categorized as lullabies and play songs according to their function (Trehub, Hill, & Kamenetsky, 1997; Trehub & Trainor, 1998). Lullabies are soothing songs that serve the purpose of calming infants and attuning their emotional arousal and distress, whereas play songs are emotionally engaging, arousing songs that aim to activate the infant (Rock et al., 1999). Lullabies and play songs can be considered musical counterparts to baby talk or motherese—that is, to infant-directed speech (Trehub et al., 1997). Interestingly, lullabies have distinctive characteristics to the extent that even ignorant listeners are able to differentiate them from other songs—even across cultures (Scherer, Banse, & Wallbott, 2001; Trehub, Unyk, & Trainor, 1993). The valence and content of maternal vocal emotion expressions reflect the quality of the mother–infant interaction, which the literature agrees to be pivotal for infant well-being and development (Le Bas et al., 2019; Madigan et al., 2019).

Research emphasizes the interactive function of singing. Mothers show more intensive facial and whole-body expressions when engaged in infant-directed singing and express a more loving tone of voice than in other types of communication (Bergeson & Trehub, 1999; Trainor, 1996; Trehub et al., 2016). They smile more and exhibit more vivid facial expressions when they are engaged in infant-directed singing than when talking to their babies (Nakata & Trehub, 2004; Trehub et al., 2016). Infants, in turn, show preference for an emotional, warm, and loving tone of voice. One study confirmed that infants turn their heads more frequently and for more extended periods of time toward infant-directed songs that are sung with a loving tone of voice in comparison to infant-absent, less emotionally-laden songs (Trainor, 1996). Importantly, infants show particular interest in the singer’s singing face—indicated by head-turn preferences, visual fixations, and movement reductions (Nakata & Trehub, 2004; Trehub et al., 2016)—and prefer singing performances that utilize a higher pitch and rhythmic, emotional engagement over less engaging ones (Trainor, 1996; Trainor, Clark, Huntley, & Adams, 1997). Nevertheless, another study found that infants attend to happy-sounding speech and singing equally and that both were effective in soothing infants’ distress (Corbeil, Trehub, & Peretz, 2013).

Maternal Mental Health and Vocal Emotion Expressions

Maternal mental health is important for the quality of mother–infant interaction and vocal emotion expression. Ample evidence shows that depressive mothers tend to be withdrawn and less responsive or, conversely, to be intrusive and loud with their infants (Field, 2010, 2017). They can face difficulties in aptly recognizing and responding to infant cues and needs (Brummelte & Galea, 2016; Flykt, Kanninen, Sinkkonen, & Punamäki, 2010) and can exhibit less stroking, affectionate touching, kissing, and eye contact in the dyadic interaction (Parsons, Young, Rochat, Kringelbach, & Stein, 2012; Pearson et al., 2012). There is also evidence that depressive mothers communicate using a flat, expressionless, and unemotional vocal tone with their infants and that they use shorter utterances and vocalizations (Kaplan, Bachorowski, & Zarlengo-Stauss, 1999). They tend to produce more unmodulated contours, more variable pauses, longer and more variable latencies, and fewer vocalizations in response to infant vocalizations (Bettes, 1988). These observations of mother–infant communication concur with the general findings that associate depression with a flat affect and a slow and monotonous voice (Braun et al., 2014).

Infants attune their responses to fit the maternal facial and vocal tone; hence, the infants of depressive mothers typically show less initiative and responsiveness (Biringen & Easterbrooks, 2012). Research suggests that, optimally, parents modify their singing to fit the infant’s mood and infants, in turn, react to the emotional messages in the singing (Trainor, 1996; Trehub et al., 2016). Depressive mothers have difficulties in meaningfully reading and interpreting the emotional signals of their infants and sensitively responding to them (which may also emerge in maternal infant-directed singing). Some evidence confirms that depression compromises the mothers’ ability to adjust their vocal expressions in accordance with their children’s age, interaction tasks, and infant signals of distress (Bettes, 1988; Reissland, Shepherd, & Herrera, 2003).

Lullaby singing has been applied as an intervention method among depressive mothers and the findings provide indirect evidence of the importance of the vocal emotion expressions in mother–infant interaction. A qualitative study of the Limerick Lullaby project suggests that singing lullabies in pregnancy endorses the

women's ability to relax and feel close to their infants (Carolan, Barry, Gamble, Turner, & Mascareñas, 2012). Importantly, other intervention studies have revealed that maternal infant-directed singing is associated with the enhanced psychological well-being of the mother, indicated by reduced anxiety and stress, as well as improved mood (Arnon et al., 2014; Bieleninik, Ghetti, & Gold, 2016) and increased postnatal maternal bonding (Persico et al., 2017).

The mothers in our study lived with their infants in conditions of war and military violence. Consequently, we analyzed the role played by posttraumatic stress disorder (PTSD) symptoms, in addition to depressiveness, in vocal emotion expressions in maternal infant-directed singing. Research on how mothers with PTSD interact with their infants is very scarce. A study among refugee parents found that maternal PTSD is associated with lower emotional availability in mother–infant interaction, indicated by low maternal sensitivity and structuring as well as low infant responsiveness (van Ee, Mooren, & Kleber, 2012). A study, in war conditions, showed that maternal PTSD, together with depressive and dissociative symptoms, predicted negative mother–infant interaction quality through a lower mother–fetus attachment (Punamaki, Isosävi, Qouta, Kuittinen, & Diab, 2017). We did not find any research on how PTSD symptoms would manifest in vocal emotion expression—neither in singing nor in speaking to an infant. However, as PTSD is associated with anxiety, dissociation, and dysfunctional emotional processing of trauma (LeBeau et al., 2014; Van der Hart, Nijenhuis, & Steele, 2005), it is reasonable to assume that mothers suffering from PTSD symptoms show more negative vocal emotion expression, maybe fear in particular, when singing to their infants.

Maternal Singing and Infant Development

It seems that the need to hear the voice of the caregiver is inherent for newborn babies (Filippa et al., 2017) and that the mother's voice can be recognized as early as in utero (Jardri et al., 2012). By conveying emotions, maternal singing is suggested to contribute to an infant's optimal self-regulation, which incorporates balancing stress and enhancing effective emotion regulation (Corbeil, Trehub, & Peretz, 2016; Shenfield,

Trehub, & Nakata, 2003; Ullsten Eriksson, Klassbo, & Volgsten, 2017a; Ullsten et al., 2017b). As an example, Corbeil et al. (2016) showed that infant-directed singing was considerably more effective than speech in delaying the onset of infant crying and distress, probably due to singing-related temporal patterning, such as regular beat, metrical organization, and tempo. Other studies show that infant-directed singing is effective in increasing the early dyadic synchrony and in promoting parental sensitivity, thus supporting secure attachment formation and the socio-emotional development of a child (Kivijärvi, Voeten, & Niemelä, 2001; Nakata & Trehub, 2004). Furthermore, parental singing can promote the early auditory neural processing of an infant, thus supporting child language development (Virtala & Partanen, 2018).

Intervention studies among mothers and their preterm babies provide further support for the beneficial influences that maternal singing can have on early infant development. According to a systematic review, maternal infant-directed singing is associated with favorable neonatal development among preterm newborns, indicated by increased physiological and behavioral stability (Filippa et al., 2017). Similarly, a meta-analysis of the efficacy of music therapy—typically using parental infant-directed singing to enhance preterm infant development—found favorable effects on their respiratory rate (Arnon et al., 2014). Thus, maternal singing seems to provide a valuable way to improve the emotional and physiological basis for infant self-regulation and sensorimotor development (Corbeil et al., 2016; Ullsten, 2017). In a prospective study among full-term infants, Persico et al. (2017) showed that maternal lullaby singing in pregnancy predicts a lower level of infant crying and colic.

Aims of the Study

In the present study, we analyzed seven vocal emotion expressions found in maternal infant-directed signing in Palestinian mother-infant dyads. Four were basic emotions of *anger*, *fear*, *joy*, and *sadness* (Ekman, 1992). The additional three emotion expressions were *love-tenderness*, which is a core emotion expression in mother–infant interaction as well as an accurately distinguishable vocal emotion (Juslin & Laukka, 2003),

playfulness-vivacity, which adequately illustrates maternal emotional engagement when singing to their infants (Trehub et al., 1997), and *tension*, which is a relevant emotion expression in the context of problematic maternal mental health and dyadic relationship (Reck, Tietz, Müller, Seibold, & Tronick, 2018).

The first goal was to analyze how exposure to traumatic war events and maternal mental health problems are associated with the valence and content of the vocal emotion expressions in the infant-directed singing of mothers. We hypothesized that high exposure to traumatic war events, along with depressive and PTSD symptoms, would be associated with a negative valence of vocal emotion expressions—indicated by high levels of anger, fear, sadness, and tension—and with low levels of joy, love-tenderness, and playfulness-vivacity. The second goal was to analyze how the valence and content of vocal emotion expressions in maternal infant-directed singing are associated and can predict the emotional and sensorimotor development of infants. We hypothesized that high levels of playfulness-vivacity, joy, and love-tenderness in infant-directed singing, together with low levels of anger, fear, sadness, and tension, would be associated with and predict (a) high levels of infant positive affectivity and emotion regulation capacity and low levels of negative affectivity, as well as (b) high levels of cognitive-language and fine- and gross-motor skills.

Two ignorant, listener groups (university students) evaluated the valence and content of the vocal emotion expressions used by Palestinian mothers in infant-directed singing. There is ample evidence that listeners are highly capable of decoding the emotional messages in human voices, indicating high emotion recognition accuracy—i.e., the match between perceived and intended emotion (Elfenbein & Ambady, 2002; Juslin & Laukka, 2003; Kraus, 2017; Laukka, Neiberg, & Elfenbein, 2014). As evaluators, Palestinian students represented a cultural in-group and Finnish students a cultural out-group. The rationale behind combining both cultural in- and out-group evaluations was that this combination provides wider aspects of the valence and content of the vocal material of infant-directed singing. There is some evidence that both cultural in- and out-groups show equal vocal recognition accuracy, especially in negative emotions (anger and sadness) (Elfenbein

& Ambady, 2002; Juslin & Laukka, 2003), although the cultural in-group has advantages, especially in terms of recognizing vocal happiness (Elfenbein & Ambady, 2002; Laukka et al., 2013).

Method

Participants and Procedures

The vocal material for this study was gathered in Palestine, Gaza Strip—an Israeli-sieged and internationally boycotted Palestinian territory—as a part of a larger research project, called “Protecting Infant Development in the Toxic Environment of War” (reference omitted for anonymity). The original sample involved 502 Palestinian mothers, who were recruited at the time of their delivery in maternity units located in four regions of the strip (T1). Of the recruited mothers, 392 were visited in their homes when their infants were 6 months old (T2; $M = 6.2$, $SD = 0.4$) and 386 mothers continued their participation when their infants were 18 months old (T3; $M = 18.0$, $SD = 1.4$). The vocal material was collected during the T2 home visit by recording the mothers singing a song of their own choice to their infants. Of the 392 mothers, 236 agreed to perform a song as part of the questionnaire interviews. The average duration of the visits was 90 minutes.

Prior to delivery, maternity care nurses presented the study and asked mothers to participate. Those interested in joining the study signed an informed consent form that allowed for a possibility that the researchers would contact them twice during the subsequent 18 months. The inclusion criteria were that women had been in their first trimester of pregnancy during the 2014 War on Gaza—a 54-day long, intensive, military operation, which involved shelling, bombing, and curfew of the Gaza Strip and resulted in extensive human and material losses and displaced families (UN/Human Rights Council, 2014).

Ten Palestinian fieldworkers, with Bachelor’s degrees and former research experience, visited the women from June to October of 2015 (T2) and from August to November of 2016 (T3). They attended comprehensive training on the research tasks, ethics, and procedures. Furthermore, a local research team

supervised their fieldwork through weekly meetings and guidance. All study procedures were conducted in the Arabic language.

The Palestinian Health Research Council and the Helsinki Committee for Ethical Approval reviewed the study and approved its research tools and procedures. The data that support the findings of this study are available from the corresponding author upon reasonable request.

Between T1 and T2 periods, 110 (22%) participants dropped out, primarily because their home address had changed due to displacements and shelled homes ($n = 90$), death of the baby ($n = 13$), and withdrawal for family reasons ($n = 7$). The drop-out rate was independent of the infant gender and birthweight as well as of the age and education of the mother and father. Instead, participation at T2 was related to a longer gestation ($t = 2.50, p < .01$) and better newborn health ($t = 7.65, p < .01$). The drop-out rate between T2 and T3 periods was only five mothers and one infant that had died.

Vocal Material of Infant-directed Singing

Of the 236 maternal infant-directed songs obtained, 50 were randomly chosen for the current analysis. The vocal material was uniformly cut so that the length of each song excerpt was 30 seconds. This choice was based on equal representation of the mothers' songs in analysis and the judges' capacity to effectively concentrate on the vocal rating task. It was deemed possible to evaluate this vocal material in one two-hour session by the judges. The judges were volunteer Palestinian ($n = 10$) and Finnish ($n = 18$) psychology students and they received course credits for participating in the evaluation. The listening and evaluation were arranged in a university's language studio in Finland and corresponding arrangements were made in Gaza (high quality technical devices in a university room). After listening to each 30-second long song extraction, the judges were instructed to rate the extent to which the singing voice they heard expressed certain emotions or emotional characteristics. They rated two song performances for practice before proceeding to the 50 study songs. There was a silent pause of 35–45 seconds in length between listening to the song performances. In addition, the

students had three short breaks in order to be able to concentrate fully from the beginning to the end of the session.

Measures

Maternal vocal emotion expressions (T2). The judges were instructed to evaluate the extent to which the singing voice in each of the 50 song performances expressed the following seven emotions in the following order: playfulness-vivacity, fear, joy, sadness, love-tenderness, anger, and tension. The rating scale for emotional expression ranged from 0 (Not at all) to 9 (Very much). In addition, verbal anchors were given for the values 1 (Very little) and 5 (In between). In case that the judges found that an evaluation of a song was absolutely impossible, they could mark “Cannot say.” This was a response option without any numerical value and it was visually separated from the 0–9 continuum.

Traumatic war events (T1). Women responded to five questions about their exposure to the 2014 war: whether their own house was bombed, whether the house next door to theirs was bombed, whether they were inside their home at the time of a shelling/attack, whether they were displaced afterwards, and whether they found use ammunition inside their dwelling (*yes* = 1; *no* = 0). The degree of home destruction was also photo documented.

Depressive symptoms (T2). The Edinburgh Postnatal Depression Scale (EPDS; Cox, Holden, & Sagovsky, 2010) was applied to measure depressive symptoms. The EPDS consists of 10 items that assess negative feelings, thoughts, and behaviors, such as sadness, fear, self-blame, and sleeping problems. Using a 4-point scale, ranging from 0 (indicating that the symptom was not present) to 3 (indicating high symptom presence), the participating mothers estimated whether and to what extent they had suffered from described symptoms during the last two week. The theoretical maximum score was 30 and a cut-off score of 13 or more was used to indicate probable major postnatal depression, as recommended by Matthey, Henshaw, Elliott, and Barnett (2006). A sum variable was constructed and Cronbach’s α was .82.

PTSD symptoms (T2). The 16-item scale of posttraumatic stress disorder (PTSD) symptoms, obtained from the Harvard Trauma Questionnaire (HTQ; Mollica et al., 1992), was applied. The HTQ covers intrusive, avoidance, and hypervigilance symptoms. Using a 4-point scale, ranging from 1 (Not at all) to 4 (Severely), the participating mothers estimated how much they suffered from the described symptoms during the previous month. A cut-off score of 2.06 was calculated from an averaged sum variable to indicate clinically significant PTSD (Oruc et al., 2009). A sum variable was constructed with an α value of .91.

Infant emotional development (T2 and T3). Infant emotion expression and regulation were measured using a very short form of the Infant Behavioral Questionnaire-Revised (IBQ-R; Putnam, Helbig, Gartstein, Rothbart, & Leerkes, 2014). The measure includes 37 descriptions of positive and negative infant affectivity, behavior, and orientation during daily situations such as eating, bathing, and separation. Mothers were asked to estimate, using a 5-point scale (1 = Never; 5 = Always), approximately how often during the past week their infant behaved in the described way. The scale had to be modified for the present study, as factor analyses of the original measure (three separate factors) revealed that several of the items had very low or non-significant loadings. Consequently, we retained the three factors that were identified as significant by earlier research (Leerkes et al., 2017; Putnam et al., 2014), but used only the highest loading items within each of the alleged dimensions. The sum scores that we used included five items for *positive affectivity* ($\alpha = .66$), three items for *negative emotionality (social fear)* ($\alpha = .83$), and seven items for *orienting/regulatory capacity* ($\alpha = .61$).

Infant sensorimotor development (T2). A 35-item questionnaire, based on the Minnesota Child Development Inventory (MCDI; Koppaarthi et al., 1991), was applied to assess the infants vocalizations and utterances as well as their fine- and gross-motor development at 6 months. The items reflect increasingly demanding skills. The 10-item scale for *language* began with “Baby’s vocalization begins to resemble utterances, e.g., ala, ila” or “Baby voices/utterances are continuous across one respiratory cycle (breathes in and out)” and ended with “Baby produces utterances that sound as real words, e.g., expressions such as umm, abu.” The 15-item scale for *fine-motor development* began with “Baby keeps both hands tightly clenched” or

“Baby grabs the parent’s finger strongly when it touches the baby's palm” and ended with “Baby can beat/hit/bang two blocks or other toys several times against each other” or “Pincer grip: The baby can grab small items by her/his fingertips and by flexing the thumb and the index finger.” The 10-item scale for *gross-motor development* began with “Raises head to the height of five centimeters, at least, and keeps it up about three seconds” or “Can roll from her/his stomach on to her/his back without help” and ended with “Can pull her/himself to stand independently, e.g., through seeking support by her/his hand against the wall or bed.” Seven of the fine-motor skills were visualized in addition to the verbal descriptions provided. Using a 3-point scale, mothers estimated whether the infant had performed the task (1 = not observed; 2 = observed once or occasionally; 3 = observed many times, routinely). The MCDI has been validated and corresponds with Bayley Sensory Motor Skills scale for 8- to 16-month old infants in North American (Kopparthi et al., 1991) and Egyptian (Baherie, 2013) samples. The current 35-item scale has been validated for the evaluation of early communication, language, and sensorimotor development among Finnish children (Lyytinen, Ahonen, Eklund, & Lyytinen, 2000) and a 15 item version was found to be reliable and valid in a Palestinian infant study (names omitted for anonymity). Sum scores were calculated for language, fine-motor, and gross-motor skills by counting the highest values, indicating that that skill was observed many times, routinely.

Child cognitive and sensorimotor development (T3). This was measured using three scales of the 50-item Arabic version of the Bayley Scales of Infant Development, BSID-III (Al Behairi, 2013). The scales used in this study cover *cognitive-language development* (22 items, e.g., “Looking at the pictures in the book”; “Put three cubes or more in the cup”; “Build a tower of two cubes or more”; “Imitating words”) and *motor and sensorimotor development* (11 items, e.g., “Sitting without support”; “Reaches items with a goal-directed attempt”), which reflect increasingly advanced skills. A psychologist assessed the 18-month old infants individually for their cognitive-language and motor development. Each task that a toddler performed was scored on a scale (yes—succeeded, performed; or no—did not perform) in accordance with the specified

performance standards of each task. Sum variables were calculated for the three development domains and Cronbach's α values were .80 for cognitive-language and .84 for motor and sensorimotor development.

Translation. All measures were taken in Arabic. The HTQ, EPDS, IBQ, BSID-III, and sensorimotor scales were translated and validated in earlier Arab studies (Isosävi et al., 2017); the traumatic war events and BSID-III were originally in Arabic.

Statistical Analyses

To legitimize the combined evaluation of vocal emotion expressions by cultural out- and in-groups, the following statistics were run. First, interrater reliability for each of the seven vocal emotion ratings was assessed using intra-class correlation coefficients (ICC; LeBreton & Senter, 2008) separately within the cultural in- and out-groups. A fully crossed design was used, where every judge evaluated each of the seven emotions separately in each of the 50 song excerpts. The ICC values were calculated by using a two-way random-effects model with consistency definition. Consistency-based ICC was optimal for the purposes of this study because it is based on similarity in the rank order of the study objects (songs) on each vocal emotion expression rather than on the same absolute values (LeBreton & Senter, 2008). Thus, it would not matter even if the judges used the rating scale in different ways (e.g., some using the lower end of the scale more than others), as long as they ranked some of the songs higher and some lower for each emotion. Second, pair-wise correlations were run within each vocal emotion evaluation between the in- and out-group judges and, third, the mean values of each of the seven vocal emotion evaluations were compared between the in- and out-groups using the Student's t-tests.

The background variables were compared between the subsample of vocal data and all mothers participating in T2 using Chi² cross-tables. Bivariate Pearson's Product Moment Correlations were run between study variables of traumatic war events, depressive and PTSD symptoms, and vocal emotion expressions, as well as between vocal emotion expressions and infant emotion and sensorimotor development.

To answer the first research question on the role of traumatic war events and maternal mental health problems in association with a mother's vocal emotion expressions, we applied linear regression analyses. The independent variables were war trauma, as well as depressive and PTSD symptoms, while the dependent variables were three positive vocal emotions and four negative vocal emotions (each regressed separately). To answer the second research question on the impact of maternal vocal emotion expressions in infant-directed singing on infant emotional and cognitive development, we applied the two-stage least squares (TSLS) regression analyses. The independent variables were vocal emotions of playfulness-vivacity, joy, love-tenderness, fear, sadness, anger, and tension. The dependent variables were (a) infant positive affectivity, negative affectivity, and regulatory capacity to indicate emotional development at both T2 and T3, as well as (b) infant language, fine-motor, and gross-motor skills, indicating cognitive and sensorimotor development at T2 and T3. The choice of the TSLS regression was based on high correlations between vocal emotions, indicating multicollinearity with large standard errors. The TSLS regression creates instrumental variables that are uncorrelated with the error terms to compute estimated values of the problematic predictors (the first stage) and it then uses these computed values to estimate a linear regression model of the dependent variables (the second stage). The computation of instrumental values imposes orthogonality conditions in the sample and these computed orthogonal values are based on variables that are uncorrelated with the errors, thus providing a more controlled model (James & Singh, 1978).

Results

Descriptive Results

Table 1 presents the mother- and infant-related characteristics at T1 of the subsample of mothers providing infant-directed singing ($n = 50$). The mothers were in their mid-twenties ($M = 26.3$, $SD = 5.7$ years) and for about one third (29%) this was their first child. Concerning the type of residence, almost half (46%) of the families lived in refugee camps and 40% in urban areas. The majority of women worked at home (90%),

while a third of their husbands (34%) were professionals, 42% workers, and a quarter (24%) were unemployed. Little more than a half of the infants (56%) were boys. Two thirds of newborns had excellent (66%) health while the rest had good (34%) health. Only one infant had low-birth weight and none were premature in the subsample.

The selected subsample was similar to the original sample at T2 ($n = 392$) in terms of mother's age ($\chi^2(3) = 2.71, p = .44$), father's age ($\chi^2(3) = 1.69, p = .64$), the number of children ($\chi^2(3) = 1.78, p = .62$), maternal working status ($\chi^2(2) = .49, p = .79$), paternal working status ($\chi^2(2) = .40, p = .82$), and type of residence ($\chi^2(2) = 4.40, p = .11$). The infant gestational age was more normative in the subsample than in the original ($\chi^2(2) = 6.94, p = .031$). The share of premature babies was zero in the subsample and 5% in the original. The subsample did not differ from the original in terms of infant sex ($\chi^2(1) = .94, p = .33$), birth weight ($\chi^2(3) = 2.47, p = .48$), or newborn health ($\chi^2(2) = 1.49, p = .39$).

Concerning maternal mental health, 48% ($n = 24$) of the women in the subsample suffered from clinically significant PTSD and 18% ($n = 19$) had probable major postpartum depression. In this, they did not differ from the original sample at T2, where the corresponding shares were 42% ($n = 158$) and 16% ($n = 80$), respectively.

Cultural In- and Out-Group Evaluation of Vocal Emotion Expression

The Palestinian (cultural in-group, $n = 10$) and Finnish (cultural out-group, $n = 18$) judges differed in age, number of children, and current musical activity. The total mean age was 26 years ($SD = 6.17$), ranging from 20 to 50 ($Md = 25.0$), with the Palestinian group ($Md = 27.5$) being older than the Finnish one ($Md = 24.0$), ($U(1) = 6.15, p = .013$). All but one of the judges were women (96.4%). Four of the Palestinian judges had children (2–7 years old) but none of the Finnish ones did. Concerning musical background, 88.9% ($n = 16$) of the Finnish and 66.7% ($n = 6$) of the Palestinian judges reported interest in singing or playing some instrument as a hobby, which was continuous for 6.5 and 10 years (median), respectively. However, only 22.2%

of the Finnish ($n = 4$) and 55.6% of the Palestinian students ($n = 5$) were still active in terms of singing or playing.

The interrater reliabilities (intra-class correlations, ICC) of the evaluations of vocal emotion expressions were reported separately within the cultural in- and out-group in Table 2. All ICCs were high or moderate but the reliabilities were somewhat lower in the in-group than in the out-group. For instance, concerning fear, the ICC was .95 in the out-group and only .41 in the in-group, whereas, concerning love-tenderness, the ICC was .94 in the out-group and .78 in the in-group.

Table 2 also presents the pair-wise correlations between the cultural in- and out-group judges. The results indicate high between-group concurrences in the evaluations of vocal emotion expressions. All correlations were statistically highly significant ($p < .0001$), except that of tension ($p < .001$). The highest pair-wise correlations between the cultural in- and out-groups were found for joy (.81), moderate ones for love-tenderness (.62) and anger (.60), and the lowest for fear (.48) and tension (.47).

The mean values of the evaluations of vocal emotion expressions among the cultural in- and out-group judges are illustrated in Figure 1. The in-group perceived more negative and the out-group more positive vocal emotion expressions, as the Finnish judges perceived more playfulness-vivacity ($t(26) = 2.15, p = .041$) and joy ($t(26) = 2.15, p = .041$), while the Palestinian judges perceived more anger ($t(27) = -3.15, p = .010$).

War Events, Mental Health, and Vocal Emotion Expressions

Table 3 introduces correlations between traumatic war events, mental health problems, and maternal vocal emotion expressions in infant-directed singing. The study results showed that war trauma did not correlate with any vocal emotion expression and only one significant positive correlation was found between maternal depressive symptoms and vocal anger. Both positive and negative maternal vocal emotion expressions were significantly correlated, except for sadness, which did not correlate significantly with anger or tension.

Concerning the first research question on the impact of traumatic war events and maternal mental health problems on vocal emotion expressions, the results showed significant regression models for vocal love-tenderness (19% explained variance, $F(3,47) = 3.38, p = .027$), anger (22% explained variance, $F(3,47) = 4.17, p = .011$), and tension (19% explained variance, $F(3,47) = 3.32, p = .028$). Table 4 shows, as hypothesized, that severe traumatic war events were associated with low levels of vocal love-tenderness ($\beta = -.33, t = -2.39, p = .021$) and with high levels of vocal anger ($\beta = .28, t = 2.04, p = .048$) and tension ($\beta = .38, t = 2.71, p = .010$). Furthermore, as hypothesized, high levels of maternal depressive symptoms were associated with high levels of vocal anger ($\beta = .41, t = 2.76, p = .008$). Contrary to our hypotheses, PTSD symptoms were not associated with any vocal emotion expression in infant-directed singing.

Vocal Emotion Expressions and Infant Emotional Development

The results showed only one significant and few marginally significant correlations between vocal emotion expressions in maternal infant-directed singing and infant emotional development at 6 (T2) and 18 (T3) months of age. Vocal tension correlated positively with infant negative affectivity ($r = .36, p = .016$) at T3. Marginally, vocal anger ($r = -.27, p = .054$) and tension ($r = -.28, p = .051$) correlated negatively with infant emotion regulatory capacity at T2 and vocal tension also correlated negatively with emotion regulatory capacity ($r = -.27, p = .060$) at T3.

The results of studying the impact of maternal vocal emotion expressions on infant emotional development showed a significant regression model for positive affectivity only (30% explained variance, $F(3,41) = 2.56, p = .028$). The results presented in Table 5 show, as hypothesized, that high levels of maternal vocal emotion expressions of playfulness-vivacity and joy, as well as low levels of vocal fear and tension, were associated with a high level of infant positive affectivity. A high level of vocal love-tenderness was marginally associated with regulatory capacity, as hypothesized. The valence or content of maternal vocal emotion expressions did not significantly predict emotional development at T3 when infants were 18 months old.

Vocal Emotion Expressions and Infant Sensorimotor and Cognitive Development

The results showed only one significant and few marginally significant correlations between negative maternal vocal expressions and infant (T2) and toddler (T3) sensorimotor and cognitive development. Vocal anger ($r = -.27, p = .053$) and sadness ($r = -.24, p = .089$) showed a marginal negative correlation with language skills at T2. Vocal sadness also correlated negatively with language skills at T3 ($r = -.33, p = .026$), while marginally vocal fear ($r = -.29, p = .053$) and sadness ($r = -.27, p = .058$) correlated negatively with sensorimotor skills at T3.

The results of the impact of maternal vocal emotion expressions on infant sensorimotor and cognitive development showed a significant regression model for language skills (29% explained variance, $F(3,42) = 2.48, p = .032$) and a marginally significant model for gross-motor skills (25% explained variance, $F(3,42) = 1.99, p = .080$). As hypothesized, Table 6 shows that a high level of the vocal emotion expression of joy and low levels of fear, anger, and tension were associated with a high level of infant language skills. Furthermore, as hypothesized, but only marginally, a high level of vocal playfulness-vivacity and low levels of vocal fear, sadness, and tension were associated with a high level of gross-motor skills.

Concerning the impact of maternal vocal emotion expressions on child sensorimotor and cognitive development at T3, only marginal results were found. As hypothesized, low levels of vocal anger ($\beta = .53, t = 1.95, p = .058$) and sadness ($\beta = .83, t = 1.72, p = .093$) predicted good sensorimotor skills. However, the regression model on sensorimotor skills was only marginally significant (26% explained variance; $F(7,39) = 1.92, p = .093$).

Discussion

This study examined the role played by war trauma and mental health in the vocal emotion expressions of mothers while they sing to their 6-month old infants in the context of the Israel-Palestinian conflict. It further analyzed the impact of vocal emotion expressions on infant emotional and sensorimotor development. As

expected, the results suggested that infant-directed singing of mothers exposed to severe war trauma incorporated low levels of love and tenderness and high levels of anger and tension, thus indicating a relatively comprehensive trauma impact. Instead, maternal mental health had only a limited impact on vocal expressions—depressive symptoms were associated with a higher presence of vocal anger, while PTSD symptoms were not found to have a significant effect. Furthermore, the valence and content of emotion expressions in infant-directed singing concurrently contributed to infant development, thereby providing validity to the view that mothers convey significant emotional messages to their babies while singing. The study design was based on cultural in-group (Palestinian students) and out-group (Finnish students) evaluations of the singing of mothers. The judges showed consensus in their evaluations, although the in-group perceived more negative and the out-group more positive valence in maternal vocal emotion expressions.

Infant-Directed Singing in War Conditions

As hypothesized, traumatic war events, such as loss of home and threat to life, negatively influenced maternal infant-directed singing by decreasing vocal expression of love and tenderness and increasing that of anger and tension. We could not find other research on how maternal trauma impacts infant-directed singing. Case studies have shown that the helplessness and neediness of an infant can evoke a mother's traumatic memories, resulting in fear of and hostility toward the infant. These dynamics were found among mothers exposed to both interpersonal trauma, such as childhood maltreatment or sexual abuse (Schechter & Willheim, 2009), and war trauma, such as terrorism (Kaitz et al., 2009; Levi, 2006). There are also studies that have suggested that mothers heighten their efforts to protect their infants in war conditions and invest more intensively in maintaining good dyadic interactions (Diab, Qouta, Isosävi, Kuittinen, & Punamäki, 2018). Singing, as vocal communication, is apparently highly sensitive to stress and trauma because the exposure of mothers to war trauma both decreased the positive emotion valence and content and increased the negative ones. Positive maternal emotions of joy and love are highly essential in early communication with the still

helpless, needy, and dependent infant (Puura et al., 2013). Therefore, mothers caring for infants in war conditions should be provided effective professional help that enables them to protect the important dyadic interaction. Increasing core positive emotions and decreasing anger and tension in lullaby and activity singing can be legitimate and effective elements in therapeutic interventions.

Research is unanimous about the vital role of maternal mental health in the quality of the mother–infant interaction and there is ample evidence on the risking role of depression (Field, 2010). Similarly, research shows that maternal depression negatively affects vocal emotion expressions in mother–infant communication (Bettes, 1988; Kaplan et al., 1999). As maternal infant-directed singing is an important element in mother–infant communication and interaction, we expected maternal mental health problems to play a comprehensive negative role in singing. However, only the mother’s depressive symptoms were associated with a high level of angry vocal expression and, against to our hypothesis, these symptoms did not significantly associate with a low positive valence in singing, such as joy, love, and tenderness. Sadness is considered to be the core emotion of depression (Leventhal, 2008), which did not realize in our vocal analysis. Thus, the findings have failed to confirm the presence of negativity, gloom, and flatness in vocal expressions of depressive mothers, as documented by Bettes (1988) and Kaplan et al. (1999). Nevertheless, the finding that depressive mothers expressed more anger or even hatred in their singing concurred with the observations that depressed mothers can be more negative toward their infants by showing overstimulation and intrusiveness in addition to withdrawal and flat affect (Brummelte & Galea, 2016; Flykt et al., 2010).

Theories emphasize that all emotions have a function—whether to maintain well-being, meaningfulness, self-respect, and communal harmony or to stabilize distressing experiences (Dalglish & Power, 2015; Darwin, 2009; Frijda & Mesquita, 1994). Anger is a highly stimulating and energizing emotion, according to the circumplex-model by Larsen and Diener (1992), and a perceived loss of significant goals or a violation of salient values typically elicit anger. Functionally, anger gives a person the energy to overcome obstacles, disappointments, and pain, which is visible through increased physiological activity, goal-directed behavior,

and heuristic thinking (Dalglish & Power, 2015). Caring and protecting infant well-being in conditions of war and political violence is a complex and often impossible task so that mothers tend to express guilt and self-blame for their children's suffering (Kaitz Levy, Ebstein, Faraone, & Mankuta, 2009; Punamaki, 2014). We may speculate that mothers suffering from postpartum depression feel worthless, ashamed, or guilty about their withdrawn emotions and for their incompetence to protect their infants. Subsequently they can attempt to stimulate themselves, which leads to overactive emotions that are recognized as anger in their vocal emotion expressions. Our finding is important to indicate that maternal depression can be reflected in negative vocal emotions, which is considered to be a core element of risky early dyadic interaction. Thus, the quality of maternal infant-directed singing can help identify emotional problems in dyadic interactions.

Against to our hypothesis, PTSD symptoms were not significantly associated with the valence and content of maternal emotional expressions in infant-directed singing. Our result contradicts the models that propose that the occurrence of PTSD—rather than the trauma itself—forms risks for developmental and mental problems (Qureshi et al., 2011; Malarbi, Abu-Rayya, Muscara, & Stargatt, 2017). Concerning early dyadic interaction, the Gaza Infant study confirmed that maternal PTSD rather than war trauma itself predicted fearful maternal representations (Isosävi, et al., 2019). A Dutch study found that refugee mothers with PTSD showed low sensitivity and either intrusiveness or withdrawal in the interactions with their toddlers (van Ee et al., 2012). Nevertheless, more research is needed to understand the role of maternal mental health in infant-directed maternal singing in war conditions—for instance, whether intrusive, avoidant, and hypervigilant PTSD symptoms have specific impacts on the dyadic emotion expressions in singing.

Importance of Maternal Singing in Infant Development

As hypothesized, high positive and low negative valence and content of vocal emotion expressions in maternal infant-directed singing were associated with beneficial emotional and sensorimotor development when the infants were 6 months old. Also, maternal vocal anger and sadness marginally predicted an infant's

low sensorimotor skills at 18 months of age. Earlier research on the developmental impacts of maternal lullaby singing has provided evidence of beneficial impacts of singing itself on newborn and infant stress and emotion regulation as well as on the psychophysiological processes underlying an infant's development (Arnon et al., 2014; Filippa et al., 2017). Our findings contribute to the literature by showing how a specific, high vocal quality of infant-directed singing, characterized by the presence of playful, vivacious, and joyful emotion expressions and the absence of fearful and tense ones, was important for infants to show positive affectivity. This kind of affectivity—involving high activity level, tendency to approach others, high intensity of pleasure, and frequent smiling and laughter—is highly important during the first-year of development as it invites caring and sharing (Reddy, 2019). Moments of shared joy are fundamental in the early months between a mother and an infant, creating a space for optimal further relationship growth and development (Puura et al., 2013).

However, different from earlier research, the maternal vocal emotion expressions in our sample were not associated with infant regulatory capacity. The result is unexpected because self-regulation is a core developmental task during the first year of life. Infants need parental help to stabilize between overwhelming stimuli and their own, still underdeveloped, regulation capacities (Calkins & Hill, 2007) and maternal singing has been found to attune infant distress and calm non-regulated arousals (Arnon et al., 2014; Corbeil et al., 2016; Persico et al., 2017). The evidence that high-quality infant-directed singing enhances self-regulation is mostly available for premature infants, who need even more help in maintaining a homeostasis between external and internal stimuli and in modulating affective equilibrium (Stolt et al., 2010). The reason that high-quality maternal vocal emotion expressions could enhance positive affectivity of infants but not their emotion regulatory capacities may relate to the sheer threat to life that dyads experience in war conditions. External disruptions and danger interfere with infant regulatory development, despite the struggle of mothers to maintain safety and normality.

As hypothesized, high positive and low negative maternal vocal emotion expressions were associated with optimal infant cognitive and sensorimotor development at 6 months. However, the results were vocal

emotion-specific and infant skill-specific. A high presence of joy and absence of fear, anger, and tension in maternal singing were associated with advanced infant language skills, while a low level of vocal tension was also associated with advanced gross-motor skills.

The finding of the comprehensive positive impact of a high quality of maternal emotion expressions on the language development of infants emphasizes the importance of intensive dyadic communication in these first formative months. Typically, optimal infant-directed singing involves a variety of rhythms with high and exaggerated pitch contours, repetitious sounds, and emotional engagement, which encourages infants to respond, imitate, and repeat both novel and familiar vocal communications (Bergeson & Trehub, 1999; Trainor, 1996; Trainor et al., 1997). There is evidence that reading together with an infant predicts successful development of early language skills (Raikes et al., 2006; Vally, Murray, Tomlinson, & Cooper, 2015). We may analogously suggest that joyful singing to the infant without negative vocal messages is also beneficial for language-enhancing elements. Maternal singing that incorporates positive emotions also communicates socioemotional safety and involves apt stimuli tailored to the needs and skills of infants, both of which contribute to language development (Saxton, 2017).

The finding that good quality of maternal infant-directed singing was associated with both infant positive affectivity and language development is important when tailoring interventions for mother–infant dyads in conditions of war and military violence. Research shows that maternal lullaby singing can endorse relaxation, mother–infant emotional bonding, and early infant self-regulation (Carolan et al., 2012; Persico et al., 2017). Our study did not analyze the *impact* of maternal infant-directed singing on dyadic interaction but it does suggest that positive vocal emotional characteristics of maternal singing, such as joy and love-tenderness, may serve as vital encouragement for optimal infant development. Thus, interventions targeting to increase early positive vocal communication, including infant-directed singing, are justified as they can prospectively protect maternal mental health, dyadic interaction, and infant development.

Methodological Consideration of Cultural In- and Out-Group Evaluations

Pair-wise correlations showed general concord between the cultural in- and out-group judges' evaluations. Yet, comparisons also revealed that in-group judges perceived more negative emotions of anger, while the out-group judges perceived more positive emotions of playfulness-vivacity and joy in maternal singing voices instead. The finding that the Palestinian judges perceived more negative vocal emotion expressions than the Finnish ones may reflect cultural standards, scripts, or "baseline" valence of emotion expressions. There is some evidence on cultural differences in the acceptance and appreciation of sadness, anger, and joy manifestations (Matsumoto et al., 2002; Tanaka et al., 2010). Palestinian society, as part of ancient Arab Islamic culture, may expect mothers to be generally highly expressive and happy-sounding with their babies, whereas Finnish society is considered to be more reserved in manifesting both positive and negative emotions (Parkinson, Fischer, & Manstead, 2005). These basic cultural implicit expectations may indicate that Palestinian judges were more sensitive to non-normative, negative maternal vocal messages, whereas Finnish judges better recognized vocal positivity or expressivity that were novel or non-normative to them. Thus, we may speculate that, due to cultural standard expectations, Palestinian mothers sounded happier to the Finnish judges even if they did not sound happy enough to their own cultural peers (Parkinson et al., 2005; Tanaka et al., 2010).

The finding that the out-group did perceive more positive and the in-group more negative vocal emotion expressions is somewhat contradictory to earlier studies on the impact of culture on emotion recognition accuracy. Those studies have emphasized that the in-group and out-group are equally capable of recognizing vocal emotions of anger and sadness (Elfenbein & Ambady, 2002; Juslin & Laukka, 2003) but that in-groups were more accurate in recognizing vocal happiness (Elfenbein & Ambady, 2002). However, it is important to remember that our study setting did not deal with the question of recognition accuracy or empathic accuracy of the vocal material because the cultural in- and out-groups did not evaluate exact stimuli.

Limitations

Several limitations should be taken into account when assessing the results. First, from a general methodological point of view, our study featured three characteristics that, according to the meta-analysis by Juslin and Laukka (2003), contribute to lower accuracy in vocal emotion perception—the use of a rating scale instead of forced choice, the use of cross-cultural evaluations of vocal emotion expressions, and the use of natural expressions of emotions.

Second, although the student-judges—in their evaluation task—were instructed to focus on the voice (performance characteristics) and to ignore the melody and other structural characteristics of the songs as much as possible, it is very likely that these characteristics nevertheless contributed to the evaluations of emotion expressions in maternal singing (Trainor, 1996; Trehub et al., 1997). The vocal expressions were also considered from a small portion of a song only (30 seconds), which may explain some of the non-significant or marginal findings. Furthermore, the English language was used between Finnish and Arabic translations of the emotion words. Consequently, the translations of the emotions may have been less than optimally accurate, which may have had an effect on the emotion ratings. For instance, mothers chose the song that was recorded themselves, which may have confounded the results. Mothers prone to depressive symptoms may have preferred melancholic songs over songs with more engaging, activating, soothing, or amusing characteristics.

Third, the mothers themselves reported their depressive and PTSD symptoms, resulting in biases typical of self-reports. The use of clinical, structured interviews would have provided a more accurate view of the maternal mental health statuses. In addition, similar to self-report biases, our methodology could not neutralize the performance effect (or social desirability), meaning that mothers might sing differently to their infants while they were being watched and recorded. Nevertheless, it may be more difficult to voluntarily change how one expresses emotions vocally than when talking to or playing with the baby.

Fourth, statistically, we faced multicollinearity problems when using maternal vocal emotion expressions as the independent variables and infant developmental indicators as dependent variables. We dealt with the

problem using TSLS regression but cannot completely rule out the confounding effects of the high correlations in our sample. Also, we reported marginally significant correlations and beta-values, which are open to criticism. At the same time, our prospective study was pioneering—in the sense that infant-directed singing has not been studied in war conditions nor with multiple developmentally salient infant characteristics. The findings should, however, be considered tentative and would need replication with greater samples and with more sophisticated methodologies. Moreover, our results showed an anomaly in the fact that the correlations between traumatic war events and vocal emotion expressions were non-significant, while linear regression analyses showed trauma to increase the negative and decrease the positive emotion valences and contents. A speculative explanation may be that, in the two-variable correlation analysis, a third variable was neutralizing the association. PTSD and depressive symptoms are candidates for invisible cofounders as they significantly correlated with traumatic war events. A regression model might have correctly conditioned these cofounders that were incidentally cancelling out the potential effect of traumatic war events and vocal emotion expressions variables (Greenland, 2003).

Finally, we recorded and analyzed only the singing of mothers even though fathers are also important for infant development (Vänskä, 2017). In the Palestinian context, including grandmothers would also have been fruitful because their repertoire of songs and melodies might have been culturally richer. Unfortunately, we were forced to leave out fathers and other important caregivers due to limited research resources.

Conclusions

This study reported associations between traumatic war events, depressive and PTSD symptoms, and maternal vocal emotion expressions when mothers sing to their infants. The findings highlight the importance of singing as a form of early dyadic interaction that is potentially open to positive changes through interventions. Further information was obtained on the role that maternal singing plays in impacting children's emotional and sensorimotor development. The findings contribute to both basic research on multimodal

communication between mothers and infants and to efforts to build evidence-based and culturally meaningful early interventions with mothers at risk in both peaceful and war-affected societies.

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Table 1

Mother and Infant Characteristics (%)

	Participants ^a	
	%	<i>N</i>
Mother's age (years)		
16–20	20.0	10
21–30	64.0	32
31–40	16.0	8
Father's age (years)		
18–20	2.0	1
21–30	60.0	30
31–40	32.0	16
41–50	6.0	3
Number of children		
Expecting first child	28.6	14
1–3	57.1	28
4–6	10.2	5
7–10	4.1	2
Mother working status		
Works at home	90.0	45
In professional life	8.0	4
Student	2.0	1
Father working status		
Worker	42.0	21
Professional (teacher, officer)	34.0	17
Unemployed	24.0	12
Type of residence		
Urban area	40.0	20
Village	14.0	7
Refugee camp	46.0	23
Child's sex		
Girl	44.0	22

Boy	56.0	28
Gestational age (weeks)		
< 37	0	0
37	20.8	10
38-42	79.2	38
Birth weight (gr)		
< 2500	2.3	1
2500–3499	62.8	27
3500–4499	34.9	15
> 4500	0	0
Newborn health		
Excellent	66.0	33
Good	34.0	17
Health problems	0	0

Note: ^a $n= 50$ is a subgroup that was randomly selected from 236 women providing vocal data on infant-directed singing (from 392 participants at T2 when the infant was seven-months)

Table 2.

Inter-rater Reliabilities (intra-class correlations, ICC) of Vocal Emotion Expressions within Cultural In- and Out-groups and Pair-wise Correlations between the Cultural In- and Out-group Judges' Evaluations

	ICC		Pair-wise correlations
	In-group ^a	Out-group ^a	
<i>Positive valence</i>			
Playfulness-vivacity	.85	.96	.72****
Joy	.83	.95	.81****
Love-tenderness	.78	.94	.62****
<i>Negative valence</i>			
Fear	.41	.86	.48****
Sadness	.74	.93	.78****
Anger	.75	.74	.60****
Tension	.71	.82	.47***

Note: ^a In-group judges are 10 Palestinian students and out-group judges are 18 Finnish students;.

*** $p < .001$, **** $p < .0001$; Number of songs $n = 50$

Table 3

Pearson's Product Moment Correlations between Traumatic War Events, Maternal Mental Health, and Vocal Emotion Expression^a

	Trauma	Mental health		Positive vocal emotions			Negative vocal emotions			
	1.	2.	3	4.	5.	6.	7.	8.	9.	10.
<i>Trauma</i>										
1. Traumatic war events										
<i>Maternal mental health</i>										
2. PTSD ^a symptoms	.44****									
3. Depressive symptoms	.06	.55****								
<i>Positive vocal emotions</i>										
4. Playfulness-vivacity	-.03	-.23+	-.16							
5. Joy	-.10	-.19	-.10	.97***						
6. Love-tenderness	-.12	-.14	-.26+	.76***	.75***					
<i>Negative vocal emotions</i>										
7. Fear	.05	.12	.07	-.68***	-.72***	-.53***				
8. Sadness	.11	.15	.02	-.83***	-.86***	-.41**	.70***			
9. Anger	.18	.02	.34*	-.40**	-.42**	-.75***	.31**	.20		
10. Tension	.03	.09	.19	-.46**	-.50***	-.69***	.65***	.16	.74***	

Note: + $p < .10$; * $p < .05$, ** $p < .001$; *** $p < .0001$, $N = 50$, ^a PTSD is posttraumatic stress disorder

Table 4.

Significant Models of Hierarchical Regression Analyses of Traumatic War Events and Maternal Mental Health Problems (PTSD and Depressive Symptoms) Associating with Vocal Emotion Expression in Infant-targeted Singing

	Love-tenderness			Anger			Tension		
	B	StdE	β^a	B	StdE	β^a	B	StdE	β^a
Traumatic war events	-0.59	.25	-.33*	0.27	.13	.28*	-.47	.17	.38**
PTSD-symptoms	-0.58	.62	-.14	0.17	.34	.08	-.41	.43	-.15
Depressive symptoms	-1.01	.65	-.23	0.98	.36	.41**	-.51	.46	-.17
Models	$F(3,47) = 3.38, p = .027$ 19% explained variance			$F(3,47) = 4.17, p = .011$ 22% explained variance			$F(3,47) = 3.32, p = .028$ 19% explained variance		

Note: * $p < .05$, ** $p < .01$; ^a β -values are from the final fifth step of the regression model

Table 5.

Two-stage Least Squares Regression Models of Vocal Emotion Expression Associating with Infant Emotional Development at Six Months (T2)

	Positive affectivity			Negative affectivity			Regulatory capacity		
	B	StdE	β^a	B	StdE	β^a	B	StdE	β^a
Playfulness-vivacity	2.06	.12	.38**	-0.04	.13	-.21	0.14	.10	.22
Joy	2.00	.15	.36**	-0.03	.16	-.15	0.04	.13	.23
Love-tenderness	0.03	.08	.13	-0.06	.09	-.25	0.09	.08	.45+
Fear	-0.39	.16	-.73*	0.06	.17	.11	-0.03	.14	-.06
Sadness	0.9	.11	.37	0.02	.12	.08	-0.03	.10	-.16
Anger	-0.17	.11	-.39	0.02	.12	.05	-0.03	.10	-.08
Tension	-0.30	.11	-.85**	0.03	.12	.10	-0.04	.10	-.14
Models	$F(7,41) = 2.56, p = .028;$ 30% explained variance			$F(7, 41) = 0.22, p = ns.$ 4% explained variance			$F(7, 41) = 1.46, p = ns.$ 20% explained variance		

Note: + $p < .10$; * $p < .05$, ** $p < .01$

Table 6.

Two-stage Least Squares Regression Models of Vocal Emotion Expression Associating with Infant Cognitive and Sensorimotor Development at Six Months (T2)

	Language skills			Gross-motor skills			Fine-motor skills		
	B	StdE	β^a	B	StdE	β^a	B	StdE	β^a
Playfulness-vivacity	0.20	.15	.81	1.19	.24	.45+	1.05	.300	.45
Joy	0.21	.19	.86*	1.36	.30	.50	0.35	.38	.83
Love-tenderness	0.04	.11	.11	0.15	.18	.29	0.07	.22	.11
Fear	-0.52	.21	-.74*	-0.62	.32	-.58+	-0.07	.41	-.06
Sadness	-0.21	.14	-.68	-0.40	.22	-.84+	-0.06	.28	-.10
Anger	-0.38	.15	-.64*	-0.24	.23	-.26	-0.23	.30	-.22
Tension	-0.32	.14	-.69*	-0.40	.23	-.64+	-0.13	.29	-.16
Models	$F(7,42) = 2.48, p < .032;$ 29% explained variance			$F(7, 42) = 1.99, p = < .080$ 25% explained variance			$F(7, 42) = 0.51, p = ns.$ 8% explained variance		

Note: + $p < .10$; * $p < .05$

FIGURE CAPTIONS

Figure 1.

Evaluations of vocal emotion valence and content by cultural in-group (Palestinian students) and cultural out-group (Finnish students) of maternal infant-directed singing (Means)

