



Full length article

## Acoustic parameters of infant-directed singing in mothers of infants with down syndrome

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## ABSTRACT

This study compared the acoustic parameters and degree of perceived warmth in two types of infant-directed (ID) songs – the lullaby and the playsong – between mothers of infants with Down syndrome (DS) and mothers of typically-developing (TD) infants. Participants included mothers of 15 DS infants and 15 TD infants between 3 and 9 months of age. Each mother's singing voice was digitally recorded while singing to her infant and subjected to feature extraction and data mining. Mothers of DS infants and TD infants sang both lullabies and playsongs with similar frequency. In comparison with mothers of TD infants, mothers of DS infants used a higher maximum pitch and more key changes during playsong. Mothers of DS infants also took more time to establish a rhythmic structure in their singing. These differences suggest mothers are sensitive to the attentional and arousal needs of their DS infants. Mothers of TD infants sang with a higher degree of perceived warmth which does not agree with previous observations of “forceful warmth” in mothers of DS infants. In comparison with lullaby, all mothers sang playsong with higher overall pitch and slower tempo. Playsongs were also distinguished by higher levels of spectral centroid properties related to emotional expressivity, as well as higher degrees of perceived warmth. These similarities help to define specific song types, and suggest that all mothers sing in an expressive manner that can modulate infant arousal, including mothers of DS infants.

Infant-directed (ID) singing is the distinct way mothers sing to young infants as part of caregiving (Dissanayake, 2000; Trehub, Becker, & Morley, 2015; Trehub & Gudmundsdottir, 2015). In an effort to either match or alter infant state, mothers instinctively manipulate the acoustic features of their singing, thus establishing a dynamic interaction through which infants gain valuable experience in self-regulation. To explain, ID singing is characterized by salient rhythmic components, such as regular beat, metrical structure, and small-scale temporal deviations; as well as high levels of repetition (Corbeil, Trehub, & Peretz, 2013a; Delavenne, Gratier, & Devouche, 2013; Longhi, 2009; Margulis, 2013; Nakata & Mitani, 2005). Such qualities create perceptual expectancies, thereby effectively attracting and directing infant attention to the caregiver, and maintaining infant attention over time.

In addition to these temporal features, mothers commonly adjust the pitch, dynamics, and timbre of their singing, thus providing a rich affective experience for infants (Longhi, 2009; Trainor, 1996; Trainor, Clark, Huntley, & Adams, 1997; Trehub, Ghazban, & Corbeil, 2015; Tsang & Conrad, 2010). As an example, mothers commonly smile when singing to infants which alters the mouth opening and changes vocal tract shape, thus elevating pitch and increasing amplitude (Tarter, 1980). Singing in this manner impacts vocal timbre, thereby producing high positive vocal affect which serves to regulate infant attention (Corbeil et al., 2013a). Consequently, infants undergo affect regulation that is reflected through changes in both behavioral and physiological markers of

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arousal (Corbeil et al., 2013b; Ghazban, 2013; Shenfield et al., 2003). Ultimately, mothers use ID singing to guide infants toward focused attention and optimal arousal; two ingredients considered essential for self-regulation (Berger, 2011a; Thompson, 1994).

By modifying these acoustic features, mothers create specific types of ID songs, including lullabies that soothe and calm infants (Trehub & Trainor, 1998), as well as playsongs which increase stimulation and promote more lively interactions (Rock et al., 1999; Trainor, 1996). While the two song types share certain acoustic features, each one is characterized by unique elements. For instance, both lullabies and playsongs are marked by high mean pitch and high levels of jitter (e.g., variation in fundamental frequency). At the same time, playsongs are known to be more rhythmic than lullabies, and to convey feelings of joy and happiness through greater pitch variability and increased dynamic range (Trainor et al., 1997). Meanwhile, lullabies are perceived as tender and soothing due to having a slower tempo, more regular rhythm, lower mean pitch and pitch variability, and being sung with a full or resonant timbre (Juslin & Laukka, 2003; Trainor et al., 1997).

A mother's choice of song type is largely dictated by her infant's self-regulatory needs and capacities in the moment. As an example, Ghazban (2013) found that when 10-month-old infants were upset, most mothers sang lively playsongs which effectively captured infant attention, promoted their engagement, and reduced physiological distress. In essence, mothers appeared to choose a song type associated with the desired infant state, as opposed to selecting a song type that reflected current infant state. Ghazban (2013) suggests that infant response to song type may be further mediated by age and familiarity, as mothers tend to sing lullabies more frequently to very young infants and less often with older (i.e., 10-month-old) infants. Additionally, lullabies may be less familiar to infants as they are typically limited to being sung at bedtime, and not repeatedly throughout the day, like playsongs. Thus, playsongs may be more familiar to infants and thereby, comforting in a stressful situation.

Through providing the appropriate song type, mothers help infants practice critical skills of self-regulation. By definition, self-regulation encompasses all efforts designed to modify ones' inner state or responses and is essential for emotional capacity across the life span, having significant ramifications for social and cognitive functioning (Calkins & Hill, 2007; McCabe et al., 2004; Vohs & Baumeister, 2004). The ability to self-regulate begins to develop during infancy and is largely dependent upon the consistent provision of sensitive caregiving early in life (Berger, 2011b; Feldman, 2007; McCabe, Cunningham, & Brooks-Gunn, 2004; Sroufe, 2000). Infants with Down syndrome may be at a disadvantage for acquiring self-regulation due to various neurological anomalies that impact attention and arousal mechanisms, and that subsequently may alter the nature of caregiver interactions.

For infants with Down syndrome (DS), delayed maturation of neuroregulatory systems can manifest as diminished emotionality and responsivity (Carvajal & Iglesias, 2002; Cicchetti et al., 1991). These infants may therefore be slower to respond and orient during caregiver interactions and appear to be passive or disengaged. Such cues may be more challenging or less rewarding for mothers to read, who then respond with an adapted interaction style described as warm, yet directive (Cebula et al., 2010; Spiker, 2006). Through "forceful warmth," mothers may effectively engage infants with DS, but may not recognize their infants' social bids, thus their interaction style may lack the sensitivity needed for self-regulation (Moore et al., 2002). Over time, a forcefully-warm interaction style may also result in DS infants becoming dependent on their mothers for attention regulation, thereby limiting opportunities for triadic engagement as needed for language development and various cognitive functions, such as problem-solving (Cebula, Moore, & Wishart, 2010; Moore, Oates, Hobson, & Goodwin, 2002).

To summarize, the unique acoustic features of ID singing appear to promote infant self-regulation. An important developmental milestone, self-regulation supports social and cognitive functioning, yet may be delayed or impaired in infants with DS due to neurological differences inherent in the diagnosis as well as subsequent changes in caregiver interaction style. The impact of Down syndrome on the acoustic parameters of maternal singing has not yet been articulated, nor has the construct of warmth been explored in relation to ID singing. Thus, evidence is lacking to explain whether or not mothers' singing toward DS infants includes the acoustic and musical features that effectively direct infant attention and modulate infant arousal as needed for self-regulation.

The purpose of this exploratory study was to compare the acoustic parameters and degree of perceived warmth in two types of ID songs – the lullaby and the playsong – between mothers of DS infants and mothers of typically-developing (TD) infants. Findings will help clarify whether or not a modified interaction style transfers to ID singing, to the extent that self-regulation could be supported or compromised in infants with DS. Specifically, the following research questions were addressed: what effect does the diagnosis of DS and/or song type have on the way a mother manipulates the musical and vocal qualities of her singing? Further, what is the effect of the DS diagnosis and/or song type on perceived warmth in ID singing? Finally, which acoustic parameters are common to or specific to song type (i.e., lullaby vs. playsong) in mothers' singing?

## 1. Method

### 1.1. Participants

Participants included 16 mothers and their infants with Down syndrome (DS), as well as 15 mothers and their typically-developing (TD) infants. Recruiting occurred in community organizations serving mothers and infants in a culturally diverse, major metropolitan area within the southeastern United States, following approval from a university human subject committee. Data were discarded for the mother of one infant with DS because the mother did not sing during the testing procedure. The subsequent data analyses pertain to the remaining 30 mothers of infants who ranged in age from 3 to 9 months and were matched by chronological age across the two groups. Infants were matched by chronological age due to the fact that developmental differences between DS and TD infants become more pronounced during the second post-natal year (Carvajal & Iglesias, 2002). Thus, most research pertaining to DS and TD infants within the first post-natal year involves matching by chronological age, as opposed to matching by verbal or mental age.

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