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# THE ROLE AND FUNCTIONS OF INFANT-DIRECTED SINGING IN EARLY DEVELOPMENT

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During early infancy, many of the basic auditory abilities required to process both music and language are already in place. For example, infants are able to discriminate pitch contours in vowels (Nazzi, Floccia, & Bertoncini, 1998), recognize familiar melodies (Trainor, Wu, & Tsang, 2004), process rhythmic variations (Trehub & Hannon, 2009), and are sensitive to timbral differences (e.g., Tsang & Trainor, 2002). Infants' sensitivity to these sound properties is matched by the pervasive presence of musical features that combine with speech during early caregiver–infant interactions. For example, caregivers' speech directed to infants (ID speech) contains prominent musical qualities (i.e., prosody) that conversations among adults usually lack. In ID speech, caregivers use a unique set of prominent pitch contours (Papoušek, Papoušek, & Symmes, 1991). ID speech can also display enhanced rhythmicity (Malloch, 1999) or even harmonic intervals (Van Puyvelde et al., 2010). These enhanced structural properties may lead to better processing of the signal and possibly play a role in language development (Falk, 2009; Fernald, 1989). Functionally, it has been proposed that ID speech is especially rich in prosodic information that points to the boundaries and inner structure of lexical or syntactic units (e.g., extended pause duration, prominent accent patterns, increased vowel length (Fernald, 1989)). Infants use these prosodic cues to build the grammar and lexicon of their native language over time (Soderstrom, Seidl, Nelson, & Jusczyk, 2003).

Similar to ID speech, singing directed to infants (ID singing) combines verbal and musical structure, and is also found to be a very common musical caregiving practice. Adult and infant listeners appear to readily discriminate between these two forms of infant-directed communication (Tsang, Falk, & Hessel, 2017). Recent surveys of parents in North America indicate that singing is a prominent activity for the majority of mother–infant dyads (Ilari, 2005). Around the world, ID singing has been documented to be a universal aspect of child rearing (e.g., see Trehub & Trainor, 1998). The prevalence of singing to infants as part of caregiving practice suggests that cultures around the world utilize singing to enhance infants' and caregivers' comfort and promote caregiver–infant bonding (Trehub, Becker, & Morley, 2015). However, while a wealth of research has been dedicated to investigating the properties and functions of ID speech that help infants to acquire language and social skills, much less is known about ID singing.

The dynamics and properties of early caregiver–infant interactions may serve the general purpose of "maintaining a given optimal range of attention and arousal in which social behaviors will be performed" (Stern, 1974, p. 404). In the present chapter, we argue that in ID communication, caregivers exploit *combined musical and verbal properties* to effectively fulfill this goal. Overall, due to its combined musical and linguistic nature, ID singing offers more levels of structural regularity that infants can access. We also suggest that ID singing is a particularly salient form of communication for infants and might potentially serve functions beyond those of ID speech.

## Emotional Aspects: Interactive Regulation of Internal States and Social Bonding

In both ID speech and ID singing, parents use a particular set of intonation and melodic contours to attract infants' attention (Papoušek et al., 1991). For example, steeply ascending intonation contours in ID speech seem to be correlated to arousing caregiving intentions, while smoothly descending contours are related to soothing affective intentions (Fernald, 1989; Papoušek et al., 1991). In ID singing, a predominance of arousing contours is found in the melody of playsongs (Falk, 2011a), which is the most prevalent style of ID singing in North America and Western Europe (Trehub & Trainor, 1998). Indeed, infants from Western households react differently to arousing playsongs versus soothing lullabies, showing higher motor activation during the singing of playsongs and displaying more attention to self during the singing of lullabies (Rock, Trainor, & Addison, 1999). Finally, the arousing and soothing functions of ID singing have been found to shape infants' preferences for fast and slow tempos and higher or lower pitch in playsongs and lullabies (Conrad, Walsh, Allen, & Tsang, 2011; Tsang & Conrad, 2010).

The regulatory functions of music may be particularly helpful for infants to cope with stressful situations. For example, in clinical contexts, pre-term infants benefit from live instrumental music in showing lower salivary cortisol and pain levels after music exposure (Schwilling et al., 2015). Filippa, Devouche, Arioni, Imberty, and Gratier (2013) showed that when mothers sang or spoke to their pre-term infants, infants had greater oxygen saturation, higher heart rate, fewer critical events, and greater incidence of calm behavioral states compared to a silent baseline condition. Even in full-term infants, ID singing promotes calm alert states (de l'Etoile, 2006) and modulates stress and arousal responses, as measured by salivary cortisol (Shenfield, Trehub, & Nakata, 2003). Generally, ID singing appears to be highly effective in modulating infant stress or distress levels, even more than ID speech. Corbeil, Trehub, and Peretz (2016) examined whether listening to playful ID-like singing or ID-like recitation of the lyrics of the song in an unknown language would sustain infants' attention longer before they were becoming fussy or distressed. Results clearly showed that ID singing sustained a contented or emotionally neutral state in six- to ten-month-old infants twice as long as ID speaking. Similar results have been observed during more naturalistic interactions between mother–infant dyads (de l'Etoile, 2006). Another potentially unique effect of ID singing is its effectiveness in helping infants to recover from episodes of distress during mother–infant interactions (see Trehub, Ghazban, & Corbeil, 2015). The rhythmicity of playsongs and the special multimodal nature of ID singing, for example accompanying rhythmic movements, higher incidence of smiling (for the latter, see Trehub, Plantinga, & Russo, 2016), may be key aspects to distract fretful infants from their woes.

Recurrent accent patterns, such as beat structures, foster movement synchronization among humans and, thereby, social coordination and joint action (e.g., Phillips-Silver & Keller, 2012). Child-directed activities, and in particular playsongs, are often performed with synchronized movements such as bouncing or hand clapping (e.g., Opie & Opie, 1997). Therefore, multimodal rhythmic aspects of ID singing could be particularly effective in stimulating joint activity and intersubjectivity (i.e., social relations) in mother–infant dyads (Malloch, 1999; Van Puyvelde

et al., 2014). Cirelli, Einarson, and Trainor (2014) showed that infants who were bounced in synchrony to a musical rhythm with the bouncing movements of an unknown person displayed more helpfulness and reacted quicker toward this person compared to a condition with non-synchronized joint bouncing. It should be noted that ID singing and ID speech also differ in terms of the patterns of vocal coordination between infants and caregivers. While ID speech clearly promotes the practice of turn-taking as early as 8 weeks of age in infant–caregiver dyads (Gratier, Devouche, Guellai, Infanti, Yilmaz, & Parlato-Oliveira, 2015), ID singing seems to be more diverse in promoting associated coordination patterns. During singing, infants may increase frequency of co-vocalizations, take turns with the caregiver or remain silent for long periods of time (de l'Etoile, 2006; Nakata & Trehub, 2004; Rock et al., 1999). How these different practices for ID speech and ID song evolve and impact social, music or language development has, so far, not been investigated and future research should focus on the role of coordinated vocal interactional patterns during caregiving.

Parents communicate their positive attitude and affect to their infants through a smiling voice quality, positive facial expressions or reciprocal visual feedback (Singh, Morgan, & Best, 2002; Trehub et al., 2016). These *happy sounds* (Corbeil, Trehub, & Peretz, 2013) are very attractive to infants (Singh et al., 2002). ID singing in particular seems associated with the emotional quality of parent–infant interactions as highlighted by several studies on parental depression (de l'Etoile & Leider, 2011). Therefore, intervention strategies with ID singing might be particularly helpful for improving the quality of parent–infant interactions in situations of parental distress (Van Puyvelde et al., 2014).

In sum, ID communication impacts infants' affective states, social bonding, and coordination. ID singing appears to be particularly effective in affect regulation and joint action, thereby fostering social bonds and attachment. Next, we will discuss the acoustic properties of ID singing and how these may attract infants' attention to singing as well as to ID versus adult directed (AD) registers.

## Acoustic Properties of ID Registers: "Ear-catchers" for the Infant?

ID communication shows very distinctive acoustic and temporal signatures from AD communication. When addressing infants, adults exploit more articulatory and acoustical possibilities in their verbal expression, in both speech and singing. Utterances become shorter, pitch of individual syllables is more variable, overall pitch ($f_o$) is higher, and the durations of vowels and syllables are longer, changing the overall temporal organization compared to AD communication (e.g., Falk & Kello, 2017; Papoušek et al., 1991; Trainor, Clark, Huntley, & Adams, 1997). In ID speech, a particular salient feature is the larger pitch range exploited by adults compared to AD speech and a repertoire of recurring pitch contours uniquely marking the ID register (e.g., Inoue, Nakagawa, Kondou, Koga, & Shinohara, 2011). It is possible that the exaggerated acoustic manner of verbal expression makes ID registers highly attractive to infants. Many studies have shown that infants attend longer to ID than to AD or non-ID communication, singing and speech alike, at least in their first year of life (e.g., Cooper & Aslin, 1990; Trainor et al., 1997). In speech, infant preferences for ID vs. AD stimuli were found to be associated with the characteristic ID pitch structure rather than with amplitude or durational properties (Fernald & Kuhl, 1987). However, even when $f_o$ characteristics are filtered out, infants still prefer ID speech over AD speech, provided that spectral characteristics are preserved (Inoue et al., 2011). Spectral properties may also play a role in adult ratings of voice quality ("loving tone of voice") which correlate with infant preferences for ID singing (Trainor, 1996).

This body of research suggests that infant preferences for ID communication are primarily a consequence of adults' expression of positive and joyful emotions (see also previous section).

Alternatively, Inoue et al. (2011) suggest that given the important role of spectral features in ID preferences, it is the phonetic clarity of speech that particularly attracts infants' attention (see Kuhl et al. (1997); but also Martin et al. (2015), for a controversial discussion on speech clarity in ID registers). In a recent study, Masapollo, Polka and Ménard (2016) found that infants aged four to six months prefer vowels that have vocal properties (i.e., higher voice pitch, formant structure) typical for infants' own productions of vowels. Hence, it is an additional hypothesis that infants prefer to listen to what is closest to their own vocal productions. Although future research needs to evaluate these different accounts of ID preferences, the results to date suggest that infants' auditory preferences for ID registers are based on a hierarchy of acoustic features with spectral properties and $f_o$ (at least for ID speech) in the top ranks.

When comparing ID singing and ID speech, there are reliable differences between both types of vocalization in acoustic features characteristic of verbal units (such as vowels, syllables) (Corbeil et al., 2013; Tsang et al., 2017). Overall, ID singing displays less acoustic variability than ID speech. When caregivers sing to an infant, the pitch contour in the vowels is flatter and less variable (i.e., more stable) compared to ID speech (Trainor et al., 1997) to convey the melody. In terms of duration, singing is generally slower than speaking which relates to its longer, durationally less variable vowels (Falk, Maslow, Thum, & Hoole, 2016). ID singing also displays greater metrical stability and regularity (i.e., beat-like structure) compared to ID speech (Bergeson & Trehub, 2002).

Infants show more attention to vowels than to consonants and to longer over shorter vowels, at least in ID speech during their first months of life (e.g., Bouchon, Floccia, Fux, Adda-Decker, & Nazzi, 2015; Kitamura & Notley, 2009); thus longer and less variable vowels, inserted in globally more rhythmical, regular phrases, could be a factor enhancing attractiveness of ID singing to infants.

Given these acoustic differences, do infants distinguish between ID speech and singing in early development? Infants as young as seven months are able to discriminate between naturalistic excerpts of ID speech and ID singing (Reigado & Rodrigues, 2017; Tsang et al., 2017). They are attracted and listen longer to ID singing than ID speech, particularly in a non-native language (Corbeil et al., 2016; Tsang et al., 2017), and in their native language when multimodal cues (e.g., audio-visual) are present (Costa-Giomi, 2014; Nakata & Trehub, 2004). However, other studies found that ID-like singing and speech in a foreign language as well as naturalistic ID singing and ID speech in the native language were equally attractive to infants (e.g., Corbeil et al., 2013), suggesting that acoustic and other factors (e.g., age, native language, ID vs. ID-like registers) for early preferences of speech and singing are not yet sufficiently understood.

Brain research investigating differences in (instrumental) music and speech processing also provide mixed results, mirroring behavioral findings in infants' speech and song perception. Kotilahti et al. (2010) examined neonates' brain responses to spoken excerpts of a fairy tale and musical excerpts from a piano concerto by Mozart as measured by near-infrared spectroscopy (NIRS). Their results showed that the two types of stimuli did not elicit significant differences in response lateralization or response amplitudes, although responses to speech showed more coherence in the left than the right hemisphere. At two months, the bias for left-lateralized brain responses in the temporal lobe was again found for speech in an fMRI study, but no lateralization was evident for music (Dehaene-Lambertz et al., 2010). More left temporal lobe responses to ID speech were found in infant listeners compared to AD speech (Naoi et al., 2012). Another NIRS study with older infants (four to 11 months) failed to show differences between instrumental music and ID-like speech stimuli that were processed in similar cortical regions (Fava, Hull, Baumbauer, & Bortfeld, 2014). These data point toward early development of hemispheric specialization for speech stimuli in the first year of life; however, no clear difference in specialization for music and speech processing has yet been definitively established.

In sum, caregivers provide exaggerated acoustics in verbal expressions of ID speech and singing that both seem inherently attractive to infants. In addition, some studies have underlined the particularity of ID singing to attract and sustain infants' attention (Corbeil et al., 2016; Nakata & Trehub, 2004; Tsang et al., 2017). ID singing features unique and salient modifications in verbal acoustics compared to ID speech. In particular, vowels are expanded and both the rhythmic and pitch dimension (regular accent structure, stable vocalic pitch) show more systematic changes over time. In the next section, we discuss whether these properties could also contribute to infants' processing of linguistic structure.

## Toward a Processing Account of ID Singing

Do the combined musical and verbal properties of ID singing contribute to make the verbal content more accessible or learnable to infants? So far, the extant research literature has not answered this question. However, there is increasing evidence that musical learning is intertwined with language learning. As learning is tightly linked to age and processing capacities, we will discuss the issue under the header of a potential "processing account" of ID communication, specifically related to ID singing.

A starting point for a potential processing account of ID singing comes from the classic language acquisition literature. It has been found that discovering the "musical" regularities of speech (i.e., prosodic structure built through intonation, rhythm, and pauses), paves the way for infants to segment and learn about meaningful units, such as lexical words, syntactic phrases and sentences. This process has been called prosodic bootstrapping (Gleitman & Wanner, 1982). For example, infants in their second half year of life learning English or other stress-based languages start segmenting their first words with the aid of metrical stress patterns (e.g., Jusczyk, Houston, & Newsome, 1999). Infants at eight months show better word segmentation at the boundaries of prosodic utterances compared to utterance-medial positions (Seidl & Johnson, 2006). ID speech could facilitate such boundary-oriented segmentation strategies in infants. Adults produce more prosodic boundaries which are more prominent than in AD speech in terms of acoustic pre-boundary lengthening and pauses (e.g., Albin & Echols, 1996; Martin et al., 2015). Parallels in boundary-emphasis have been reported in ID singing (Delavenne, Gratier, & Devouche, 2013; Trainor et al., 1997). Interestingly, infants segment phrase boundaries similarly in music and speech, using the same auditory pitch and duration cues (e.g., Jusczyk et al., 1999; Jusczyk & Krumhansl, 1993). Further parallels between musical and speech processing were found in the capacity of infants to discriminate lexical tones and musical pitch (Chen, Stevens, & Kager, 2017), and to exploit statistical properties of syllable and tone sequences in order to extract recurring tone or syllable patterns (Saffran, Aslin, & Newport, 1996; Saffran, Johnson, Aslin, & Newport, 1999). Moreover, the acoustics of ID speech have been shown to facilitate word segmentation based on statistical properties compared to AD speech (Thiessen, Hill, & Saffran, 2005).

Given these findings, one could ask whether prosodic bootstrapping in infants ought to be considered a form of musical bootstrapping and whether language acquisition during infancy benefits from musical processing abilities. The last decade has produced some literature showing that musical and verbal abilities are intimately linked in children. In eight- to ten-year-old children, musical training was shown to impact on verbal skills such as speech segmentation and discrimination of pitch variation in speech (François, Chobert, Besson, & Schön, 2013; Moreno et al., 2009). For infants, musical experience is more difficult to evaluate. However, prosodic skills (i.e., rhythmic discrimination of syllable patterns) at four months predicted verbal morpho-syntactic capacities of the same children at five years of age (Höhle, Pauen, Hesse, & Weissenborn, 2014). These results are encouraging for future research deepening our understanding of musical and verbal interrelations.

The effect of combined musical and verbal structure on speech perception and learning has occasionally been investigated. Schön et al. (2008) examined statistical learning of syllable sequences in song vs. speech in a foreign language in a group of adults. Results showed that word extraction was enhanced in song when a consistent pitch-to-syllable mapping supported joint musical and verbal patterning. In an infant study, Lebedeva and Kuhl (2010) found a trend in 11 month-olds to better discriminate changes in syllable order when the lyrics were sung rather than spoken. However, this result was statistically non-significant ($.05 < p < .1$). Another study found that musical training based on the rhythmic structure in children's songs, in combination with synchronized movements, can enhance nine month-olds' temporal perception of syllable structure in speech (Zhao & Kuhl, 2016). These few results are promising points of departure for future studies on the perception of the verbal components in sung speech by infants. Note that infants, young children, and adults show high memory retention of sung melodies. Children aged seven to 11 years remember familiarized vocal melodies better than instrumental melodies (Weiss, Schellenberg, Trehub, & Dawber, 2015). Infant listeners have been found to recognize familiarized sung melodies as long as eight months after initial exposure (e.g., Trainor et al., 2004). High levels of repetition, common in music and ID singing in particular (Trainor et al., 1997), and stereotyped, ritualized performances featuring similar pitch and tempo across multiple performances (Bergeson & Trehub, 2002) may facilitate memory of joint verbal and musical structures in song.

Crucially, learning from ID singing might depend on the capacity of caregiver–infant dyads to achieve the optimal range of attention and arousal in the infant, as discussed above (Stern, 1974). Infants are interested and aroused by novelty and variability, but they also look for predictable and familiar information (Kidd, Piantadosi, & Aslin, 2012). Therefore, the balance between unexpected (i.e., variable) and expected (i.e., predictable) information in ID singing may set the stage for learning in parent–infant interactions. For example, increased pitch or temporal variability in ID compared to AD registers (e.g., Falk & Kello, 2017) may contribute to the salience of ID registers and serve to heighten arousal (e.g., Wiethoff et al., 2008). Falk and Kello (2017) found that mothers provided higher amounts of durational variability and contrast at different timescales in the structure of ID singing (and story reading) compared to AD singing (and reading). They also found that the systematic hierarchical temporal structure of language in ID registers (i.e., acoustic variation is nested, like syllables are nested into words, which are in turn nested into phrases, etc.) was emphasized compared to AD registers. Hence, the pattern of variability and predictable information specific to ID registers might help infants to exploit temporal aspects of speech for language learning – an interesting avenue awaiting further investigation.

ID singing, compared to ID speech, might have advantages in creating an appropriate balance between variable and predictable information for infant listeners. Greater pitch stability of vowels in ID singing allows for discrete pitch and interval perception. This, in turn, might foster the perception of global pitch contours. Therefore, greater pitch stability in singing might help to enhance global contour and melody perception, providing salient cues to aid information processing and memorization in infants. Rhythmic structure in ID singing, in particular the occurrence of a predictable beat, may attract infants' attention and help them to focus on joint beat and verbal occurrences. Sensitivity to a musical beat has already been found in newborns (Winkler, Haden, Ladinig, Sziller, & Honing, 2009). Text-setting lyrics to a melody in children's songs that respects verbal stress-beat $f_o$ co-occurrences could thus be an additional cue for infants to learn about joint verbal and musical rhythmic patterns. However, there may be a risk that musical properties could also counteract speech processing. For example, the prolonged vowels in ID singing might risk distorting the phonological structure of words or lead to mis-segmentations, and high pitch in ID speech has been found to impair six- and seven-month-old infants' ability to discriminate vowel categories (Trainor & Desjardins, 2002). However, it should also be noted

that mothers who sing with their babies have been shown to preserve the relative durations of vowel and consonants that are important for speech intelligibility and meaning (Falk, 2011b), and that the exaggerated pitch contours of ID speech can aid in vowel discrimination (Trainor & Desjardins, 2002). Future research should examine the impact of conflicting cues on infant perception of speech and song, and their associated linguistic and social functions.

Finally, age might be an important consideration in assessing a processing account of ID singing. Eventually, beneficial effects of ID singing for auditory processing of verbal properties may be most relevant during the first months of life. Up to six months, infants' perception resembles a "musical listening mode", a holistic processing strategy with increased attention to the global shape of auditory signals (Seidl & Cristia, 2008). Younger infants seem to prefer longer vowels which may be more physically and perceptually distinct (Kitamura & Notley, 2009). Therefore, for young infants, who might still be learning critical linguistic features, auditory processing of ID singing (e.g., contour extraction and memorization, rhythmic segmentation) might be easier to process than for ID speech.

In contrast, older infants (e.g., 12-month-olds) may already benefit more from ID speech stimuli for communication. They are fully immersed in the discovery of the characteristics of their mother tongue and have particular interests in language-specific segmental variation (e.g., Fernald & Kuhl, 1987). They have had significantly more experience with language and show a language-specific bias in processing speech prosody (e.g., Seidl & Cristia, 2008). Although ID singing might still serve affect regulation, social bonding, and musical learning, there may be a progressive attraction to ID speech, corresponding to the infants' level of language learning and communicative needs.

## Future Directions and Conclusions

In this chapter, we present an argument for conceptualizing ID singing as an equally important vocal register as ID speech to foster communication, learning, and social development during infancy and early childhood. Musical properties of ID singing are particularly efficient in regulating infants' arousal levels, keeping them in a happy attentive state, and fostering social bonding. We also suggest that the combination of verbal and musical properties of ID singing might ease linguistic processing and learning, particularly in the first year of life, by providing a balance between acoustic variability and predictability. Together, the characteristics of ID singing may be particularly helpful in attracting and sustaining infants' attention and supporting auditory signal processing. (see also Chapter 2 by Stadler Elmer, which also suggests the relatively greater ease for the infant of singing than speaking).

Future research should aim to tease apart which structural and acoustic characteristics of ID song promote different functions in comparison with ID speech during and beyond infancy. Another aim would be to clarify the role of variability and predictability in ID registers in infants' developmental progression. ID singing should be investigated with regard to its role in the development of language, cognition, music perception, and social functions during infancy – thus far under-investigated in the literature. To conclude, ID singing is a ubiquitous and universal aspect of infant caregiving that might be an essential "infant-friendly" vocal signal facilitating infants' ability to derive affective meaning and messages from caregiver vocalizations.

## Glossary

**Playsong** a type of song that is typically used to arouse or stimulate action in the listener.

**Musical bootstrapping** idea that musical processing, such as perception of pitch, rhythm, and melodic contour, may facilitate or aid the development of early language acquisition, such as perception of speech sounds.

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