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Singing Delays the Onset of Infant Distress

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Much is known about the efficacy of infant-directed (ID) speech and singing for capturing attention, but little is known about their role in regulating affect. In Experiment 1, infants 7–10 months of age listened to scripted recordings of ID speech, adult-directed speech, or singing in an unfamiliar language (Turkish) until they met a criterion of distress based on negative facial expression. They listened to singing for roughly twice as long as speech before meeting the distress criterion. In Experiment 2, they were exposed to natural recordings of ID speech or singing in a familiar language. As in Experiment 1, ID singing was considerably more effective than speech for delaying the onset of distress. We suggest that the temporal patterning of ID singing, with its regular beat, metrical organization, and tempo, plays

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an important role in inhibiting distress, perhaps by promoting entrainment and predictive listening.

The most ubiquitous and most important function of music listening in contemporary Western cultures is emotional self-regulation aimed at relaxation, prolonging positive moods, or discharging negative emotions (Saarikallio, 2011; Sloboda, Lamont, & Greasley, 2009). Because infants' self-regulation skills are limited (Kopp, 1989; Thompson, 1994), caregivers' role in regulating their arousal and emotion is critical (Gunnar & Quevedo, 2007). Maternal regulatory behaviors include carrying (Gammie, 2013), touch (Jean & Stack, 2009), melodious speech (Fernald, 1992; Papoušek, 1994), and singing (Trehub, Hannon, & Schachner, 2011; Trehub & Trainor, 1998). The emotion-regulatory consequences of touch (Feldman, Singer, & Zagoory, 2010; Stack & Muir, 1992; Tronick, 1995), rocking, and carrying (Byrne & Horowitz, 1981; Esposito et al., 2013) have been documented, but there is no comparable evidence for infant-directed (ID) speech or singing.

Instead, studies of ID speech and singing have focused largely on their acoustic features (e.g., Delavenne, Gratier, & Devouche, 2013; Longhi, 2009; Nakata & Trehub, 2011; Trainor, Clark, Huntley, & Adams, 1997) or efficacy in capturing infant attention (e.g., Masataka, 1999; Trainor, 1996), with little consideration of their efficacy in emotion regulation (e.g., promoting displays of positive affect, inhibiting displays of negative affect).

Infant-directed speech typically has higher pitch, greater pitch and dynamic (amplitude) range, slower speaking rate, and greater rhythmicity than adult-directed (AD) speech (Ferguson, 1964; Fernald & Simon, 1984; Jacobson, Boersma, Fields, & Olson, 1983). The distinctive pitch contours and slow tempo of ID speech make it sound rather more musical than conventional speech (Brandt, Gebrian, & Slevc, 2012; Fernald, 1989, 1992). In fact, the acoustic features of ID speech (e.g., pitch level, tempo) are closer to those of ID singing than to AD speech (Corbeil, Trehub, & Peretz, 2013).

Like ID speech, ID singing has higher pitch, slower tempo, more regular timing, and a greater dynamic (i.e., amplitude) range than non-ID singing (Nakata & Trehub, 2011; Trainor et al., 1997; Trehub, Hill, & Kamenetsky, 1997; Trehub, Unyk, et al., 1997). Unlike speech, however, each song (e.g., *Itsy Bitsy Spider*, *Frère Jacques*) has a specified pitch range and rhythm. As a result, ID speech is more acoustically variable than ID singing (Corbeil et al., 2013). Music, whether vocal or instrumental, differs from speech in other important respects. Most music has a

regular pulse or beat and elements (e.g., notes, pitch contours, phrases, themes) that repeat at small and large timescales (Margulis, 2014). Repetitive motifs are especially prominent in children's songs. In *Frère Jacques*, for example, motifs and lyrical fragments repeat in parallel (*Frère Jacques*, *Frère Jacques*. *Dormez vous? Dormez vous? Sonnez les matines*. *Sonnez les matines*. *Ding*, *dang*, *dong*. *Ding*, *dang*, *dong*.). Mothers amplify the repetitive nature of children's songs by singing them almost identically on different occasions (Bergeson & Trehub, 2002).

Newborns are sensitive to the musical beat (Winkler, Háden, Ladinig, Sziller, & Honing, 2009), and by 5 months, infants are sensitive to the metrical structure, or pattern of strong and weak beats (Hannon & Trehub, 2005; Phillips-Silver & Trainor, 2005; Soley & Hannon, 2010). At 5 months, they also move rhythmically to rhythmic music but not to speech (Zentner & Eerola, 2010), highlighting the importance of temporal regularity. Temporally regular music also captures infant attention more effectively than temporally irregular music (Soley & Hannon, 2010).

Infants' attention is captured more readily by ID speech than by AD speech (Cooper & Aslin, 1990; Fernald, 1985; Pegg, Werker, & McLeod, 1992; Werker & McLeod, 1989), by ID hand and facial gestures than by AD gestures (Brand & Shallcross, 2008; Kim & Johnson, 2014), and by ID singing than by non-ID singing (Masataka, 1999; Trainor, 1996). Positive emotional expressiveness, such as happy-sounding speaking or singing voices (Corbeil et al., 2013; Kitamura & Burnham, 1998; Singh, Morgan, & Best, 2002) or happy-looking faces (Kim & Johnson, 2013), seems to underlie the attention-getting consequences of these stimuli. Indeed, happy-sounding speech and singing induce comparable attention capture (Corbeil et al., 2013; Costa-Giomi & Ilari, 2014; Trehub, Plantinga, & Russo, 2015), as do happy-looking ID and AD faces (Kim & Johnson, 2013). Attention capture is greater, however, to audiovisual renditions of maternal singing than to maternal speech (Nakata & Trehub, 2004), perhaps because mothers smile more when they sing than when they speak to infants (Trehub et al., 2015).

In the single study that examined the effects of ID singing on infant arousal (Shenfield, Trehub, & Nakata, 2003), multimodal (live) maternal singing modulated salivary cortisol levels, which index arousal or stress. Such modulation occurred within modest bounds, however, because infants were attentive or absorbed without exhibiting overt signs of pleasure or displeasure.

In the present study, we asked whether ID speech and singing (audio only), which are comparable in capturing infant attention (Corbeil et al., 2013; Costa-Giomi & Ilari, 2014; Trehub et al., 2015), differ in their efficacy of inhibiting distress. The onset of distress is readily amenable to

measurement because it is typically marked by negative vocalization and facial expression. Accordingly, we compared the efficacy of ID speech and singing for delaying infant distress. Experiment 1 used scripted portrayals of Turkish speech and singing, which ensured comparable content across vocal modes and unfamiliarity with the sung and spoken materials. Experiment 2 used natural ID speech and singing in the ambient language of infant listeners.

Infants in both experiments were tested in a minimally stimulating, nonsocial environment designed to highlight the target auditory stimulus and limit distraction. They listened to a continuous recording of speech or singing until they met a criterion of distress based on facial displays alone, specifically, the cry face. The cry face, which is characterized by lowered brows, lip corners pulled to the side, and variable degrees of mouth opening and raised cheeks, is the most common expression of negative affect in infants (Messinger, 2002). Infant vocalizations also provide cues to distress, but it was necessary to block access to such cues so that the observer remained blind to the nature of auditory stimuli (speech or singing) presented to infants. On the basis of the high temporal regularity in singing, especially ID singing (Nakata & Trehub, 2011), and much lesser regularity in speech, we predicted greater latency to infant distress for singing than for speech.

Entrainment to music, a human universal (Grahn, 2012; Merker, Madison, & Eckerdal, 2009), involves synchronized *internal* rhythmic processes to regular or pulsed auditory sequences (Grahn, 2012; Large & Jones, 1999). Nevertheless, the typical focus of study has been on its *external* manifestation in tapping, drumming, or moving to the beat (Kirschner & Tomasello, 2009; McAuley, Jones, Holub, Johnston, & Miller, 2006). Infants do not entrain their movements to the beat of music (Zentner & Eerola, 2010), perhaps because of immature motor control, but they may be capable of internal entrainment in view of their sensitivity to the beat and to the metrical structure of music (Hannon & Trehub, 2005; Phillips-Silver & Trainor, 2005; Winkler et al., 2009). Entrainment of internal rhythmic processes would confer a distinct advantage for music over speech with respect to forestalling distress.

EXPERIMENT 1

We aimed to ascertain the relative efficacy of recorded speech and singing —unfamiliar song and language—in delaying visible signs of distress in preverbal infants. Infants were presented with one of three audio recordings: (1) a rhythmic Turkish play song (unfamiliar melody in Western

tonality) sung in a lively ID manner, (2) the words of the Turkish song spoken in an ID manner, with the spoken version having greater variability in pitch, dynamics, and timing than the sung version, and (3) the same words spoken in a neutral or AD manner, with smaller pitch and dynamic range than the version spoken in an ID style. The designated recording played continuously until infants met a criterion of mild distress based on facial expression alone. On the basis of the greater rhythmicity of ID singing, with its implications for the entrainment of internal responses (Grahn, 2012; Large & Jones, 1999), we expected infants to exhibit longer latency to distress for singing than for speech. Moreover, on the basis of greater attention capture for ID than for AD speech (Fernald, 1985; Pegg et al., 1992; Werker & McLeod, 1989) and for happy-sounding than for neutral or sad-sounding speech (Kitamura & Burnham, 1998; Singh et al., 2002), we expected longer latency to distress for ID speech than for AD speech.

Method

Participants

The sample consisted of 30 healthy, full-term infants (16 girls, 14 boys) who were 6.9–9.7 months of age (M = 8.5 months, SD = 0.8). Infants had no family history of hearing loss or personal history of ear infections, and they were free of recent colds, according to parents' report. An additional five infants were excluded from the sample because of unwillingness to sit in the high chair (n = 2), computer failure (n = 2), and experimenter error (n = 1). Parents reported that the ambient language in infants' environment was exclusively French (n = 20), 50% or more French combined with one or more other languages (English, Arabic, Spanish, Polish, German, or Hebrew; n = 7), Italian only (n = 2), or English only (n = 1). No infant had any exposure to Turkish.

Apparatus

Testing was conducted in a dimly lit sound-attenuating booth (IAC) 4 by 4 m in size. Infants sat in a high chair facing a central computer monitor at a distance of 100 cm, with parent seated behind and out of view. The walls and table (for monitors) were covered with black cloth to reduce visual distraction and optimize attention to the target stimuli. A camera immediately above the central screen provided a continuous record of infant visual behavior on a monitor outside the booth. Two loudspeakers (Genelec 804A) equidistant from the central monitor transmitted the sounds at the same comfortable listening level for speech and singing,

approximately 60–65 dB (A). The procedure was controlled by customized software on a computer (Mac Pro 8 cores, Apple Inc., Cupertino, CA, USA) located outside the booth.

Stimuli

The auditory stimuli from Corbeil et al. (2013) consisted of unfamiliar foreign (Turkish) lyrics of a play song spoken in conversational style or sung in duple meter (i.e., accented on every second beat). The performer, a native Turkish speaker and trained singer, had considerable experience with children. She listened to many samples of ID speech and singing and attempted to speak and sing as if interacting with an infant (aided by an infant photograph). Subsequently, she attempted to speak with neutral affective tone as if conversing with an adult. Overall durations of the ID singing, ID speech, and AD speech versions were 26.8, 24.6, and 19.02 sec, respectively, indicating a similar rate of vocalization for ID speech and singing and faster AD speech. Each stimulus was repeated, without interruption, until infants met the distress criterion. Excerpts of the three stimuli (ID speech, ID singing, and AD speech) are available in Supporting Information.

Procedure

Parents, who were out of infants' view throughout the test phase, were asked to refrain from interacting with infants (e.g., vocalization, touch) during testing and to minimize their movement. They remained in infants' line of sight only until the central screen flashed red, which was their cue to sit behind the infant because testing was about to begin. Custom software randomly assigned infants to one of the three conditions—ID speech, AD speech, or ID singing—without the knowledge of the observer. During the presentation of auditory stimuli (all conditions), a monitor in front of the infant displayed slow-motion movement of shaded animal forms. The visual display functioned to illuminate the infant's face and maintain it in full view for transmission to the observer. Auditory and visual stimuli continued until infants met the criterion of mild distress, which consisted of continuous negative facial expressions or the cry face (Messinger, 2002) for 4 sec or two briefer episodes of negative facial expression within any 10-sec period. The observer, who had no access to sound (auditory stimuli or infant vocalization) and no knowledge of infants' condition, watched the monitor outside the test room and maintained a continuous record of negative facial expression by means of key codes on a computer keyboard.

Results and discussion

The distress criterion was achieved considerably later for singing (M = 8.96 min, SD = 3.18, range: 2.95–15.00 min) than for speech (ID speech: M = 4.20 min, SD = 3.42, range: 0.72–9.27 min; AD speech: M = 3.91 min, SD = 2.14, range: 1.09–6.85 min). An analysis of variance (ANOVA) revealed a significant effect of condition (ID singing, ID speech, AD speech) on latency to the distress criterion, $F(2, 27) = 7.70$, $p < .01$, $\omega^2 = .30$ (large effect size) (see Figure 1). Omega- squared was used instead of eta-squared because the latter overestimates effect sizes, especially for small samples (Olejnik & Algina, 2003). *Post hoc* Tukey tests revealed significant differences between ID singing and each speech condition ($p < .05$) but no difference between ID and AD speech conditions.

When listening to unfamiliar music sung in an unfamiliar language by an unfamiliar singer, infants maintained their composure for almost 9 min before meeting the distress criterion, roughly twice as long as for unfamiliar ID or AD speech by an unfamiliar speaker. Contrary to expectations,

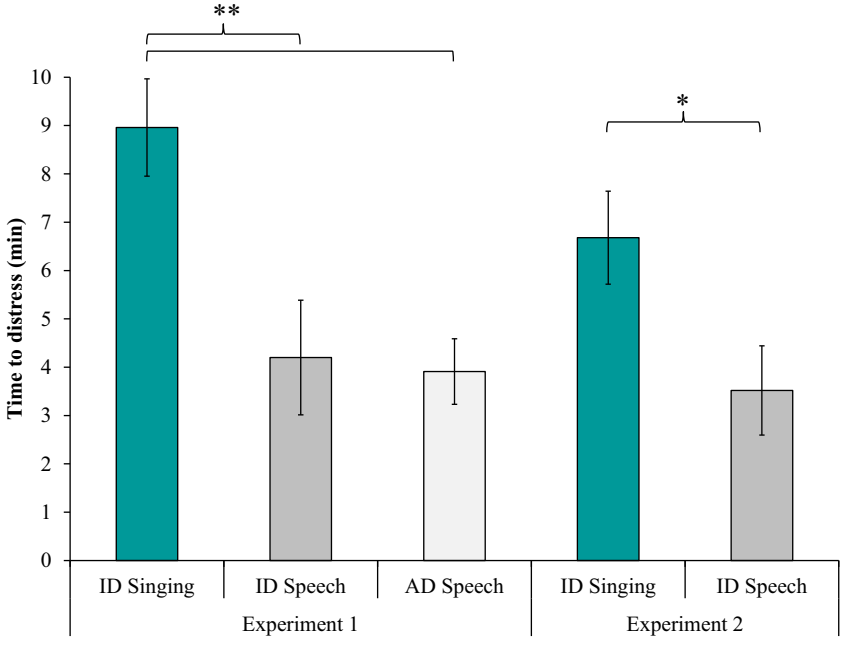

Figure 1 Time to distress (in min) for singing and speech in experiments 1 and 2. Error bars are standard errors (**$p < .01$; *$p < .05$).

ID speech was no more effective than AD speech in delaying the onset of distress, even though ID speech in familiar and unfamiliar languages is more effective than AD speech in capturing infant attention (Fernald, 1985; Pegg et al., 1992).

Unfamiliar sound sequences may not detract from the engaging qualities of singing, but they may detract from the impact of speech, as least for infants in the age range tested (6.9–9.7 months). It is also possible that the engaging qualities of singing arose, in part, from the use of a professional singer. Moreover, the spoken lyrics of a song lacked some of the qualities of conventional maternal speech. To address these issues, we tested infants with natural speech and singing samples from their ambient language.

EXPERIMENT 2

The present goal was to compare the efficacy of natural samples of ID speech and singing in a familiar language for delaying the onset of distress. Infants were presented with one of two audio recordings: an ID version of a rhythmic French play song or ID speech. Instead of scripted portrayals, as in Experiment 1, which are used frequently in research on infant listening preferences (e.g., Cooper & Aslin, 1990; Kitamura & Lam, 2009; Singh et al., 2002), the present stimuli were drawn from natural maternal interactions with 6-month-old infants. For infant listeners, the language was familiar, but the singing or speaking voice was unfamiliar. As in Experiment 1, the speech or singing stimuli were presented continuously until infants met the same distress criterion based exclusively on facial expression. On the basis of the rhythmicity and regularity of singing (e.g., Margulis, 2014; Nakata & Trehub, 2011) and its presumed consequences for internal entrainment (Grahn, 2012; Large & Jones, 1999), we expected the advantage of ID singing over ID speech to be evident with materials in a familiar language, as with the unfamiliar language in Experiment 1.

Method

Participants

The sample consisted of 28 healthy, full-term infants (11 girls, 17 boys) who were 7.3–10.0 months of age (M = 8.5 months, SD = 0.8). Infants' ambient language was French only (n = 16), 70% or more French combined with another language (English: n = 7, Creole: n = 1, Cambodian: n = 1, Spanish: n = 1), equal French and English (n = 1), and 60%

German combined with 40% French (n = 1), based on parental estimates. Two additional infants were excluded from the final sample because parents interacted with infants during the test session (n = 1) or because of technical problems (n = 1).

Apparatus and stimuli

The apparatus was the same as in Experiment 1. French-speaking mothers were recorded speaking and singing to their infants in a sound-attenuating booth. For the 2-min period of singing, mothers were asked to sing play songs that they usually sang to their infants. For the speech interactions, mothers were asked to speak to infants as they usually did but to refrain from using the child's name. Mothers placed infants in the high chair, held infants, or remained together on the floor, as they chose. All mothers wore lapel microphones, and the sessions were recorded in stereo 44.1-kHz, 16-bit uncompressed WAV audio files (Adobe Audition Software, Adobe Systems Inc., San Jose, CA, USA), then converted to monaural files. Some maternal recordings were excluded because of poor sound quality (e.g., breathing noises that interfered with the audibility of vocalizations, singing substantially out of tune, audible infant hiccups). Recordings of singing had 20–45 sec continuous segments of good sound quality with a maximum of five infant vocalizations. Speech samples of equal duration were selected, usually from the beginning of the recording (to avoid selection biases), as long as they excluded the infant's name or cues to child gender. Nonvocal sounds (e.g., audible microphone movement) and infant sounds (e.g., sighs, laughs, cries) were removed if they occurred during maternal pauses. Otherwise, they were attenuated (using iZotope RX2 Advance software, iZotope Inc., Cambridge, MA, USA) or equalized by adding a similar vocalization to a similar location in the comparison stimulus (i.e., singing from the same mother). The final singing and speech stimuli were of equal overall duration, with an equal number of infant vocalizations. There were 14 songs and corresponding speech samples (M = 33.10 sec, SD = 8.52 sec) generated from 11 mothers. In three instances, the same mother generated two different singing and speech samples. Repeated motifs are readily apparent in *Une Souris Verte*, a common French children's song that was included in the current stimulus set (see Figure 2 and Supporting Information).

Procedure

To preclude the possibility of age differences across conditions, each infant was matched to another infant of similar age (age difference:

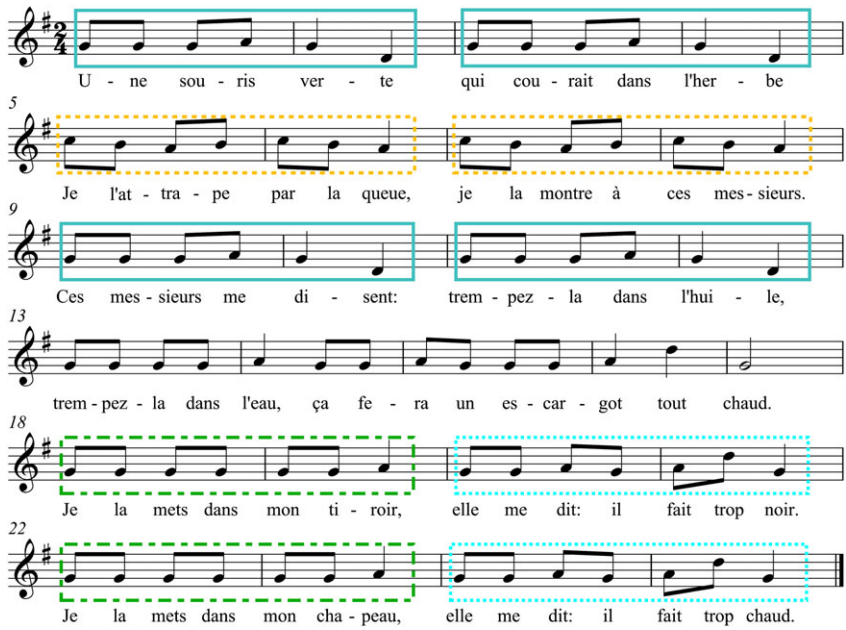

Figure 2 Musical notation and lyrics for a common French children's song, *Une Souris Verte*, which was part of the stimulus set in Experiment 2 (audio version in Supporting Information). Repeating melodic sequences are depicted in matching boxes.

M = 6.43 days, SD = 4.33 days, maximum = 16 days) and randomly assigned to a specific mother's ID speech or singing. A new observer (i.e., not the one from Experiment 1) who was unaware of the conditions and had no access to the stimulus or infant sounds judged negative facial expressions from the monitor outside the booth.

Results and discussion

The distress criterion was achieved significantly later for ID singing (M = 6.68 min, SD = 3.60, range: 1.62–14.45 min) than for ID speech (M = 3.52 min, SD = 3.46, range: 0.12–12.76 min), $t(26) = 2.37$, $p < .05$, $\omega^2 = .18$ (large effect size) (see Figure 1). When the data from the ID speech and singing conditions from Experiment 1 were compared with those from the present experiment, there was a main effect of condition, $F(1, 44) = 13.06$, $p < .001$, partial $\omega^2 = .11$ (moderate effect size), reflecting greater latency to distress for singing (M = 7.63, SD = 3.55, range:

1.62–15.00) than for speech (M = 3.80, SD = 3.38, range: 0.12–12.76 min), but there was no significant effect of experiment (familiar/unfamiliar language and portrayal/natural), $F(1, 44) = 2.86$, $p = .098$, and no interaction between experiment and condition, $F(1,44) = .29$, $p = .592$.

As in Experiment 1, infants exhibited longer latency to distress for ID singing than for ID speech. Infants' ability to remain visibly content for longer periods while hearing French play songs rather than French ID speech confirms the generality of ID singing as an affect regulator. Language familiarity had no discernible benefit for infants who listened to ID singing or speech.

GENERAL DISCUSSION

The present study is the first to assess the relative efficacy of unfamiliar audio excerpts of speech and singing for inhibiting infant distress rather than merely capturing attention (Corbeil et al., 2013; Costa-Giomi & Ilari, 2014). In Experiment 1, a Turkish play song was more effective than spoken versions of the lyrics, in ID or AD style, in delaying signs of distress in 6.9- to 9.7-month-old infants (M = 8.5 months) from largely French-speaking homes. Despite previous research revealing the greater efficacy of ID over AD speech for capturing infant attention (e.g., Cooper & Aslin, 1990; Fernald, 1985), ID speech was no better than AD speech at delaying distress. Moreover, despite evidence that happy-sounding ID speech and singing are equally effective at capturing infant attention (Corbeil et al., 2013; Costa-Giomi & Ilari, 2014), ID singing was more effective at delaying distress.

The use of identical verbal phrases across the three conditions of Experiment 1 (ID singing, ID speech, AD speech) ensured that the stimuli differed primarily in their pitch and temporal patterning, highlighting the key differences between speech and singing. In principle, the greater efficacy of ID singing could have stemmed from the use of an unfamiliar language—a frequent occurrence in songs (e.g., *Frère Jacques*)—as well as highly repetitive text with alliteration and rhyme combined with beat-based timing, which is typical of song (e.g., *Skidamarink a dink a dink*, *Skidamarink a do*, *I love you*) but not speech, even ID speech. In addition, the proficiency of a professional singer could have contributed to the efficacy of singing. In Experiment 2, however, French ID songs were more effective than French ID speech—both derived from natural maternal interactions with infants—in delaying the onset of distress in 7.3- to 10-month-old infants (M = 8.5 months) from French-speaking homes.

The findings leave little doubt about the efficacy of ID singing for maintaining infants' composure for extended periods. Even in a relatively sterile environment—black walls, dim illumination, no toys, and no human visual or tactile stimulation—the sound of a woman singing prolonged infants' positive or neutral states and inhibited distress. In fact, infants listened to the Turkish play song for roughly 9 min before meeting the cry-face criterion. For the French play songs, latency to the cry-face criterion exceeded 6 min. The temporal pattern of ID singing, with its regular beat, metrical organization, and tempo, facilitates predictive listening, involving expectations for the timing of subsequent events (Jones & Boltz, 1989), and the entrainment of internal, if not external, systems (Grahn, 2012; Large & Jones, 1999). In addition to the repetitive nature of music in general (Margulis, 2014) and children's songs in particular, the continuously repeating songs increased the salience of the motifs and rhythms, enhancing their familiarity and appeal, as for adults (e.g., Thompson, Balkwill, & Vernescu, 2000). Familiarity also enhances adults' liking of specific musical selections (Szpunar, Schellenberg, & Pliner, 2004; Topolinski & Strack, 2009), and it is likely to do so for infants as well (e.g., Trehub et al., 2015).

Perceiving the beat of music is not merely an auditory experience. Rhythm processing intensifies neural activity between auditory and motor regions presumed to underlie internal beat generation (Chen, Zatorre, & Penhune, 2006; Grahn & Rowe, 2009). Moreover, the perception of rhythm is affected by vestibular stimulation (Phillips-Silver & Trainor, 2007, 2008; Trainor, Gao, Lei, Lehtovaara, & Harris, 2009), even in infancy (Phillips-Silver & Trainor, 2005). Perhaps it is no accident, then, that singing to infants is often accompanied by vestibular stimulation arising from rocking or carrying, both of which are potent affect regulators (Byrne & Horowitz, 1981; Esposito et al., 2013). The efficacy of movement for affect regulation may depend on its rate, as indicated by greater calming at the highest bouncing rate tested (1.5 Hz, corresponding to 90 bpm) (Vrugt & Pederson, 1973). In principle, the consequences of rhythmic singing—internal entrainment—could be similar to those of rocking or carrying, a question that awaits further investigation.

The success of ID singing in inhibiting or delaying infant distress implies that it was also successful in sustaining infant attention even though sustained attention was not measured directly. Nevertheless, infant distress onset indicated diminished attention or disengagement in relation to the stimulus, so that latency to distress provided an indirect index of sustained attention to that stimulus.

To date, comparisons of infant attention to ID and AD speech (e.g., Cooper & Aslin, 1990; Fernald, 1985; Singh et al., 2002), to ID and

non-ID singing (e.g., Masataka, 1999; Trainor, 1996), and to ID speech and singing (Corbeil et al., 2013; Costa-Giomi & Ilari, 2014) have indexed such attention by infants' initial fixation of a visual stimulus on a series of trials in which the presentation of auditory stimuli was contingent on fixation of the visual stimulus (see Trehub, 2012). Such measures of initial visual fixation reveal the relative efficacy of two auditory stimuli for *capturing* infant attention, but they reveal nothing about their efficacy in *sustaining* or holding infant attention. When infants are exposed to a continuous audiovisual recording of maternal speech or singing (i.e., their own mother) for 3 min, the singing is considerably more effective than speech in capturing their attention, as indicated by longer initial fixations, and in sustaining their attention, as indicated by cumulative fixation over the 3-min period. Interestingly, attention capture and attention holding have different autonomic, neural, and behavioral signatures (Colombo, Richman, Shaddy, Greenhoot, & Maikranz, 2001; Courage, Reynolds, & Richards, 2006; Richards, Reynolds, & Courage, 2010). Although previous research revealed that ID speech and singing (audio only) are equally effective in capturing infant attention (Corbeil et al., 2013; Costa-Giomi & Ilari, 2014; Trehub et al., 2015), the present research suggests that their efficacy in sustaining attention differs substantially.

Despite speech being less effective than singing in preventing infant distress in a relatively unstimulating environment, it still managed to keep infants reasonably content for over 3 min. Mothers—Western mothers, in particular—speak to preverbal infants much more than they sing (Eckerdal & Merker, 2009). It is notable, however, that ID speech is musical in many respects (Brandt et al., 2012; Corbeil et al., 2013; Fernald, 1992) even though it lacks the temporal regularity and predictability that are likely to enhance the efficacy of music. Interestingly, mothers in some cultures speak directly to infants only after infants exhibit rudimentary verbal skills (Ochs & Schieffelin, 1995), but there is no evidence of a culture in which caregivers do not sing to infants.

In everyday life, infants typically experience singing multimodally, with mothers' rhythmic melodies accompanied by rhythmic movement and smiling (Trehub & Gudmundsdottir, 2015; Trehub et al., 2015). Caregivers' multimodal singing is likely to be more effective than their multimodal speech in sustaining attention and forestalling distress in preverbal infants. Live maternal singing in face-to-face contexts, even without touch, modulates infant arousal (Shenfield et al., 2003). Moreover, maternal touch, on its own, moderates the distress induced by maternal unresponsiveness in the still-face procedure (Feldman et al., 2010; Stack & Muir, 1992). Although recorded singing in the present study had greater efficacy than speech (audio only, unfamiliar voices) for delaying distress, audio

recordings of singing are unlikely to be effective in ameliorating infant distress. We predict, however, that multimodal maternal singing would have such efficacy.

Maternal speech and singing share the advantages of a familiar voice, familiar face, familiar movement patterns, and behavior attuned to infant feedback (Braarud & Stormark, 2008; Smith & Trainor, 2008; Trehub et al., 2015). Maternal singing has the additional advantages of familiar songs sung in a familiar style with familiar pitch level and tempo (Bergeson & Trehub, 2002) aside from temporal regularity (Nakata & Trehub, 2011). Future studies of the affect-regulatory consequences of maternal speech and singing could benefit from physiological measures (e.g., skin conductance, heart rate) and additional behavioral measures such as facial expression. Such measures may provide an early warning system, revealing changes in infant arousal levels that precede overt manifestations of distress.

Future research could also include measures of infant temperament. Just as irritable temperament influences self-soothing and recovery from distress induced by an unresponsive mother in the still-face procedure (Gunning, Halligan, & Murray, 2013), so temperament may influence infant composure when mother is out of view. In principle, infants with positive temperament and a repertoire of self-soothing strategies could remain content for longer periods than more irritable and less resourceful infants.

The present findings have implications for those with parenting challenges by virtue of adverse socio-economic or emotional circumstances. Although infant distress signals typically prompt parental comforting interventions, they induce frustration and anger in some at-risk parents, leading to insensitive responding and, in the worst cases, to infant neglect or abuse (Barr, Trent, & Cross, 2007; Frodi & Lamb, 1980; Leerkes & Siepak, 2006). At-risk parents within the purview of social service agencies could be encouraged to play vocal music to infants and, better still, to sing to them.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article:

Data S1. Turkish ID singing.
Data S2. Turkish ID speech.
Data S3. Turkish AD speech.
Data S4. French ID singing.