Singing to infants matters:

Early singing interactions affect musical preferences and facilitate vocabulary building

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Authors' note

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Responsibilities:

Conception and design: FF; Implementation: FF and MF; data collection: IK; supervision data collection: MF; data analysis: FF, MS, CS, MF; preparation of first draft: FF; writing of paper: FF, MS, CS, IK; final manuscript revision: FF, MS, CS, MF

Abstract

This research revealed that the frequency of infant-parents singing interactions predicted 6-month-old infants' performance in laboratory music experiments and mediated their language development in the second year. At 6 months, infants (n=36) were tested using an operant preferential listening procedure assessing their responses to instrumental and sung versions of the same novel music tunes whilst the parents completed a questionnaire assessing home musical interactions with their infants. The infants were followed-up at 14 months to assess language development. The main results showed that at 6 months infants preferred listening to sung than instrumental melodies, and self-reported high levels of parental singing with their infants [i] were associated with less pronounced preference for vocal over instrumental music at 6 months, and [ii] predicted significant advantages on the language outcomes in the second year. The results are interpreted in terms of early plasticity effects on infants' sound processing.

Introduction

This study aimed to study the relationship between early exposure to musical interactions and attention to sung vs. instrumental versions of novel tunes in six-month-old infants, and to further explore the associations between these early behaviours with language development in their second year.

Human speech has been shown to be the most powerful auditory stimulus to capture and hold infant attention over and above other sounds, including monkeys' calls, nonspeech sounds and filtered versions of speech (Shultz & Vouloumanos, 2010; Vouloumanos & Werker, 2004; Vouloumanos & Werker, 2007; Vouloumanos, Hauser, Werker & Martin, 2010). While characteristics of infant-directed (ID- henceforth) speech have been extensively investigated, research on the relationship of ID-singing with language development is only at its dawn. However, an association between ID-speech and 'musicality' was already suggested by Papoušek and colleagues (Papoušek, Papoušek & Symmes, 1991; Papoušek, 1994), and pioneering work by Trehub and collaborators (Trehub, Hill & Kamenetsky, 1997; Trehub, Trainor & Unyk, 1993; Trehub, Unyk, Kamenetsky, Hill, Trainor, Henderson & Saraza, 1997; Trehub & Trainor, 1998) elucidated near-universal features of ID-singing, so that, for example, Western listeners can recognize lullabies from all over the world as child-directed singing. It is therefore timely to address questions concerning the contribution of ID-singing to the early stages of language development. Some recent studies are encouraging in supporting the existence of a positive transfer relationship between the two domains. For example, school-age children assigned to musical training achieved superior language targets than those assigned, e.g., to visual arts (François, Chobert, Besson & Schön, 2012). Even more cogently, six-months of participatory musical activities in infancy were shown to predict higher social abilities including communicative gestures than passive exposure to background music (Gerry, Unrau & Trainor, 2012).

It has been shown that across different languages, ID-speech is specifically characterised by exaggerated intonation, higher pitch, and slower tempo with respect to AD-speech (Fernald, 1989; Fernald, Perfors & Marchman, 2006; Fernald, Taeschner, Dunn, Papousek, de Boysson-Bardies & Fukui, 1989; for a meta-analysis see Spinelli, Fasolo & Mesman, 2017). Trainor, Austin, and Desjardins (2000) highlighted that the exaggerated intonation characteristic of ID-speech is associated with better discrimination of vowels in 6-month-old infants. Crucially, Fernald (1985) also revealed that babies prefer ID- to AD-speech, and that adults identify affect more easily from low-pass filtered versions of ID- than AD-speech (Fernald & Kuhl, 1987). Thus, the emotional dimensions appear to be part of the specialization of early ID-speech (see also Trainor & Desjardins, 2002) while at the end of the first year of life, at the time of focusing on and recruiting items to the vocabulary, other aspects will come into play, e.g. pitch peaks in utterance-final position used with target words (Fernald & Simon, 1984; see also Delavenne, Gratier & Devouche, 2013; Longhi, 2009 for similar considerations concerning singing interactions).

Singing to infants matters

Gratier and Davouche (2011) found that 3-month-olds and their mothers imitate each other's productions of prosodic contours, especially those more expressive of affect. More directly relevant for musical aspects, Van Puyvelde and colleagues (Van Puyvelde, Vanfleteren, Loots, Deschuyffeleer, Vinck, Jacquet & Verhelst, 2010; Van Puyvelde, Loots, Meys, Neyt, Mairesse, Simcock & Pattyn, 2015; Van Puyvelde, Loots, Vinck, De Coster, Matthijs, Mouvet & Pattyn, 2013) revealed that adjacent mother-infant vocalisations are tonally related ('tonal synchrony') and associated with physiological co-regulation at 3 months. Specifically, consecutive infant-mother turns fall mostly within tonal interval ratios that are highly consonant. When dissonant sequences occur, they are usually associated with subsequent repair turns in the interaction. Thus, it appears that musical and linguistic features are intertwined in early communication with infants, and deeply rooted in emotional meanings (Franco, 1997; Van Puyvelde & Franco, 2015).

Finally, the ID-register is often associated with vowel expansion in both speech (Vosoughi & Roy, 2012; Cristia & Seidl, 2014) and song (Falk, 2007). Expanded vowel space is associated with speech clarity, which, in maternal speech, has been found to predict superior outcomes in cornerstone language development abilities for babies, such as perceptual narrowing in phonetic discrimination (Liu, Kuhl & Tsao, 2003; Tsao, Liu & Kuhl, 2004). Such abilities have been shown to be relevant for speech segmentation, which is in turn crucial for the recruitment of items to the growing vocabulary. For instance, performance on speech segmentation tasks at 7-12 months predicted productive vocabulary at 24 months of age (using a retrospective research design, Newman, Ratner, Jusczyk, Jusczyk & Dow, 2006), using a prospective design (Singh, Steven Reznick & Xuehua, 2012).

More recently, in cross-linguistic analyses Falk (2007; 2011a) highlighted that ID-singing presents a number of characteristics very similar to ID-speech (e.g., higher pitch) as well as containing phonetic and prosodic information which is language-specific, hence providing rich material to learn the native language from. In particular, higher similarity is found between melodic contours in ID-song and ID-speech produced in play rather than soothing contexts (Falk, 2011b). Thiessen and Saffran (2009) showed that 7-month-old infants learned words more easily when they were presented with a melody than in isolation, and some tenuous but intriguing findings suggested that melodies may support the discrimination of syllables in 11-month-olds (Lebedeva & Kuhl, 2010).

Overall, research has produced robust evidence of a powerful relationship between characteristics of language input in terms of individual differences, and language development outcomes in toddlers and young children (Fernald & Mazzie, 1991; Suttora, Salerni, Zanchi, Zampini, Spinelli & Fasolo, 2017; Weisleder & Fernald, 2013). In this framework, besides being 'as good as speech', it is possible that ID-song might even present specific contributions to language development in its own right. For example, the acquisition of a new artificial language has been shown to be facilitated by sung contexts in adults and school-age children (Schön, Boyer, Moreno, Besson, Peretz & Kolinsky, 2008), possibly thanks to the higher predictability of song in a naturalistic context as a result of entrainment to a regular

beat, enhancing predictability, and pitch attraction (Schön *et al*., 2008; Woolhouse, Cross & Horton, 2016), which may support speech segmentation. Thus, attentional demands might be lower in singing conditions also for babies hence lending support to the developing infant vocabulary-building skills. Maternal singing has been shown to be also effective in regulating arousal in infants (Shenfield, Trehub & Nakata, 2003), thus being a good candidate to offer an optimal learning context for words and speech sounds. Based on these studies, it is possible to hypothesise that infants exposed more frequently to singing interactions in their first year would experience facilitating effects on language development.

Song recruits higher levels of attention than speech in 6- to 10-month-old infants (Nakata & Trehub, 2004; Tsang, Falk & Hessel, 2017), possibly in association with more 'happy sounding' performances (Corbeil, Trehub & Peretz, 2013). However, this preference did not appear in a study with ≥11-month-olds (Costa-Giomi & Ilari, 2014), which raises the possibility that attention to language was heightened in this older age group, due to the infants' focus being directed to matching auditory with articulatory/visual targets at the early stages of their speech production. Consistently, Delavenne *et al*. (2013) and Longhi (2009) identified subtle but systematic changes in the temporal and hierarchical structure of naturalistic singing interactions between mothers and infants when comparing different developmental levels within the first year of life, with the older groups adjusting to accommodate both the later triadic nature of infant attention (including referents external to the dyad) and phonetic adjustments functional to speech segmentation / word recognition.

The present study

Whilst only a longitudinal approach would be able to answer conclusively the question of infant preferences (or lack of) for song/speech over the first year of life, the evidence available at present remains in need of further clarification. The first part of the present study contributes to this clarification by studying infant preferences for instrumental vs. vocal versions of the same 'happy' songs in infant-directed style, with the vocal versions containing pseudowords to maintain complexity while avoiding potentially uneven familiarity effects. We aimed to test if infants aged six months would/would not display any preference when using auditory stimuli in which the same tune was presented as song or instrumental performance. If the infant preferences found in Nakata, and Trehub (2004) and Tsang *et al*. (2017) were guided by the musical aspect per se, no preference should emerge between the two musical conditions in the present experiment. However, if the speech-like quality of singing is important, songs are expected to attract infants to a greater extent than instrumental pieces.

We also hypothesized that infant attention in the laboratory tasks may be affected by previous experience and familiarity with musical interactions. In order to evaluate this aspect, information about the frequency and type of

musical experiences reported in the infants' families was collected with a questionnaire specifically designed for this study.

Finally, a longitudinal follow-up when the infants were 14 months-old was carried out in order to test if language development outcomes are predicted by infants' musical preferences at 6 months directly or indirectly when considering their home music experiences and maternal characteristics (education, and sensitivity as measured by PCERA - Clark, 1985).

Method

Longitudinal data were collected at two time points, when the infants were 6- (*M* = 0;06.17, *SD* = 11 days) and 14- (*M* = 1;02.10, *SD* = 19 days). These ages were selected as corresponding to two developmentally salient points for communication, respectively: [Time 1] prior to established babbling (Oller, 1978) and joint attention (Mundy, Block, Delgado, Pomares, Van Hecke & Parlade, 2007); [Time 2] phonetic repertoire narrowed to native language (Kuhl, Ramírez, Bosseler, Lin & Imada, 2014; Werker & Tees, 1984) and consistent canonical babbling (Fasolo, D'odorico, Costantini & Cassibba, 2010; Molemans, van den Berg, Van Severen & Gillis, 2012).

Participants

Participants were recruited using a mailing list derived from the municipality birth records in North Italy. The invitation was directed to families with infants having the target age of 6 months who were living within a reasonable distance from the University campus. The response rate was approximately 50%. Volunteers who responded to the invitation were subsequently contacted to provide them with further information about the study and arrange a testing appointment at Time 1 (6 months). Only infants from Italian-speaking families were included, with 5 infants being exposed also to a L2. In this way n = 36 healthy infants were recruited (50% female). Two boys were born preterm hence they were tested at the infants' corrected age. Of this sample, n = 26 were available at Time 2 (14 months, 46% female) corresponding to a drop-out of 27.8%.

At Time 1, 7/36 infants had one person in the family who received musical training at some point in their lives but only one of them was still actively practicing. Siblings were present for 12/36 infants and 14/36 infants attended nursery or playgroups. Maternal education measured in years in full time education was *M* = 15 (*SD* = 3), with 13 years corresponding to completion of secondary school and 16 years to a university degree.

Procedure

Time 1 (6 months; T1 henceforth)

Together with demographic information, maternal reports of singing interactions and home music were collected using a novel ad-hoc questionnaire (see Materials).

A preferential listening experiment was conducted in a 1.5 X 2 m Amplifon soundproof booth, with the infant sitting on the parent's lap. Parents were asked to wear headphones exposing them to white noise so as to cover sound from the experiment; parents were allowed to adjust the volume at a comfortable level with preliminary tests. Parent and infant were facing a 26.3" computer monitor positioned at a 40 cm distance. Music stimuli were presented at a constant level of 60 db with a 2.1 JBL Creature III System located below the monitor (see Materials). An interesting animation with sound was displayed throughout the set up and adjustment phase. Once the experiment began, a colourful attention-getter was used to capture infant's attention to the centre of the screen between trials, and a black & white checkerboard was displayed on the screen in association with the experiment music tracks. Infants were exposed to a sequence of six musical tracks in semi-random order, including three vocal and three instrumental 1-minute trials (see below for details). An experimenter monitored infant's behaviour through a videocamera but was blind to the sound condition and, at the time of testing, to the individual's family background variables. Infant behaviour was recorded via key-press signalling looking-on vs. looking-away from the screen. A trial was started with the infant gaze in central position and included the visual presentation of the checkerboard in association with a musical track. When the infant looked away from the screen, the music stopped but resumed when the infant returned attention back to screen. The experiment was programmed using MATLAB software, which also time-stamped all output events indicated by the experimenter. Two consecutive pauses of two seconds were the threshold for a look-away event to trigger discontinuation of a trial and beginning of the next trial. The behavioural measures analysed from the preferential listening experiment were, for each music track: [i] mean listening event (duration of mean continuative listening event after the first orientation), [ii] distraction events (mean number of off-screen attention events).

Mothers and infants were also video-recorded during a 5 minutes free-play interaction with age-appropriate toys. Mothers were asked to play as they normally do.

Time 2 (14 months; T2 henceforth)

All participant families were contacted when the infant reached 14 months and invited to complete the parental report *Primo Vocabolario del Bambino* inventory (Caselli & Casadio, 1995), which is the Italian adaptation of the MacArthur-Bates Communicative Development Inventory (CDI – Fenson, Bates, Dale, Marchman, Reznick & Thal, 2007) see details in Materials section.

Materials

The music for the laboratory test was composed ad-hoc, in order to avoid possible influences of uneven prior familiarity with songs or music. Three child-directed tracks characterised by 'happy' affect and lasting approx. 1 minute each (68.5 *s*) were available in both instrumental and vocal versions, all presented at 60dB. They all had a 4/4 time signature and used expressive cues associated with positive affect in music (for a review, see Gabrielsson & Lindström, 2010) namely major keys (respectively, D, G and C major), fast tempos (respectively, 126, 134 and 113 BPM), staccato articulations, and instruments with fast attack times and shorter sustain and release times (e.g., drums, marimba, pizzicato strings), and they were highly consonant. The vocals were recorded in the soprano range with a trained female singer working with toddlers and young children at the time of recording and who was asked to imagine singing for a toddler pictured in photographs available in the studio. Rather than using meaningful lyrics, nonsense syllables were used to create pseudowords in order to prevent possible influences of uneven prior familiarity with some words across the infants (Thiessen & Saffran, 2009; Bortfeld, Morgan, Golinkoff & Rathbun, 2005).

Assessment of the home musical environment at 0-6 months

A parental report, constituted by 12 items (*Musical Experience in the Family*, *MEF*, Franco, Brunswick & Kiakides, 2014) was administered to collect information about parents' musical education, music listening in the home (frequency and genres), activities, and singing interactions with the infants (frequency; context, e.g. play, sleep time; type of songs, e.g. lullabies, play songs). For the purpose of this study, two variables were derived, Active Engagements (exposure to ID-singing) and Passive Engagements (exposure to background music), which were evaluated on a 4-point frequency scale (0 = only occasionally, 1 = sometimes, e.g. every couple of weeks max. once a week, 2 = daily, 3 = several times every day). Levels 0 - 1 were scored as 'low exposure' and levels 2 - 3 as 'high exposure' in the analyses.

Assessment of language development

At Time 2, the CDI (Italian adaptation, Caselli & Casadio, 1995) *Words and Gestures* form was collected from the infants' parents, lending four measures of language development: Sentence Comprehension (CDI-SC), Word Comprehension (CDI-WC), Word Production (CDI-WP) and Gestures (CDI-G).

Maternal variables

Given the established importance of maternal variables in language development (Landry, Smith & Swank, 2006), we included maternal education and sensitivity in our study. The former is considered a general proxy of SES (e.g., Smith, Hart, Hole, MacKinnon, Gillis, Watt & Hawthorne, 1998) and measured in years of formal education. The Parent-Child Early Relationship Assessment (PCERA – Clark, 1985) is considered part of sensitivity-based measures

that can be used with young infants (Mesman & Emmen, 2013) and was used to code the 5 minutes free-paly interactions at 6 months. It is a system designed to assess behavioural characteristics of parents and infants and the frequency, duration, and intensity of affect that occur during 5 min of face-to-face interactions. On the basis of the 5-min observation, each variable is coded on a scale ranging from 1 (negative relational quality) to 5 (positive relational quality). In the present study, we focused on the 29 parent variables that could be coded at 6 months. These included tone of voice, affect and mood, attitude toward the child, affective and behavioural involvement, and style. A total maternal interaction quality score was calculated and finally the mean score between the items was calculated as an index of maternal interactive quality (PCERA maternal total mean score). This mean score ranged between 1 and 5 with higher scores indicating better quality of interaction. The PCERA (Clark, 1985) has an acceptable range of internal consistency, factor validity, and discriminate validity between high risk and well-functioning mothers (Clark, 1999; Spinelli, Poehlmann & Bolt, 2013).

Data analysis

Pearson correlations were used to assess the relationship between variables.

In order to assess infant attention during the preferential listening experiment in function of musical experience at home, mixed factor GLM ANOVAs were performed for the listening variables for (i) music type (vocal, instrumental) X Home Active Engagements (High/Low) and (ii) music type (vocal, instrumental) X Home Passive Engagements (High/Low). Results will be first reported for the preferential listening experiment at 6 months, with the environmental background effects and interactions reported in a specific section.

In order to assess the relationship between Time 1 (infant listening preferences) and Time 2 (language), GLM ANOVAs were conducted for the infant listening variables during the experiment and each language development variable.

Finally, mediation analyses (Hayes, 2013; Clark, Paulson & Conlin, 1993; Preacher & Hayes, 2008; Preacher, 2015) were conducted on language development outcomes including, respectively, Home Active and Passive Engagement as independent variables and infant preferential listening variables as mediators. PCERA maternal total mean score and maternal education were used in moderation analyses when relevant.

Ethics

Ethical approval was granted by the Psychology Ethics Committees of the University conforming to the principles of the Helsinki Declaration for research involving human participants. Informed written consent was collected from the children's parents before testing and debriefing was provided at the end of each session.

Results

The number of participants for each variable assessed with the *MEF questionnaire* (Franco *et al*., 2014) at T1 and T2 are shown in Table 1. Parents reported that active (Home ID-singing interactions) and passive (Home Background Music) engagements with music were common for most infants. The results will summarise first infant attention in vocal/instrumental musical conditions at T1 (6 months), including the relationship between these measures and language outcomes at T2 (14 months). Subsequently, environmental effects will be examined separately for the exposure to active and passive musical engagements reported at T1, and for maternal variables (education, sensitivity).

Table 1. Infant Musical Environment Screening at 6 (T1) and 14 (T2) months.

Experience	Level	T1	T2
ACTIVE ENGAGEMENTS			
Frequency of Home ID-singing	Low (never/occasionally)	12	9
	High (daily/several times a day)	24	17
Contexts of ID-singing	Mostly One	4	3
	Several	32	23
Genres in ID-singing	Mostly Lullabies	8	5
	Playsongs & Lullabies	28	21
PASSIVE ENGAGEMENTS			
Frequency of home background music	Low (never/few times a week)	8	7
	High (daily/several times a day)	28	19
Home music diversity	1-4 genres (e.g., pop, classical, jazz etc.)	10	8
	>4 genres	26	18
Total (*N* infants)		36	26

Infant attention in the preferential listening experiment

Table 2 displays the infants' listening variables in function of the experimental conditions. There was a general tendency for the infants to show longer listening events with the vocal than the instrumental version of the tunes, with a large significant effect for mean listening event, $F(1,34) = 10.53$, $p = .003$, $\eta_p^2 = .24$ suggesting that overall infants preferred vocal music. The overall distribution of Distraction events was not affected by condition , $F(1,34) = 0.48$, $p = .492$, $\eta_p^2 = .01$

Table 2. Mean (SD) Mean Listening Events and Distraction Events in Vocal and Instrumental musical conditions (*N* = 36 infants).

	Vocal Music		Instrumental Music	
	M	*SD*	*M*	*SD*
Mean Listening Event (sec)	9.99	8.04	6.63	4.79
Distraction Event (n)	9.46	4.47	9.47	4.17

Home Active and Passive Musical Engagements: Effects on infant listening preference

The results of the GLM ANOVAs for Active Engagements with vocal/instrumental music conditions on infant attention yielded significant interaction effects for both variables, respectively, Mean Listening Event, $F(1,34) = 6.12$, p =.019, $\eta_p^2 = 0.15$, and Distraction Events, $F(1,34) = 4.19$, $p = .049$, $\eta_p^2 = 0.11$. The results are displayed in Figures 1 and 2. Post-hoc analyses revealed that infants from Low ID-singing exposure displayed longer Mean Listening Events with vocal than instrumental music, $t(11) = 3.02$, $p = .012$, but infants from High ID-singing exposure did not show a preference, $t(23) = .73$, $p = .472$, see Fig 1. When considering Distraction Events, infants with Low ID-singing exposure displayed a trend for higher levels of Distraction with instrumental than vocal music, $t(11) = -2.10$, $p = .060$, whereas infants with High ID-singing exposure did not, $t(23) = 1.08$, $p = .290$. As Fig 2 shows, infants from High ID-singing environment were more distracted than infants from Low ID-singing environment in vocal music conditions, $t(32) = -3.62$, $p = .001$. There were no significant main effects of Active Engagements on the listening variables (Mean Listening Events: $F(1.34) = .913$, $p = .346$, $\eta_p^2 = .03$),with a trend for Distraction, $F(1,34) = 3.49$, $p = .070$, $\eta_p^2 = .09$, suggesting that, independently from musical condition, infants having high ID-singing exposure tended to display

overall more frequent Distraction events during the experiment than infants with low ID-singing exposure (respectively, M_{high} = 10.19, *SE* = .67 and M_{low} = 8.01, *SE* = .95).

Fig 1. Mean Listening Event (sec) in vocal and instrumental conditions for Active Music Engagements (high vs. low ID-Singing exposure) (N= 36).

Note: Error bar = SEM.

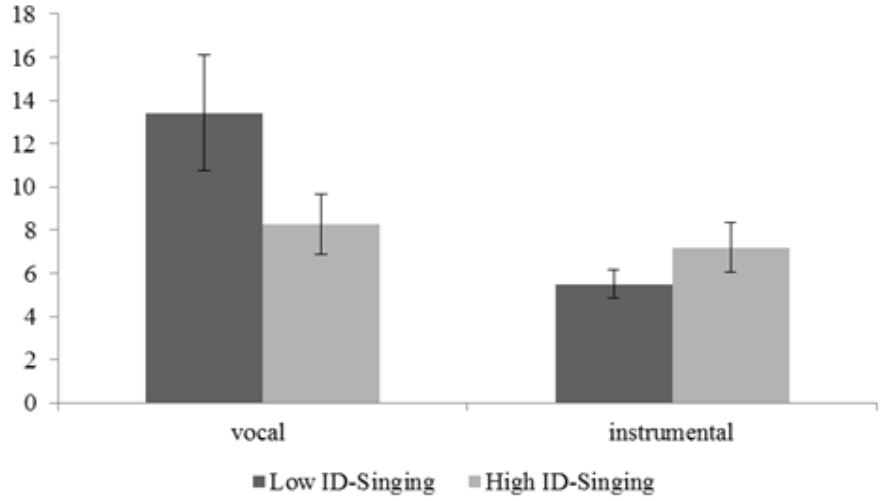
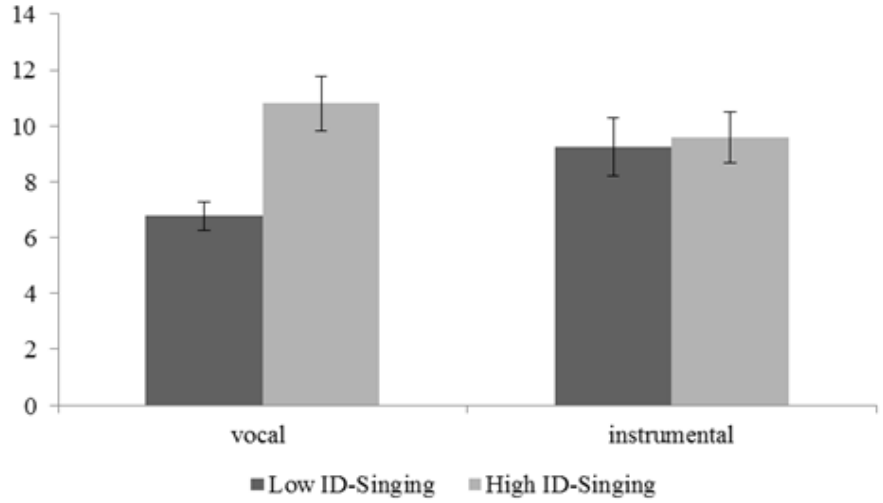


Fig 2. Distraction Events (N) in vocal and instrumental conditions for Active Music Engagements (high vs. low ID-Singing exposure) (N= 36).

Note: Error bar = SEM.



The corresponding GLM ANOVAs for Passive Musical Engagements (High/Low level X vocal/instrumental music condition) did not reveal significant interactions or main effects for either infant attention measures, see Table 3.

Table 3. Infant attention to vocal and instrumental music during the preferential listening experiment at 6 months in function of Passive Music Engagements (high vs. low exposure to background music) (N= 36).

	Low background music exposure		High background music exposure		Music type X Background music exposure		
	M	*SD*	*M*	*SD*	*F(1,34)*	*p*	η_p^2
Mean Listening Events (sec)							
Vocal	9.70	8.73	10.07	8.00	.01	.945	.01
Instrument	6.52	2.40	6.66	5.32			
Distraction Events (n)							
Vocal	7.33	1.65	10.07	4.85	1.04	.316	.03
Instrument	9.03	3.66	9.59	4.36			

In sum, early home musical experiences influenced infant attention measures only when they involved active interactions involving ID-singing addressed to the infants, with infant overall preference for vocal over instrumental tunes being reduced by high levels of singing in the first six months.

Associations of infant attention to vocal/instrumental tunes at 6 months with language development at 14 months

Correlational analyses were conducted to investigate the relationships between infant listening during the preferential listening experiment at 6 months and language development outcomes at 14 months (CDI). Table 4 summarises the results. When considering vocal trials, the trend to find a negative association between Mean Listening Event and language outcomes was non-significant. However, significant positive relationships were found between frequency of Distraction Events and both CDI-Sentence Comprehension (p = .016) and -Word Comprehension (p = .004), indicating that the more distraction during the vocal trials at 6 months, the higher the scores on language development in these two CDI components. None of the corresponding analyses with instrumental music yielded any significant correlations, suggesting that attention to instrumental music was not specifically associated with any aspects measured by CDI.

Table 4. Pearson's correlations between the behavioral measures of infant attention in the preferential listening experiment at 6 months and measures of language and communication development at 14 months (N= 26).

Condition	Infant attention measure	CDI-SC	CDI-WC	CDI-WP	CDI-G
Vocal	Mean Listening Event	-.34	-.26	-.06	-.31
	Distraction	.47*	.55**	-.06	.34
Instrumental	Mean Listening Event	.03	.01	.05	.22
	Distraction	.08	.27	.22	-.10

*Notes: * p < .05; ** p < .01; *** p < .001.*

Legend: CDI-SC= Sentence Comprehension; CDI-WC=Word Comprehension; CDI-WP=Word Production; CDI-G=Gestures

Effects of early Active and Passive Musical Engagements at home on language outcomes at 14months (n=26)

The effect of Active Musical Engagements (High/Low ID-singing exposure) at T1 and language development measures at T2 was explored using GLM ANOVAs. Active Musical Engagements produced large significant effects on all CDI outcome variables: CDI-Sentence comprehension, $F(1,24) = 13.91$, $p = .001$, $\eta_p^2 = .37$, CDI-Word Comprehension, $F(1,24) = 11.05$, $p = .003$, $\eta_p^2 = .31$, CDI-Word production, $F(1,24) = 5.64$, $p = .026$, $\eta_p^2 = .19$, CDI-Gesture production $F(1,24) = 9.34$, $p = .005$, $\eta_p^2 = .28$. As can be seen in Fig 3, infants with higher exposure to singing interactions in their daily lives during their first 6 months of life outperformed infants with lower ID-singing exposure on all language development measures at 14 months.

Table 5. Mean language development measures at 14 months in function of Passive Musical Engagements at home (high vs. low exposure to background music) reported at 6 months (N= 26).

	Low exposure background music		High exposure background music		GLM effect		
Language	*M*	*SD*	*M*	*SD*	*F (1,24)*	*p*	η_p^2
CDI-SC	13.71	7.61	17.32	6.85	1.34	.259	.05
CDI-WC	66.00	63.52	139.63	80.10	4.77	.039	.17
CDI-WP	8.43	6.58	16.37	18.54	1.20	.284	.05
CDI-G	30.57	9.76	36.89	10.99	1.79	.194	.07
CSBS Total	76.00	16.18	82.58	18.31	0.70	.411	.03

Legend: CDI-SC= Sentence Comprehension; CDI-WC=Word Comprehension; CDI-WP=Word Production; CDI-G=Gestures.

Notes: Legend: *CDI-SC= Sentence Comprehension; CDI-WC=Word Comprehension; CDI-WP=Word Production; CDI-G=Gestures.*

The results of the language development measures in function of Passive Musical Engagements at home (High/Low background music exposure) are reported in Table 5 with the effects of the GLM ANOVAs. Only the CDI-Word Comprehension outcome showed a moderate significant relationship between levels of exposure to background music at T1 and language development at T2, with infants less frequently exposed to background music displaying smaller receptive vocabularies than infants for whom exposure to background music was part of their everyday life at T1.

Assessment of the contribution of maternal variables

Maternal education

Reported home musical interactions appeared independent from maternal education. The association of maternal level of education (middle/high school vs. university levels) with Active (Low vs. High exposure to ID-singing) and Passive Musical Engagements (Low vs. High exposure to background music) was tested with Pearson Chi-squared tests, which did not reveal any significant associations (Active Musical Engagements: $X^2(1) = .39$, $p = .53$; Passive Musical Engagements: $X^2(1) = .09$, $p = .768$) In other words, the extent to which families engaged in active and passive musical activities was independent from maternal education.

Maternal quality of interaction

Univariate ANOVAs conducted to compare PCERA maternal total mean score between high and low levels of exposure to home musical experiences revealed significant effects for both Active, $F(1,28) = 5.32$, $p = .029$, $\eta_p^2 = .17$, and Passive, $F(1,28) = 4.36$, $p = .046$, $\eta_p^2 = .14$, Engagements, with higher PCERA mean scores found in higher than lower exposure groups. However, mothers in this sample presented PCERA scores situated on the highest range of the 1-5 scale in both high- and low-exposure groups, indicating that overall parents in the sample were quite- to highly-positive during the interaction with their infants (respectively, Active Engagements: Low exposure $M = 3.74$ and High exposure $M = 4.08$; Passive Engagements: Low exposure $M = 3.68$, High exposure $M = 4.05$).

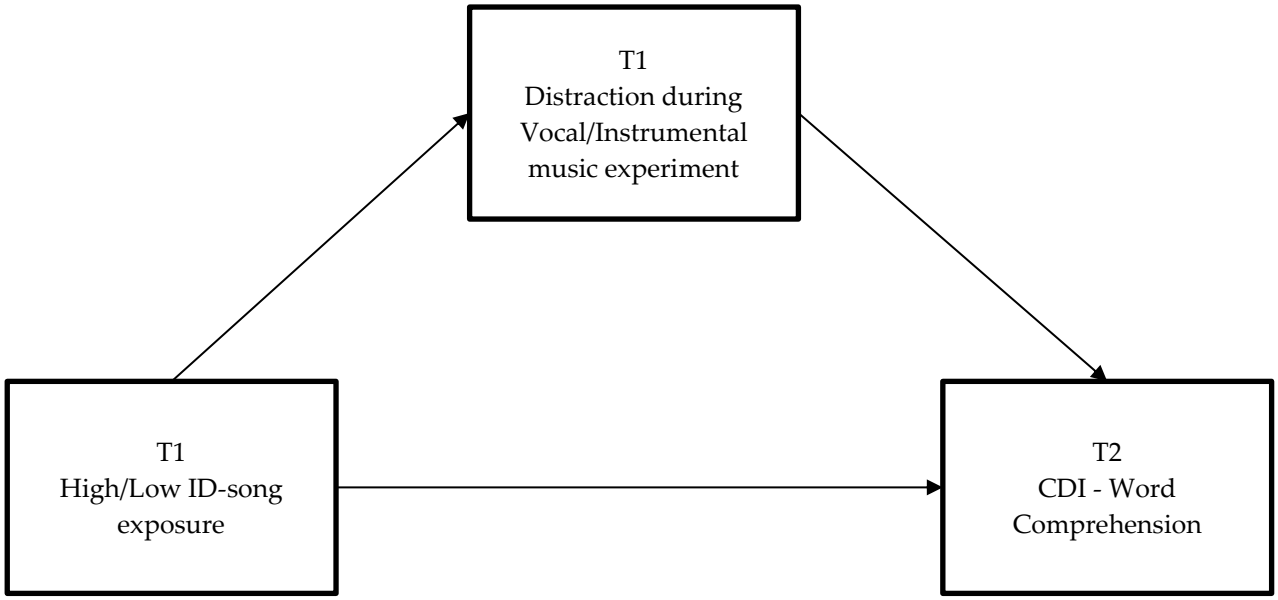
Assessment of mediation and moderation relationships

In order to elucidate the relationships underlying the variables considered in this study, mediation and moderation models were used to test indirect effects between the variables that yielded consistent and significant associations. Thus, first the association between family musical engagements and, respectively, [i] infants' Distraction events at T1 (showing significantly more frequent Distraction during Vocal tracks in infants from high- than low-ID-singing exposure) and [ii] language development outcomes at T2 (showing superior outcomes in infants from high- than low-ID-singing exposure) was tested with mediation analyses. Secondly, maternal variables were entered in the models as moderators.

Infants' Distraction during Vocal tracks at 6 months was tested as mediator between Active Musical Engagements at T1 (High vs Low ID-singing exposure) and relevant infants' language outcomes at T2 (receptive vocabulary - CDI-WC, and Sentence Comprehension - CDI-SC) employing the bootstrapping method developed by Preacher and Hayes (2008) with 5000 replications. In the receptive vocabulary model, both direct (B = 66.94, SE = 29.55, 95% *CI* = 5.81- 128.1) and indirect (B = 27.75, SE = 13.08, 95% *CI* = 6.72-57.43) effects of ID-Singing exposure on children's Word Comprehension score (CDI-WC) were significant – see Fig 4. The same test conducted using infants' Sentence Comprehension score (CDI-SC) as the outcome variable showed that while the direct effect of ID-singing exposure on CDI-SC was significant (B = 7.26, SE = 2.59, 95% *CI* = 1.90-12.61), the indirect effect through Vocal Distraction was not (B = 1.59. SE = 1.40, 95% *CI* = -0.26-4.03). This means that the early Active Musical Engagements (exposure to high or low levels of ID-singing) affected word comprehension (but not sentence comprehension) at T2 also indirectly through infant listening preferences at 6 months.

Another mediation model was conducted considering the effects of Passive Musical Engagements (high/low exposure to background music) on the receptive vocabulary (CDI-WC) with infants' Distraction events during Vocal tracks as mediator. The results suggested that the influence of exposure to background music on vocabulary building is entirely acting through shaping infant early attentional preferences. Specifically, the indirect effect of Passive Musical Engagements through infants' Distraction events during Vocal tracks on CDI-WC was significant with B = 23.90, SE = 12.64, 95% *CI* = 1.11-50.54. as was the total effect, with B = 73.63, SE = 33.73, 95% *CI* = 4.01-143.26. However, the direct effect was not significant with B = 49.73, SE = 31.14, 95% *CI* = -14.70-114.16.

Fig 4. Mediation model including direct and indirect effects of Active Musical Engagements and patterns of infant attention to sound at 6 months (T1) on language development outcomes at 14 months (T2).



Finally, the potential effect of maternal variables was also investigated using this approach, which elucidated that these variables did not enter the relationships identified above. Moderation analyses were conducted using, respectively, Maternal Education and PCERA total mean score as a moderator between, Active and Passive Musical Engagements and the most relevant language development measure at 14 months, i.e., CDI-WC outcome. Concerning Maternal Education, the model for Active Engagements (high/low exposure to ID-singing) explained 34% of variance, $F_{(3,22)} = 3.76$, $p = .025$, with ID-singing affecting significantly infants' word comprehension consistently with what established above (β=.58, $p = .003$), but maternal education and ID-singing X maternal education did not yield significant effects (β=.01, $p = .95$, β=.15, $p = .38$ respectively) . Similarly, the results of the model concerning Passive Musical Engagements (19% variance), $F_{(3,22)} = 1.79$, $p = .18$, supported that Passive Musical Engagements affected children word comprehension (β=.38, $p = .04$) but indicated a lack of moderation for both maternal education (β=.14, $p = .45$) and Passive Musical Engagements X maternal education effect (β=.10, $p = .56$) in the relationship between Passive Musical Engagements and CDI-WC outcome. Thus, Maternal Education did not moderate the relationships between either musical engagement experiences in the home and CDI-WC.

Next, in the moderation analyses concerning maternal sensitivity (PCERA score), the model for Active Musical Engagements (High/Low exposure to ID-singing) explained 44% of variance, $F_{(3,17)} = 4.54$, $p = .016$. The effect of ID-singing exposure confirmed the significant effects found above on CDI-WC ($\beta = .65$, $p = .01$) but both PCERA score and Active Engagements X PCERA score interaction effects were not ($\beta = .05$, $p = .84$ and $\beta = -.05$, $p = .83$, respectively). Similarly for Passive Musical Engagements, the model explained 30% of variance, $F_{(3,17)} = 2.44$, $p = .09$. In this model, Passive Musical Engagements, PCERA maternal total mean score and Passive Musical Engagements X

PCERA maternal total mean score were all not significant (β = .45, p = .10, β = .26, p = .32 and β = .08, p = .72, respectively). This means that maternal sensitivity as measured by PCERA total mean score not only did not have a direct effect on language outcomes, but also it did not moderate the effect of either Active or Passive Musical Engagements on CDI-WC.

Discussion

This study showed that, when keeping music structural properties constant, 6-month-old infants tended to prefer vocal to instrumental 'happy' music tracks. In this respect, the results are consistent with Nakata and Trehub (2004) and Tsang *et al*. (2017), suggesting superior attention to ID-song than ID-speech in this age group. However, the present experiment allows us to disambiguate some claims associated with the above studies and elucidate that at this age infant attention is attracted specifically by songs, that is a rich combination of speech sounds with musical structure. If the superiority effect were due to the musical aspect per se, we should not observe an overall preference for vocal over instrumental music. One possibility is that in early development, the human voice continues to be a most attention-grabbing and -holding type of stimulus (Vouloumanos & Werker, 2007). On the other hand, songs cannot simply be reduced to an extreme type of the ID-speech category. Although ID-singing presents specific adjustments along the ID-register characteristics, some important differences occur too, namely the song organization around a regular beat, and pitch stability occurring with singing – neither of which is needed or typical of ID-speech (Falk, 2007). ID-singing is a particular communicative device, which appears specifically suited to attract and hold 6-month-olds attention (Tsang *et al*., 2017). Besides the association with positive affect (Trainor & Desjardins, 2002), it is likely that song's regular pulse facilitates the building of infant expectations, engagement and stream-segmentation, while pitch stability helps the infant to identify phonetic regularities particularly in vowels and surrounding elements. It is also possible that ID-songs facilitate the processing of the acoustical content by means of the interpersonal focus and synchronisation supported by an underlying regular pulse, which may give infants facilitated access to embodied aspects (e.g., breathing for vocalising).

However, the results revealed that infants' inclination to listen to songs, not just instrumental versions of the same tunes, does not resist environmental influences. Babies growing up in families reporting very high levels of informal musical interactions in the home appeared to be less pervasively fascinated by the experimental songs, with some infants actually displaying more interest for instrumental tracks. On the contrary, babies from families reporting low levels of musical engagements at home did consistently show preference for vocal over instrumental music. Thus, the results suggest that environmental influences are already shaping infant attention as observed in the laboratory, in a direction that may be cautiously interpreted as capturing some novelty effect (vs. lack of). Whilst songs attract all

infants' attention and appear to be an appealing acoustical stimulus, a low level of exposure to this experience will accentuate this preference in the laboratory setting whereas a high level of exposure will attenuate the attraction effect. This novel environmental effect corroborates recent suggestions that early musical exchanges including ID-singing and vocal interactions would play an important role in the development of communication (Van Puyvelde & Franco, 2015) hence will need further investigation, particularly in consideration of the longitudinal findings on language development.

The follow-up at 14 months presented powerful results, showing an association between exposure to high levels of musical interactions in the first 6 months of life and considerable advantages in early language development: the scores of all subcomponents of the CDI were significantly higher in infants from high-music families compared with low-music families. These results are important since these measures, particularly receptive vocabulary at this age (14 months), are an important predictor of developments in productive vocabulary, hence paving the way to better outcomes in early language acquisition (Tsao *et al*., 2004; Kuhl *et al*., 2014). Interestingly, this relationship was reflected indirectly in the infant preferential listening experiment: infants from high-music families showed attenuated preference for song in the lab at 6 months (this acoustic form being largely familiar to them) while displaying better language development outcomes in their second year. On the contrary, infants from low-music families were those who were most attracted by songs in the laboratory at 6 months (having less home experience of this highly attractive acoustical form) but also those who displayed lower levels of language development in the second year. This means that early informal musical experiences in the home shapes infant attention to sound, and that the cumulative experiences associated with them predict different developmental outcomes. It also suggests that laboratory measures taken at only one point in development, without family context nor longitudinal perspective, may reveal only one part of the developmental story and its significance.

The strong association found between musical experience in the home and early language development was further examined by separating active engagements (with a specific focus on singing with the infant) from passive engagements (e.g., exposing the infant to a variety of background music). In a nutshell, active engagements revealed more extensive effects than passive exposure (cf. Gerry *et al*., 2012, for similar trends in developmental measures as a result of structured infant group activities). Specifically, high levels of ID-singing exposure appeared both directly and indirectly (mediated by infant preferences to sound types) associated with better developmental outcomes in early language measures, whereas high levels of passive engagements (exposure to background music) only displayed one significant direct relationship, namely, with higher scores in CDI-word comprehension at 14 months, compared to families with low levels of passive musical exposure, and no mediated effects. The contribution of background music towards the development of infant receptive vocabulary may be underpinned by statistical learning mechanisms based

on repeated exposure to transitional probabilities in verbal and melodic aspects occurring in songs (Thiessen & Saffran, 2009) – a mechanism that is vulnerable to attention loss (Toro, Sinnett & Soto-Faraco, 2005).

The more prominent effect of active musical engagements for gains in early language development may be associated to a number of factors, which future research will need to address. Schön *et al*. (2008) found that adults' and children's ability to segment 'words' out of an artificial language sound stream was superior in a musical condition coupling speech units to pitches than to a condition with flat speech (without coupling with pitches). Schön *et al*. (2008) suggested that the musical condition presented enriched material to learn from and, when generalising to more naturalistic musical contexts, would present the learner with a more predictable sound stream based on a regular beat, and typically associated with positive affect hence including a motivational aspect. In extending such speculations to the results of the present study, a first consideration is that singing with infants is often associated with motor activities (e.g., bouncing the baby on the knees) hence promoting inter-sensory redundancy that facilitate learning (Bahrick & Lickliter, 2014), exploiting auditory-vestibular or –tactile abilities that are available in young infants (Phillips-Silver & Trainor, 2005). A second advantage of ID-singing is its documented association with emotion regulation in infants (Shenfield *et al*., 2003) and neurovisceral integration (Van Puyvelde *et al*., 2013; Van Puyvelde, Loots, Vanfleteren, Meys, Simcock & Pattyn, 2014), which may optimise the infant's learning opportunities. Furthermore, there is evidence that direct interaction has superior effects on infant learning compared to passive exposure. Kuhl, Tsao and Liu (2003) showed that post-phonetic narrowing infants learned aspects of a new language (Mandarin) when interacting with a real person but not when exposed to a televised display of the Mandarin speaker or simply audio-recordings. Besides contingent adult scaffolding and opportunities for mutual and joint attention, active musical engagements between parents and infants may benefit from the entrainment to one another via the musical beat, and what has been described in vocal exchanges as 'tonal synchrony' (Van Puyvelde *et al*., 2010; Van Puyvelde *et al*., 2015). Thus songs, for instance through supported attending to a regular pulse, may facilitate vocal imitation and speech segmentation, an ability that by 12 months predicts later language development at 2 and 4-6 years (Newman *et al*., 2006).

Maternal education and demographic characteristics were similar in high/low musical families whereas PCERA sensitivity scores were higher in both groups with high active and high passive musical exposure, compared to low levels of home musical activities, and both high and low exposure groups presented scores at in the higher range of positivity. Finally, neither maternal education nor maternal sensitivity moderated the relationship of active and passive musical engagements with infant language development. These results suggest that the influence of home musical interactions on the shaping infant attention to sound and language outcomes are relatively independent form social influences per se and cannot be explained by other factors such as maternal sensitivity. In spite of substantial differences in the studies, the results of the present research are strikingly consistent with Weisleder and Fernald (2013),

who were able to show that in a demographically homogeneous low-SES sample, toddlers whose mothers offered a larger and richer ID-speech input displayed superior language development measures compared with infants who experienced less speech directed to them. This effect was mediated by infants' language processing efficiency. Overheard speech did not have the same effect.

The present study had limitations, which need to be addressed by further, more controlled investigations. Our sample was relatively highly educated, hence the lack of maternal education effects may not hold when having a much more diverse sample. Similarly, our participants scored all relatively high for sensitivity as measured by PCERA, hence limiting the generalizability of the results. However, it could be argued that given the relatively small sample size, the absence of large differences in education and sensitivity may support the view that any effects observed are actually due to other variables, particularly when considering the longitudinal design employed, measuring the same families when the infants were 6 and 14 months. Besides controlling for levels of musical interactions, future studies would be strengthened by quantified online measures of ID-adult speech such as those used by Weisleder and Fernald (2013), in order to evaluate the independence (or not) of musical input from speech input.

The type of informal musical experience gained by infants at home was introduced in the study as a potential factor affecting infant attention to musical sound. Since at the time of designing the study there was no information in the literature about possible effects of this type of experience in infancy, an ad-hoc questionnaire was created to monitor this variable in the sample. Therefore, the two subgroups identified, based on high/low levels of active or passive musical activities with the infants, do not have the same numerosity and the questionnaire does not provide a proper score based on psychometric properties. However, the results of this study are consistent with a substantial body of literature showing that, at later ages, musical training facilitates cognitive and language development (among others, François *et al*., 2012; Degé & Schwarzer, 2011; Moreno, Bialystok, Barac, Schellenberg, Cepeda & Chau, 2011; Strait, Parbery-Clark, Hittner & Kraus, 2012) and attendance to organised musical sessions in infancy enhances musical and social abilities (Gerry *et al*., 2012). More recently, some evidence is also emerging, which shows that at 2-3 years of age shared musical activities between parents and young children are associated with more mature neural processing of structural aspects of auditory stimuli (Putkinen, Tervaniemi & Huotilainen, 2013) and predict children language, attention, arithmetic and social abilities two years later (Williams, Barrett, Welch, Abad & Broughton, 2015). Although extremely interesting, these recent studies did not consider the beginning of the developmental path, and the assessment of the home musical engagements is based, respectively, on six and one items. In this respect, the present study is the first to show a relationship between infant exposure to home music (ID-singing in particular) and infant attention to sound and preferences at 6 months with early language development in the second year of life.

The results of this study identify a need of longitudinal investigations with larger samples in order to study more in depth the effect of early musical interactions on language development, also including online measures of linguistic input. New tools with reliable psychometric properties are needed to measure home musical engagements (Politimou, 2018; Politimou, Stewart, Müllensiefen & Franco, under review).

This research is important because we know from robust literature that advantages or disadvantages in early language development have major cascading effects on language and school readiness (e.g., Fernald, Marchman & Weisleder, 2013). Research-based practice of musical interactions may represent an integrative activity to propose in parenting support and early education contexts, and use with groups at risk or vulnerable for language development, with an increase of early musical interactions being possibly acting as a protecting factor in contexts of linguistic disadvantage.

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