Title

Infant Perception of Pitch Contour in Music and Speech

Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 45(45)

Authors
Kajikawa, Sachiyo
Yoshimura, Asami
Sawamizu, Mao

Publication Date
2023

Peer reviewed

Infant Perception of Pitch Contour in Music and Speech

Sachiyo Kajikawa (kajikawa@tamagawa.ac.jp)
College of Arts and Sciences, Tamagawa University

Asami Yoshimura (yshma6re@engs.tamagawa.ac.jp)
Brain Science Institute, Tamagawa University

Mao Sawamizu
Yamaha Music Foundation

Abstract

This study examined infants' ability to perceive changes in the pitch contour of music and speech and its developmental changes. Japanese 6- and 10-month-old infants were habituated to a five-note-melody and a five-syllable Japanese non-word and tested with both the habituated and non-habituated stimuli of different pitch contours. The infants of neither age group detected the pitch changes in the music melodies, whereas both did for speech. Infant performances in music and speech were moderately correlated among the 6-month-olds but not the 10-month-olds. These results suggest that the perception of pitch contour changes in a five-unit sound sequence has developed by 6 months of age for speech, especially in a pitch-accent language, but not music. The perception of pitch contour may be domain-general at the age of 6 months, and it may develop via two different pathways during the latter half of the first year after birth.

Keywords: developmental change; infant; melodic contour; music; perception; pitch; speech

Introduction

Pitch is an important element of both music and speech. In speech, pitch can function as accent, intonation, or lexical tone and, in some languages, such as Mandarin, it conveys semantics (Massaro et al., 1985), contributes to sentence structure (van der Burght et al., 2021), and sentence type (Frota et al., 2014), and conveys the speaker's affect (Busso et al., 2009). There is ongoing controversy surrounding the question of whether music and language processing share common neural circuitry or are independent.

The ability to process pitch develops very early in life, although not to the same level as in adults. French neonates were found to be sensitive to the pitch change of two-syllable Japanese words, which was an unfamiliar language for them (Nazzi et al., 1998). For music, 2-month-old infants discriminate between melodies of 14 tones and 5-8-month-old infants detect the change of one tone in 6-tone melodies (Plantiga & Trainor, 2009; Trehub et al., 1985).

It has been suggested that infant music perception skills are an aspect of general perceptual mechanisms that are neither music-specific nor species-specific. Universal parallel processing of auditory information, in both adults and children, might be limited by biological constraints that allow sufficient auditory information processing to meet social and communicational needs (Trehub & Hannon, 2006).

Various studies have provided support for the domain-general theory of music and speech processing, including infant studies. For example, Chen et al. (2017) tested the ability of Dutch infants to perceive the pitch contours of Chinese words and three-tone music melodies. They found that 4-month-olds were not sensitive to the changes in music and speech pitch contour, while 12-month-olds could discriminate between different pitch contours in both music and speech. This was considered indicative of domain-general pitch perception.

Based on adult studies, other theorists have suggested that the processing of musical sequences involves a cortical network comprising numerous brain structures (Koelsch et al., 2002). Aspects of this network are also thought to be involved in the processing of language. In particular, the right superior temporal gyrus is important for the processing of pitch.

The domain-general nature of the auditory processing of music and speech has also been suggested by studies on the effects of music practice on language skills. For example, musical training has been found to improve the detection of pitch changes at the end of spoken sentences in French 8-year-old children (Magne et al., 2006). In Italian-speaking adults and Italian children aged 6–8 years, melodic processing proficiency and musical expertise were found to predict a greater ability to identify lexical tones but not phonemes in Mandarin (Delogu et al., 2010). German 5-year-old children with high musical aptitudes for the discrimination of rhythms and tones showed a higher ability than those without these skills to imitate the speech of a foreign language (Christiner & Reiterer, 2018). These results demonstrate a common pitch processing mechanism in the perception of music and speech.

It has also been shown that the native language influences music perception. Peretz et al. (2011) reported that native speakers of tonal languages were unable to detect a drop in pitch contour, while speakers of non-tonal languages could. Creel (2016) compared the music processing skills of 3–5-year-old Mandarin-speaking children (a tonal language) and English-speaking children of the same age. The Chinese children showed superior performance in a musical pitch processing task but not in a musical timbre discrimination task. This suggests that the acquisition of a tonal language promotes children's processing of musical pitch, again

In M. Goldwater, F. K. Anggoro, B. K. Hayes, & D. C. Ong (Eds.), *Proceedings of the 45th Annual Conference of the Cognitive Science Society*.

supporting the domain-general processing theory of pitch perception in music and speech.

These studies revealed a relationship between music and speech processing both in children and adults. However, the developmental pathways for music and speech perception are not necessarily the same. Perceptions of both music and speech develop based on both pre-programmed neural development and synaptic connections that form in response to the experience of music or language and are strengthened by repeated exposure. These pathways predominantly develop during the first year of life. During this period, speech perception becomes attuned to the characteristics of the native language. A study of 7.5-, 9-, and 11-month-old infants raised bilingually, with exposure to both English and Chinese, found that the infants ignored pitch changes within English words but could distinguish known words presented at different pitches. They were able to recognize two familiar Chinese words presented in the same tone but also recognized false matches between words with different tones (Singh & Foong, 2012). Those bilingual infants correctly recognized pitch-matched and pitch-mismatched words in English but only correctly recognized tonal matches in Mandarin-Chinese. This reflects the learning of language-specific phonetic features. However, the processing of music by young children is thought to be addressed by the same cognitive processes responsible for the processing of non-native languages. Therefore, we posit that the relationship between music and speech processing should be reconsidered to allow for different processing mechanisms responsible for the perception of native and non-native languages.

Those opposed to domain-general theories argue that the processing of music and speech are independent functions that share some cognitive operations (Peretz, 2011). Adult speakers of non-tonal languages do not discriminate linguistic pitch patterns but can discriminate between musical pitches (Burnham et al., 2015). Based on the current understanding of syntactic processing, Patel (2011) proposed a resource-sharing framework, wherein the independent domains of music and speech share neural resources. This explains the overlap of active brain areas seen in imaging studies conducted during the processing of music and speech.

Developmental research can shed light on the question of whether music and speech processing are domain-general or domain-specific. A study of 4- and 10-month-old Japanese infants found that 4-month-olds were able to differentiate Japanese accent patterns for two-syllable words, but the lateralization of this processing to the left hemisphere was only seen in the 10-month-old infants (Sato et al., 2009). The researchers suggest that, by the age of 10 months, infants have begun to process pitch accent patterns as linguistic information; whereas, at 4 months, pitch accent patterns are interpreted using general acoustic signal processing. It could therefore be inferred that the perception of pitch contour in speech and music could develop along different pathways during the first 4–10 months of life. A behavioral study has shown that infants whose native language is English or French are unable to discriminate between Thai lexical tones by 9 months of age (Mattock & Burnham, 2006). This demonstrated that linguistic attunement to lexical-level prosody occurs between ages 6–9 months. In other words, infants whose native languages lack lexical-pitch accents learn to ignore the pitch changes within a word in accordance with their native language. Infants begin to process speech stimuli differently from other auditory stimuli following perceptual reorganization resulting from the learned distinction of language from other sounds.

The present study examined the ability of Japanese infants to perceive changes in the pitch contours of speech and music and developmental changes in this ability between ages 6 and 10 months. Here we focused on pitch accent patterns of Japanese speech in comparison with those in music. Pitch has linguistic functions and, to some extent, these differ in different languages. Pitch is an essential sentence-level cue in many languages, including English. However, it also functions as a word-level cue in Chinese, a tonal language, and Japanese, a pitch accent language. Previous studies comparing speech and language processing have primarily focused on the processing of lexical tones in tonal languages, as pitch pattern is relevant to lexical contrasts. On the other hand, the pitch accent in Japanese is based on relative differences between the pitches of syllables. In this regard, it is closer to musical melody, in which the sequence of a tune determines the height of the pitch. In lexical tone, it is the pitch change *within* a syllable that is essential. In view of this, it is worth comparing the perceptual processing of music with that of the speech of a pitch accent language.

Another component of this study is the testing of infants' ability to discriminate speech in their native language. Chen et al. (2017) tested the ability of Dutch infants to discriminate between Mandarin tones and their results supported the domain-general theory of music and speech pitch perception. However, it is unclear whether their findings can be applied to infants' perceptual processing of their native language, as the Dutch infants in their study may have been showing domain-general processing of music and Chinese because Chinese was unfamiliar to them.

In the present study, we hypothesized that the pitch contour of speech in 10-month-old Japanese infants' native language would be processed differently to the pitch contour of music. This is based on the previous finding that the processing of pitch accent patterns in Japanese infants is lateralized to the left hemisphere by the age of 10 months (Sato et al., 2009). Conversely, we hypothesize that 6-month-old Japanese infants will process music and Japanese speech in a domain-general way. In infants of this age, the phonological understanding of native vowel sounds is still developing, so language-specific perceptual processing is not yet distinct from other auditory stimuli. To test these hypotheses, we evaluated the perceptions of Japanese infants ages 6 and 10 months of five-syllable Japanese words and five-tone melodies. Responses were measured behaviorally using the habituation paradigm.

Methods

Participants

Participants were infants in two age groups: 6 months (n = 19; 7 girls and 12 boys; 6 m 5 d–7 m 30 d) and 10 months (n=24; 12 girls and 12 boys; 10 m 4 d–11 m 30 d). There were originally an additional 26 infants but they were excluded from the analysis because of fussiness or becoming bored and distracted over the course of the experiment. All the infants were healthy with no history of hearing problems and all were being raised in monolingual Japanese environments. They were recruited from the infant database of the Baby Lab of the Brain Science Institute, *** University. The study was conducted in accordance with the tenets of the 2013 revision of the Declaration of Helsinki. The experiment and the questionnaire were approved by the Ethics Committee of *** University (TRE18-011). All parents gave informed consent to their infant's participation in and publication of the study.

Stimuli

The test stimuli in this study comprised two musical sequences and two speech sounds (Figure 1).

The music stimuli were synthesized five-note melodies in piano tone (D4-E4-E4-D4-E4, DEEDE, and D4-E4-D4-D4-E4, DEDDE). There was also a control musical sequence stimulus, which was C4-A4-F4-D4-G4, CAFDG. The mean length of each note was 0.28 seconds (*SD* = 0.073, range = 0.24–0.42) and the total duration of each melody was 1.41 seconds.

The speech test stimuli were two five-syllable non-words. Both words consisted of the same Japanese phoneme: *kabutamaki*. The words were recorded in an infant-directed style by a native female Japanese speaker. The difference between the two words was in their pitch accents. The first word followed the pitch accent pattern: LHHLL, where L = low and H = high. This was pronounced with a high pitch at the second (*bu*) and third (*ta*) syllables. The second word followed the pitch accent pattern: LHLLL. This was pronounced with a high pitch at the second syllable only. The control speech stimulus was the non-word *tagumobushi* (LHHHH). The mean length of each syllable was 0.24 seconds (*SD* = 0.053, range = 0.17–0.33). The total duration of the first word (LHHLL) was 1.18 seconds and that of the second word (LHLLL) was 1.23 seconds. The average fundamental frequency was 335.75 Hz (223.15–444.98 Hz) for LHHLL and 293.79 Hz (232.29–450.70 Hz) for LHLLL.

Procedure

The experiment was conducted using the habituation procedure (Fennel, 2012). In a silent, dimly lit room, the infant sat on their parent's lap and faced a monitor covered with a black curtain such that there was a visible rectangle are of 46 x 66 cm, 2 m from the infant. The sound stimuli were presented through speakers mounted on the monitor. Beneath the monitor, in a central position, a video camera recorded the infant. The video movie was sent to a monitor and a recording device in the adjacent control room. The experimenter, who was blind to the condition of each trial and could not hear the auditory stimuli, observed the infant's looking behavior and controlled the presentation of stimuli from the control room using the Habit software program (Oakes et al., 2019). The parent wore noise-canceling headphones to prevent them from hearing the sound stimuli, and they were instructed to neither speak to the infant nor point at the monitor to direct the infant's attention during the experiment.

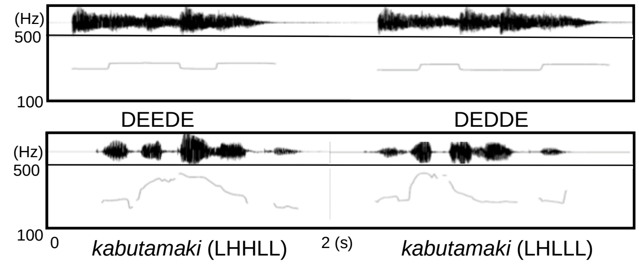

Figure 1: Pitch contours for the music (above) and speech (below) stimuli used in this study. DEEDE is a five-tone music sequence of D4-E4-E4-D4-E4, and DEDDE is D4-E4-D4-D4-E4. L= low and H = high in pitch accent.

The experiment was comprised of a music session and a speech session. A session was performed in two phases: the habituation phase and the test phase. During the habituation phase, the infant was repeatedly presented with one of the test sounds and a red-black visual checkerboard pattern simultaneously. The auditory inter-stimulus interval was 0.5 seconds. The experiment was infant-controlled so that each trial ended when the infant looked away from the monitor for two consecutive seconds. The maximum trial length was 15 seconds. The habituation phase continued until the infant's looking time per trial met the criterion (65% of the average of the first three trials).

Immediately after the habituation phase, the test phase began. The test consisted of a "same" trial in which the familiar, habituated stimulus was presented and a "switch" trial in which the novel test stimulus was presented. The test trials were also infant-controlled, and the maximum trial time was 20 seconds. At the end of the test phase, the control stimulus was presented.

The order in which the habituated (familiar) and non-habituated (unfamiliar) stimuli were presented was counterbalanced among the participants. All the infants participated in both a music session and a speech session. After the experiment, a naïve coder coded the timing of the infants' gaze on movie edit software without auditory information and the looking time for each trial was calculated for each infant. The infants whose looking time for the control stimulus was less than the average of the last three habituation trials were considered to be bored by the experiment itself and excluded from the analysis.

The parent filled out a questionnaire that asked for information on the infant's daily exposure to music and book-reading, including the approximate total time per day (in minutes) and the frequency (1: less than 2 days/week, 2: 2–3 days/ week, 3: 4–5 days/week, 4: almost every day). There were also questions about the number of productive gestures and words, temperament (smiles frequently, placid character, active behavior, and easily soothed). Each aspect of temperament was scored on a scale of 1 (disagree) to 4 (agree). Finally, the questionnaire asked parents to rate their child's interest in sounds (human voices and music) on a scale of 1 (low) to 4 (high).

Results

A two-way analysis of variance (ANOVA, IBM SPSS statistics 24), with age and condition (same or switch) as independent variables, was performed for the music sessions. This found no significant main effect for either age or condition and no significant interaction between the two (age $F[1, 41] = 2.792$, $p = 0.102$; condition $F[1, 41] = 0.236$, $p = 0.630$; interaction $F[1, 41] = 0.268$, $p = 0.607$) (Figure 2). The proportion of infants who looked longer toward the switch melody than the same melody was 63.2% in the 6-month-old group and 58.3% in the 10-month-old group.

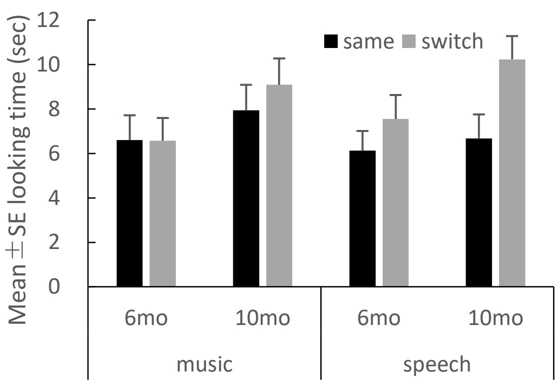

Figure 2: Mean looking times for two infant age groups in music and speech sessions. Error bars show standard errors.

A two-way ANOVA with equivalent independent variables was conducted for the speech sessions. This found main effect of the condition to be significant ($F[1, 41] = 7.118$, $p = 0.001$, $\eta^2 = 0.174$). but age and the interaction between age and condition were not significant (age $F[1, 41] = 1.844$, $p = 0.182$; interaction $F[1, 41] = 1.284$, $p = 0.264$). The infants looked significantly longer toward the switch speech stimuli than the same speech stimuli. The proportion of infants who looked longer toward the switch pattern than the same pattern was 68.4% in the 6-month-olds and 66.7% in the 10-month-olds.

The difference in looking times between the switch and same trials (difference = [looking time of switch trial]–[looking time of same trial]) showed closely a moderate positive correlation between music and speech in the 6-month-old infants ($r = 0.430$, $p = 0.066$) but no correlation in the 10-month-old infants ($r = 0.127$, $p = 0.530$).

The averages for the responses to the nine questionnaire items are shown in Table 1, with the infants categorized into two groups based on their performances. The averages for each item were compared between the infants who looked longer in the switch trial than in the same trial and those who did not for the music session and the speech sessions. There was no significant difference between the groups for any of the items.

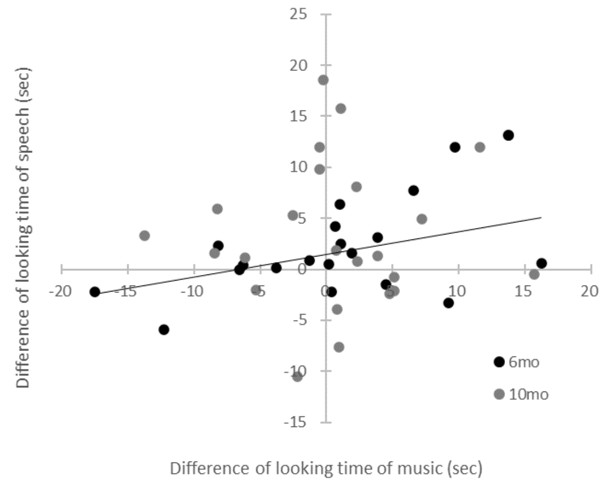

Figure 3: Scatter plots of the looking times of each infant in each age group during exposure to music and speech stimuli. The regression line is for the 6 month-old group.

Discussion

Neither the 6-month nor 10-month-old infants showed a significant difference in the time spent listening to music with the same and switch patterns. For speech, the infants in both age groups showed dishabituation to the switch pattern.

This suggests that the perception of a change in pitch contour in the middle of a five-syllable sound sequence has developed by 6 months for speech, especially Japanese speech with a pitch accent pattern, but has not yet developed for music in infants aged 10 months. Based on the proportions of infants of each age who dishabituated in the music sessions, 10-month-old infants did not perform better than 6-month-olds, although the older infants are likely to have received more musical enculturation. The frequency and time of exposure to music and book-reading were not related to infant performance in the experiment. Multiple factors, including the number of notes, the tempo, and the timbre of the music may have influenced the infants' behavioral responses. For example, the music sounds were from an electric piano, which may have been unfamiliar to some infants and this could have created an additional processing burden. Infants might also respond differently to infant-directed singing or the human voice as music stimuli, although it would be hard to make them compatible with speech stimuli. In addition, the key difference between the same and switch patterns could also have influenced the infants' performance. Previous research has found that infant processing of musical pitch is enhanced when comparative patterns are presented in

Table 1: Infant profiles showing the amount of exposure to singing, music, and book reading at home. Y denotes the infants who responded to the "switch" trial for longer than the "same" trial, N denotes the infants who did not respond to the "switch" trial for longer than the "same" trial. Freq, frequency; m, months.

		Gesture/ words	Interest voice	Interest music	Freq song	Time song	Freq music	Time music	Freq read	Time read
music										
6m	Y	0.50	3.36	2.91	3.27	12.09	3.45	39.55	2.82	8.73
	N	0.14	3.43	3.29	2.43	11.43	3.57	35.00	3.29	9.29
10m	Y	3.64	3.29	3.21	3.57	12.21	3.14	17.79	3.07	7.62
	N	1.80	3.40	3.50	3.40	7.50	3.33	34.00	2.90	10.22
speech										
6m	Y	0.31	3.31	3.00	3.15	12.92	3.54	35.77	3.00	8.92
	N	0.50	3.60	3.20	2.40	9.00	3.40	43.00	3.00	9.00
10m	Y	3.19	3.44	3.31	3.38	12.38	3.13	30.94	2.81	7.20
	N	2.25	3.13	3.38	3.75	6.00	3.38	11.75	3.38	11.86

related keys, such as a 3:2 ratio rather than in unrelated keys (Trehub, 2001).

Differences in the development of music and speech processing may be due to differing levels of exposure to these two types of auditory stimuli. Generally, infants are likely to hear speech more frequently than music and this may result in more rapid development of speech processing than music processing. If this is the case, research is needed to establish the effects of different amounts of daily exposure on infants' attunement to the key structures and features of music during the period between birth and 6 months.

A moderate correlation was found between performance in the music and speech sessions in the 6-month group but not the 10-month group. This supports the idea that the ability to detect pitch contour changes is domain-general prior to 10 months. At around 10 months, the processing of pitch contour in the native language may begin to diverge from the processing of pitch contour in music. The results of this study are inconsistent with the findings of the study by Chen et al. (2017), in which 10-month-old infants detected changes in non-native lexical tones. By around 10 months, however, speech perception has been attuned to the native language. It may be at this point that it becomes domain-specific, whereas non-native speech perception may remain subject to domain-general processing. Similarly, research suggests that infants become more attuned to the rhythms of music from their own culture. However, there is a degree of plasticity in their ability to attune to other rhythms with sufficient exposure (Hannon & Trehub, 2005).

This study was limited by the fact that the fundamental frequencies of the music and speech stimuli used were not equivalent. There was a smaller difference in pitch between the musical melodies than between the speech patterns. This meant that musical discrimination demanded greater sensitivity to the differences in fundamental frequencies and a more comprehensive working memory of precise auditory information than the discrimination of pitch accent pattern of words.

In conclusion, the current study demonstrated that the sensitivity to changes in pitch contour correlates between speech and music in 6-month-old infants who learn pitch-accented language but not in 10-month-old infants. These findings support the hypothesis that pitch contour perception develops from domain-general to domain-specific between 6 and 10 months of age.

Acknowledgments

We would like to thank the infants and their parents who participated in the study and three anonymous reviewers for their helpful comments and suggestions. This work was supported by SPS KAKENHI Grant Number 18K02457 to SK.

References

Burnham, D., Kasisopa, B., Reid, A., Luksaneeyanawin, S., Lacerda, F., Attina, V.,... & Webster, D. (2015). Universality and language-specific experience in the perception of lexical tone and pitch. *Applied Psycholinguistics*, 36(6), 1459-1491.

Busso, C., Lee, S., & Narayanan, S. (2009). Analysis of emotionally salient aspects of fundamental frequency for emotion detection. *IEEE Transactions on Audio, Speech, and Language Processing*, 17(4), 582-596.

Chen, A., Stevens, C. J., & Kager, R. (2017). Pitch perception in the first year of life, a comparison of lexical tones and musical pitch. *Frontiers in Psychology*, 8, 297.

Christiner, M., & Reiterer, S. M. (2018). Early influence of musical abilities and working memory on speech imitation abilities: study with pre-school children. *Brain Sciences*, 8(9), 169.

Creel, S. C., Weng, M., Fu, G., Heyman, G. D., & Lee, K. (2018). Speaking a tone language enhances musical pitch perception in 3–5-year-olds. *Developmental Science*, 21(1), e12503.

Dehaene-Lambertz, G., Dehaene, S., & Hertz-Pannier, L. (2002). Functional neuroimaging of speech perception in infants. *Science*, 298(5600), 2013-2015.

Delogu, F., Lampis, G., & Belardinelli, M. O. (2010). From melody to lexical tone: Musical ability enhances specific aspects of foreign language perception. *European Journal of Cognitive Psychology*, 22(1), 46-61.

Fennell, C. T. (2012). Habituation procedures. *Research methods in child language: A practical guide*, 1-16.

Frota, S., Butler, J., & Vigário, M. (2014). Infants' perception of intonation: Is it a statement or a question? *Infancy*, 19(2), 194-213.

Hannon, E. E., & Trehub, S. E. (2005). Tuning in to musical rhythms: Infants learn more readily than adults. *Proceedings of the National Academy of Sciences of the United States of America*, 102(35), 12639-12643.

Koelsch, S., Gunter, T. C., Cramon, D. Y. V., Zysset, S., Lohmann, G., & Friederici, A. D. (2002). Bach speaks: A cortical "language-network" serves the processing of music. *Neuroimage*, 17(2), 956-966.

Magne, C., Schön, D., & Besson, M. (2006). Musician children detect pitch violations in both music and language better than nonmusician children: Behavioral and electrophysiological approaches. *Journal of Cognitive Neuroscience*, 18(2), 199-211.

Massaro, D. W., Cohen, M. M., & Tseng, C. Y. (1985). The evaluation and integration of pitch height and pitch contour in lexical tone perception in Mandarin Chinese. *Journal of Chinese Linguistics*, 267-289.

Mattock, K., & Burnham, D. (2006). Chinese and English infants' tone perception: Evidence for perceptual reorganization. *Infancy*, 10(3), 241-265.

Oakes, L. M., Sperka, D., DeBolt, M. C., & Cantrell, L. M. (2019). Habit2: A stand-alone software solution for presenting stimuli and recording infant looking times in order to study infant development. *Behavior Research Methods*, 51(5), 1943-1952.

Nazzi, T., Floccia, C., & Bertoncini, J. (1998). Discrimination of pitch contours by neonates. *Infant Behavior and Development*, 21(4), 779-784.

Patel, A. D. (2011). Language, music, and the brain: A resource-sharing framework. *Language and Music as Cognitive Systems*, 204-223.

Perani, D., Saccuman, M. C., Scifo, P., Spada, D., Andreolli, G., Rovelli, R.,... & Koelsch, S. (2010). Functional specializations for music processing in the human newborn brain. *Proceedings of the National Academy of Sciences of the United States of America*, 107(10), 4758-4763.

Peretz, I. (2011). Music, language, and modularity in action. *Language and Music as Cognitive Systems*, 254-268.

Peretz, I., Nguyen, S., & Cummings, S. (2011). Tone language fluency impairs pitch discrimination. *Frontiers in Psychology*, 2, 145.

Plantinga, J., & Trainor, L. J. (2009). Melody recognition by two-month-old infants. T*he Journal of the Acoustical Society of America*, 125(2), EL58-EL62.

Sato, Y., Sogabe, Y., & Mazuka, R. (2010). Development of hemispheric specialization for lexical pitch–accent in Japanese infants. Journal of Cognitive Neuroscience, 22(11), 2503-2513.

Singh, L., & Foong, J. (2012). Influences of lexical tone and pitch on word recognition in bilingual infants. *Cognition*, 124(2), 128-142.

Trehub, S. E. (2001). Musical predispositions in infancy. *Annals of the New York Academy of Sciences*, 930(1), 1-16.

Trehub, S. E., Thorpe, L. A., & Morrongiello, B. A. (1985). Infants' perception of melodies: Changes in a single tone. *Infant Behavior and Development*, 8(2), 213-223.

Trehub, S. E., & Hannon, E. E. (2006). Infant music perception: Domain-general or domain-specific mechanisms? *Cognition*, 100(1), 73-99.

van der Burght, C. L., Friederici, A. D., Goucha, T., & Hartwigsen, G. (2021). Pitch accents create dissociable syntactic and semantic expectations during sentence processing. *Cognition*, 212, 104702.