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Enhanced Processing of Vocal Melodies in Childhood

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Music cognition is typically studied with instrumental stimuli. Adults remember melodies better, however, when they are presented in a biologically significant timbre (i.e., the human voice) than in various instrumental timbres (Weiss, Trehub, & Schellenberg, 2012). We examined the impact of vocal timbre on children's processing of melodies. In Study 1, 9- to 11-year-olds listened to 16 unfamiliar folk melodies (4 each of voice, piano, banjo, or marimba). They subsequently listened to the same melodies and 16 timbre-matched foils, and judged whether each melody was old or new. Vocal melodies were recognized better than instrumental melodies, which did not differ from one another, and the vocal advantage was consistent across age. In Study 2, 5- to 6-year-olds and 7- to 8-year-olds were tested with a simplified design that included only vocal and piano melodies. Both age groups successfully differentiated old from new melodies, but memory was more accurate for the older group. The older children recognized vocal melodies better than piano melodies, whereas the younger children tended to label vocal melodies as old whether they were old or new. The results provide the first evidence of differential processing of vocal and instrumental melodies in childhood.

Keywords: development, melody, memory, timbre, voice

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The human voice is highly salient from the earliest stages of life. Newborn infants prefer their mother's voice to other voices (DeCasper & Fifer, 1980; Hepper, Scott, & Shahidullah, 1993; Smith, Dmochowski, Muir, & Kisilevsky, 2007) and speech syllables to sine-wave analogues (Vouloumanos & Werker, 2007). By 3 months of age, infants prefer speech syllables to appetitive monkey vocalizations (Vouloumanos, Hauser, Werker, & Martin, 2010) and to human nonspeech vocalizations such as coughs and sneezes (Shultz & Vouloumanos, 2010). Human vocalizations also elicit distinctive activation patterns in the infant brain (Blasi et al., 2011; Grossmann, Oberecker, Koch, & Friederici, 2010), in line with putative voice-specific areas in the adult brain (Belin, Zatorre, & Ahad, 2002). Unquestionably, the human voice has biological as well as social significance for human listeners, which makes it difficult to separate the consequences of familiarity from other factors (Poremba, Bigelow, & Rossi, 2013).

Vocal stimuli are also ubiquitous in music. The voice, most likely the original musical instrument (Mithen, 2005), dominates music in cultures with real and digital instruments. For example, caregivers throughout the world sing to infants to regulate arousal and promote infant bonding (Trehub & Trainor, 1998). When adults speak to infants, their pitch patterning and tempo have more in common with singing than with conventional adult-directed speech (Corbeil, Trehub, & Peretz, 2013). In fact, the musical aspects of speech may underlie its salience for preverbal infants (Fernald, 1992), paving the way for language acquisition (Brandt, Gebrian, & Slevc, 2012).

The memorability of melodies allows them to be used as mnemonic tools (Calvert & Tart, 1993; Calvert, 2001). In oral cultures, songs and poems serve as a repository of knowledge transmitted across generations (Rubin, 1997). Although memory for spoken passages declines over brief delays, there is little decline for passages of metrical poetry (Tillmann & Dowling, 2007) or music (Dowling, Tillman, & Ayers, 2001). Songs also facilitate children's acquisition of culturally relevant information such as the alphabet (*ABC Song*) or numbers (e.g., counting songs), with repetition enhancing recall of lyrics after long delays (Calvert & Tart, 1993). As with adults, children have better verbatim recall of sung or recited nursery rhymes than spoken prose, but their recall of the meaning or gist is better for prose passages than for song lyrics (Johnson & Hayes, 1987). Nevertheless, children's memory for sung or recited material remains available for future consultation, as when using the *ABC Song* to learn alphabetical order. Interestingly, alphabetic knowledge in 2- to 7-year-olds enhances sound knowledge, word knowledge, and writing (Worden & Boettcher, 1990). Songs also enhance infants' memory for phonetic detail. For example, 11-month-olds more readily detect a change in syllable order when four-syllable sequences are sung rather than spoken (Lebedeva & Kuhl, 2010).

Despite the significance of vocal music for human listeners, its use in studies of music cognition has been limited. Musical timbre—the sound quality that distinguishes different instruments and voices from one another—is considered relevant to aesthetic considerations but not to fundamental cognitive processes such as

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memory. As a result, timbre selection is typically based on ease of control and use, which favors synthesized instrumental timbres over voices. Recent evidence indicates, however, that adults remember melodies better when presented vocally (sung to *la la*) rather than instrumentally (Weiss, Trehub, & Schellenberg, 2012). Here we asked whether children exhibit similar processing advantages for vocal melodies.

According to Dynamic Systems Theory (Thelen & Smith, 2006), behavior is the product of multiple processes that mature at different rates. Adults' vocal-recognition advantage may arise from several interacting processes, including a biologically based preference for the human voice, implicit knowledge of musical conventions, memory capacity, and learning strategies. Despite lifelong processing advantages for human vocalizations, developmental changes in other systems could result in age-related differences in memory for vocal and instrumental melodies.

The acquisition of implicit musical knowledge begins in infancy (Hannon & Trehub, 2005) and continues through adolescence (Trainor & Hannon, 2013). Such knowledge affects memory for music, as evidenced by adults' poor memory for musical material that is foreign (Demorest, Morrison, Beken, & Jungbluth, 2008; Gardiner & Radomski, 1999) or violates Western tonal conventions (Dowling, Kwak, & Andrews, 1995). By 4 or 5 years of age, children notice out-of-key notes in a novel melody (Corrigall & Trainor, 2010; Trainor & Trehub, 1994), but even 5th and 6th graders do not exhibit adult-like knowledge of the relative stability of notes in a musical key (Krumhansl & Keil, 1982). Although 8-year-olds demonstrate knowledge of the harmonies (simultaneous combinations of notes) implied by a novel Western melody, 5-year-olds do not (Trainor & Trehub, 1994). There are also notable changes from 5 to 11 years of age in the reliance on absolute or relational cues when judging the similarity of two melodies (Stalinski & Schellenberg, 2010). Relational information becomes increasingly important with greater maturity and musical exposure. Moreover, the ubiquitous Western preference for tone combinations that are consonant rather than dissonant (Butler & Daston, 1968) is influenced by exposure (McLachlan, Marco, Light, & Wilson, 2013), appearing at about 9 years of age in children without musical training (Valentine, 1962).

Age-related changes are also evident in the understanding of emotions conveyed by music. For example, 5-year-olds are insensitive to the emotional implications of the major-minor distinction in Western tonal melodies (Dalla Bella, Peretz, Rousseau, & Gosselin, 2001), with such sensitivity improving until 11 years of age (Dalla Bella et al., 2001; Hunter, Schellenberg, & Stalinski, 2011). In short, melody processing undergoes considerable change during middle childhood. Because implicit musical knowledge affects the distinctiveness and memorability of melodies (Dowling et al., 1995; Gardiner & Radomski, 1999), young children are likely to have weaker item-specific representations of melodies than older children.

Changing memory capacity could also affect children's processing of vocal and instrumental melodies. By 4 years of age, children exhibit some evidence of episodic memory (Souchay, Guillery-Girard, Pauly-Takacs, Wojcik, & Eustache, 2013), which improves in tandem with executive functioning, the ability to recall the source of remembered events, and the ability to bind details of events (Picard, Cousin, Guillery-Girard, Eustache, & Piolino, 2012; Raj & Bell, 2010). For example, differences in the binding of visual features are apparent between 4-year-olds and 6- to 7-year-olds (Sluzenski, Newcombe, & Kovacs, 2006; Yim, Dennis, & Sloutsky, 2013), between 7- to 8-year-olds and adults (Cycowicz, Friedman, Snodgrass, & Duff, 2001), and among 9- to 10-year-olds, 12- to 13-year-olds, and adults (de Chastelaine, Friedman, & Cycowicz, 2007).

These developing aspects of episodic memory suggest qualitative as well as quantitative differences between younger and older children in the reliability of memories. From a Dynamic Systems perspective (Thelen & Smith, 2006), developmental changes in episodic memory may interact in multiple ways with developmental changes in implicit musical knowledge and with differences in the relative salience of vocal and instrumental music. Consequently, children's memory for melodies, including the influence of vocal and instrumental timbres, could differ substantially from that of adults.

In Study 1, we exposed children 9–11 years of age to unfamiliar folk melodies in one of four timbres—voice, piano, banjo, and marimba—and subsequently tested their ability to distinguish the previously heard melodies from foils. In Study 2, we simplified the task for 5- to 8-year-old children by the use of two timbres: voice and piano. These studies allowed us to search for differential processing of vocal and instrumental melodies across a wide age range.

Study 1

We examined 9- to 11-year-old children's memory for vocal and instrumental melodies with a child-friendly version of the task used by Weiss et al. (2012), which was presented as a music-listening game with a cartoon owl. Children were exposed to 16 melodies, four each in vocal, piano, banjo, and marimba timbres. In the test phase, they heard the original 16 melodies and 16 novel melodies in the same timbres, and they were required to judge whether each was old (i.e., heard before) or new. In line with age-related changes in memory (Gathercole, 1998; Kron-Sperl, Schneider, & Hasselhorn, 2008) and implicit musical knowledge (Trainor & Hannon, 2013), we expected better memory for melodies in older than in younger children. Because of the importance of vocal music for children, we also expected an advantage for vocal melodies.

Method

Participants. Children were recruited from a laboratory database of volunteer families who previously indicated their interest in participating in research on child development. There were 48 children, 16 in each age group of 9-year-olds (M = 9.63 years, SD = 0.26; 4 girls, 12 boys), 10-year-olds (M = 10.50, SD = 0.34; 8 girls, 8 boys), and 11-year-olds (M = 11.52, SD = 0.27; 5 girls, 11 boys), recruited without regard to gender or years of formal music lessons (M = 1.56 years, SD = 1.99, median = 1, range 0–8). Children were healthy and had normal hearing, according to parental report. Four additional children were excluded from the final sample because of technical difficulties (n = 3) or experimenter error (n = 1). Children received a gift certificate for their participation commensurate with the length of the test session.

Apparatus and stimuli. Participants were tested individually in a double-walled sound-attenuating booth (Industrial Acoustics

Co.) using an iMac computer and high-quality headphones (Sony MDR-NC6). Custom-made software created with PsyScript (version 2.3; Slavin, 2007) presented stimuli and recorded responses. The stimuli were 32 British and Irish folk melodies from Weiss et al. (2012). All melodies were unfamiliar but in a familiar (Western) musical style and 13–19 s in duration. The melodies varied in metrical structure (meters of 3/4, 4/4, 6/8), tempo (100–130 beats per min), mode (major/minor), and number of notes (20–57). An amateur female singer produced the vocal renditions, singing the repeated syllable *la* instead of words. Small deviations from exact pitch and time values were pitch-corrected and quantized with Melodyne software (Celemony Software). MIDI (Musical Instrument Digital Interface) data generated from each sung melody were used to create digital piano, banjo, and marimba instrumental renditions, preserving features of sung melodies such as note onset and overall note amplitude. Sample melodies are provided in Supplemental Materials. Digital instruments were built from third-party single-note audio packs (Big Fish Audio) using the ESX sampler in Logic (Apple). Root-mean-square (RMS) amplitudes of melodies were normalized to eliminate overall differences in loudness. In previous research, adults performed no differently on these MIDI versions than on actual instrumental performances of the same melodies (Weiss et al., 2012). Song files were exported and saved as uncompressed audio files.

Procedure. The experimenter explained the procedure to parent and child, noting the types of questions that would be asked (i.e., liking and memory), but there was no emphasis on memory, and the comparison of interest—vocal versus instrumental timbres—was not mentioned until after the test session. During the session, the experimenter remained in the booth with the child but could not hear the stimuli. The task, consisting of an exposure phase and test phase, was presented as a series of music games hosted by Tito, a cartoon owl. Before each phase, the experimenter demonstrated the procedure. In the exposure phase, children heard each of 16 target melodies (four in each timbre) twice. Assignment of melodies to timbres was counterbalanced using a modified Latin square design with eight conditions (following Weiss et al., 2012). The counterbalancing ensured that each melody was heard equally often as target or foil in each of the four timbres so that potential differences in memorability would not influence response patterns. Melodies were presented in two blocks, with the melodies ordered randomly within blocks. Children rated how much they liked each melody on a 5-point scale by pointing to pictures of ice cream cones of increasing size so that Tito the owl could choose songs for a forthcoming party.

During a 5-min break after the exposure phase, children played a word-search game. In the subsequent recognition phase, children heard all 32 melodies, with order randomized separately for each child. Half of the melodies had been heard previously (targets) and half were new (foils). After each presentation, children were asked whether they had heard the melody before (i.e., "Did Tito play this song before?"). They responded by pointing to one of two buttons ("Yes" or "No") on the monitor. The entire procedure lasted approximately 40 min.

Results and Discussion

The principal analyses determined whether children remembered melodies from the exposure phase and whether memory differed as a function of timbre and age. Preliminary analyses revealed no effects of gender, so gender was not considered further. We calculated eight scores for each child, two for each of the four timbres: the percentage of targets correctly identified as old (hits) and the percentage of foils mistakenly labeled as old (false alarms). Memory was operationalized as hits minus false alarms yielding a positive value (see Figures 1, 2, and 3). We compared percentages of "old" responses with a three-way mixed-design analysis of variance (ANOVA), with timbre (voice, piano, banjo, marimba) and exposure (old, new) as repeated measures and age (9, 10, 11) as a between-subjects variable. There was a robust main effect of exposure, $F(1, 45) = 305.30$, $p < .001$, partial $\eta^2 = .87$, indicating that children successfully differentiated target melodies from foils. A two-way interaction between exposure and age, $F(2, 45) = 4.80$, $p = .013$, partial $\eta^2 = .18$, reflected age-related variation in differentiating target melodies from foils (see Figure 1). Calculated as difference scores between hits and false alarms, recognition memory was better (i.e., larger difference) for 10- and 11-year-olds than for 9-year-olds, *p*s $< .05$, but the two older groups did not differ from one another, $p > .8$. (Pairwise comparisons were corrected for multiple tests using the Holm-Bonferroni method in this and all subsequent analyses.)

A main effect of timbre, $F(3, 135) = 4.75$, $p = .004$, partial $\eta^2 = .10$, was qualified by an interaction between exposure and timbre, $F(3, 135) = 5.83$, $p < .001$, partial $\eta^2 = .11$ (see Figure 2). This interaction was explored by comparing the magnitude of hits minus false alarms for the four different timbres. Children's memory (hits minus false alarms) was more accurate (i.e., greater positive difference) for vocal melodies than for instrumental melodies, *p*s $< .05$, but memory did not differ across the three instrumental timbres, *p*s $> .9$. The lack of a three-way interaction, $p > .2$, indicated a comparable memory advantage for the voice across age groups. In short, children 9–11 years of age remembered vocal melodies better than instrumental melodies.

A secondary analysis examined differences in liking across the four timbres by considering children's ratings on the 5-point ice-cream-cone scale during exposure. Four liking scores, aver-

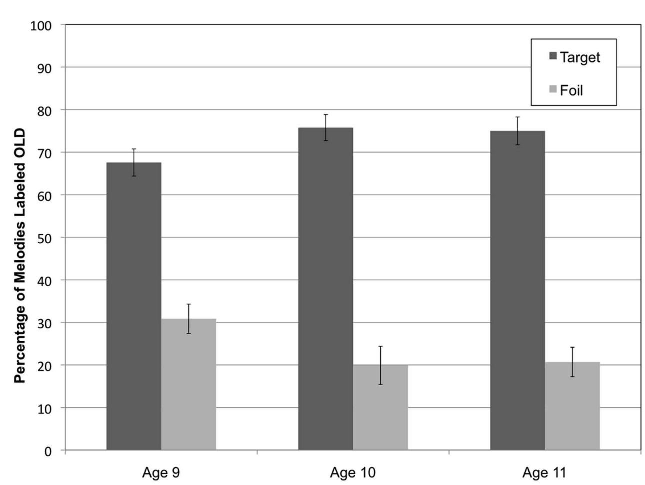

Figure 1. Mean percentage of old responses in Study 1 as a function of age and whether the melodies were old (targets) or new (foils). Error bars are standard errors of the mean.

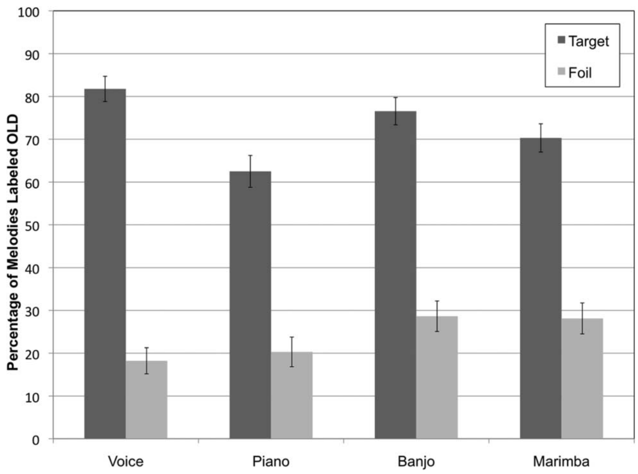

Figure 2. Mean percentage of old responses in Study 1 as a function of timbre and whether the melodies were old (targets) or new (foils). Error bars are standard errors of the mean.

aged separately for each timbre, were calculated for each child from eight original responses (four melodies in each timbre presented twice). A mixed-design ANOVA with timbre as a repeated measure and age group as a between-subjects variable revealed a main effect of timbre, $F(3, 135) = 15.91$, $p < .001$, partial $\eta^2 = .26$, but no main effect of age and no two-way interaction, Fs < 1. Pairwise comparisons of individual timbres revealed lower levels of liking for the voice ($M = 2.42$, $SD = 0.99$) than for the piano ($M = 3.41$, $SD = 0.73$), banjo ($M = 3.08$, $SD = 0.96$), or marimba ($M = 3.23$, $SD = 0.92$), ps $< .005$. No comparisons between instrumental timbres reached significance, ps $> .09$. These results replicate adults' pattern of liking for the same vocal and instrumental melodies (Weiss et al., 2012). Item analyses examined whether liking or disliking melodies was associated with their memorability. The correlation between average liking and recognition for each melody was positive but only marginally significant, $r(N = 32) = .33$, $p = .07$, and thus cannot explain better recognition but lower liking ratings for the voice than for the instruments.

In sum, children 9 to 11 years of age showed excellent differentiation of old and new melodies and a memory advantage for vocal over instrumental melodies, consistent with previous adult findings (Weiss et al., 2012). As with adults, recognition accuracy for the voice was not a consequence of differential preferences. Although 10- and 11-year-olds outperformed 9-year-olds in overall recognition accuracy, the magnitude of the voice advantage did not change with age. Important developmental changes in memory capacity and implicit musical knowledge motivated our consideration of younger children in Study 2.

Study 2

In Study 2, we examined memory for vocal and instrumental melodies in 5- to 8-year-old children. If these children have pronounced listening biases for vocalizations, as infants do (Vouloumanos & Werker, 2007), they might exhibit a greater vocal advantage than older children. Immature mnemonic strategies (e.g., Souchay, Guillery-Girard, Pauly-Takacs, Wojcik, & Eustache, 2013) could also decrease or obliterate the advantage. For example, young children's difficulty remembering contextual factors at encoding (Brainerd, Aydin, & Reyna, 2012; Pirogovsky, Gilbert, & Murphy, 2006) in conjunction with a vocal listening bias might make unfamiliar vocal melodies seem familiar. On the basis of changes in implicit musical knowledge that are evident at 7 years of age (Krumhansl & Keil, 1982; Trainor & Trehub, 1994), we expected children 7 and older to have better memory for melodies than younger children.

We used two timbres—voice and piano—instead of the four timbres used previously. In Study 1 (also Weiss et al., 2012), instrumental timbres had no differential effects on memory despite listeners' greater familiarity with piano than with banjo or marimba sounds. Limiting the design to two timbres allowed us to increase the number of vocal and piano melodies and hence the statistical power for evaluating a voice advantage. Children were exposed to 16 melodies, eight vocal and eight in piano timbre, and tested with 32 melodies, half novel, half old. We expected age-related improvement in memory for melodies, with the possibility of qualitative and quantitative changes in recognition based on timbre.

Method

Participants. Children were recruited from a database of volunteer families, as in Study 1. The participants were 80 healthy children with normal hearing (according to parental report): forty 5- to 6-year-olds ($M = 6.06$ years, $SD = 0.64$; 19 girls, 21 boys) and forty 7- to 8-year-olds ($M = 8.05$, $SD = 0.60$; 20 girls, 20 boys) recruited without regard to gender or years of formal music lessons ($M = 0.89$ years, $SD = 1.43$, median $= 0$, range $= 0–6$). Age groups were broader (2 years) than in Study 1 (1 year), because changes in component processes (memory capacity, implicit musical knowledge) during this age range were expected to generate large individual differences in melodic memory, potentially obscuring patterns of developmental change. An additional 24 children were excluded from the final sample because of perseverative responding (i.e., responding identically on long strings of successive trials). A chi-square test of independence confirmed that such perseveration was more common for younger children (5–6 years: $n = 19$) than for older children (7–8 years: $n = 5$), $\chi^2(1, N = 104) = 6.40$, $p = .011$. Six additional children were excluded because of technical errors ($n = 3$), refusing to wear headphones ($n = 1$), or insisting on parents' presence in the test booth ($n = 2$). Children received a toy for their participation.

Apparatus and stimuli. The apparatus was the same as in Study 1. The stimuli were the same 32 melodies from Study 1 but with vocal and piano timbres only. Unlike the MIDI-generated piano melodies from Study 1, the piano melodies in the present study (also from Weiss et al., 2012) were performed on a real piano so that vocal and piano melodies were real rather than MIDI versions. This change was motivated by the reduction from four timbres (Study 1) to two and the goal of matching vocal and piano renditions for naturalness. Sample melodies are provided in Supplemental Materials. As noted, however, Weiss et al. (2012) found no evidence of performance differences for real or MIDI instrumental melodies. As in Study 1, all melodies were amplitude normalized and presented as uncompressed audio files, and stim-

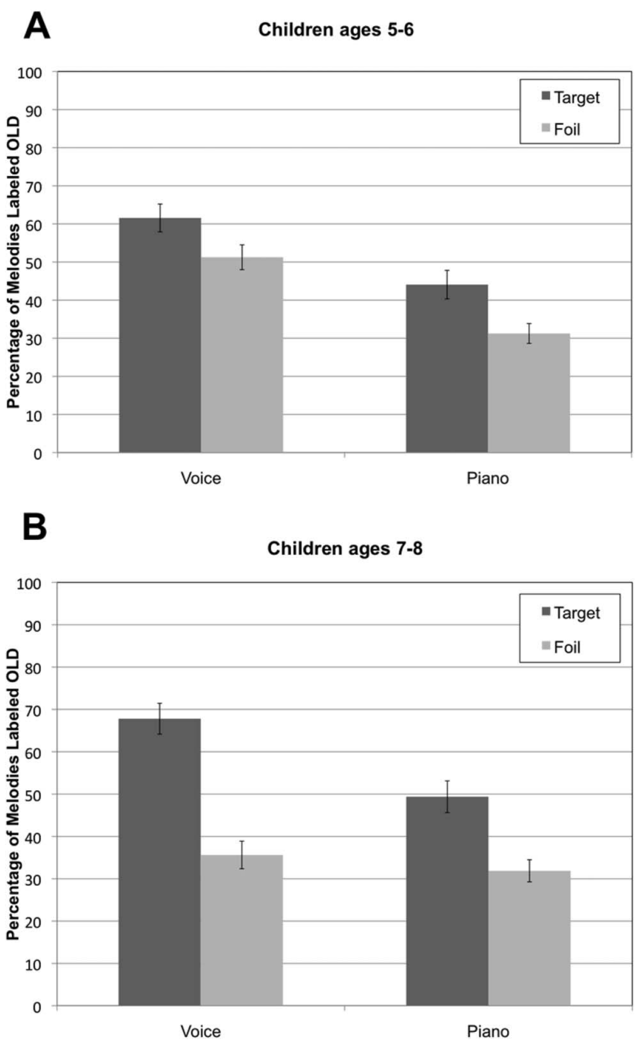

Figure 3. Mean percentage of old responses in Study 2 as a function of timbre and whether the melodies were old (targets) or new (foils) for 5- to 6-year-old children (A) and 7- to 8-year-old children (B). Error bars are standard errors of the mean.

ulus presentation and response recording were controlled by customized software created with PsyScript.

Procedure. As in Study 1, the procedure involved an exposure phase with liking ratings, a short break, and a memory test. Similarly, the general design (i.e., liking and memory questions in response to melodies) was explained to parents and children before the test session. To reduce test duration (from 40 to 30 min), children received a single exposure of each melody rather than two. Reduced test duration was motivated by previous research with 5- and 6-year-olds that revealed inattention or perseverative responding for test sessions exceeding 30 min (Hunter et al., 2011; Trainor & Trehub, 1994). Reducing exposure rather than the number of melodies preserved statistical power while increasing task difficulty, precluding direct comparisons with Study 1. Children first heard 16 different melodies (8 vocal, 8 piano) in random order and were tested with the same 16 targets plus 16 foils (8 vocal, 8 piano) in random order. Assignment of melodies to voice or piano and target or foil was randomized for each child.

Results and Discussion

The principal analyses tested whether memory for melodies varied with age and timbre. Preliminary analyses revealed no effects of gender, which was not considered further. For each participant, four scores were calculated: the percentage of previously heard vocal and piano melodies correctly identified as old (i.e., hits), and the percentage of vocal and piano foils mistakenly labeled as old (i.e., false alarms). A three-way mixed-design ANOVA with timbre (voice, piano) and exposure level (old, new) as repeated measures and age group (5–6 years, 7–8 years) as a between-subjects variable revealed a significant three-way interaction among exposure level, timbre, and age group, $F(1, 78) = 5.19$, $p = .025$, partial $\eta^2 = .06$, which motivated separate analyses of younger and older groups.

A two-way ANOVA for 5- to 6-year-olds, with exposure (old, new) and timbre (voice, piano) as repeated measures, revealed significant main effects of exposure, $F(1, 39) = 18.73$, $p < .001$, partial $\eta^2 = .32$, and timbre, $F(1, 39) = 22.15$, $p < .001$, partial $\eta^2 = .36$, but no two-way interaction, $F < 1$ (Figure 3A). Although younger children differentiated target melodies from foils, they were biased to designate vocal melodies as old (familiar) whether they had been heard before (targets) or not (foils). A comparable ANOVA for 7- to 8-year-olds revealed a significant two-way interaction between exposure and timbre, $F(1, 39) = 7.93$, $p = .008$, partial $\eta^2 = .17$ (Figure 3B). Follow-up tests revealed that target melodies and foils were differentiated in both timbres, with significantly better performance for vocal melodies, $t(39) = 7.85$, $p < .001$, than for piano melodies, $t(39) = 4.49$, $p < .001$.

In short, both age groups remembered the target melodies, and both groups showed a voice effect of some kind. Younger children considered vocal melodies more familiar than piano melodies whether or not they were heard previously. Older children's recognition was enhanced for previously heard vocal melodies, as it was for 9- to 11-year-old children in Study 1 and for adults in a previous study (Weiss et al., 2012).

The next analysis examined differences in liking between timbres. Liking responses during the exposure phase were derived from the 5-point ice-cream-cone scale. Two liking scores were calculated for each child: average liking ratings for the eight sung melodies and for the eight piano melodies. A mixed-design ANOVA with timbre as a repeated measure and age groups as a between-subjects variable revealed a main effect of timbre, $F(1, 78) = 25.42$, $p < .001$, partial $\eta^2 = .25$, with lower ratings for the voice ($M = 3.23$, $SD = 0.96$) than for the piano ($M = 3.84$, $SD = 0.75$). There was no main effect of age, $F < 1$, and no interaction between age and timbre, $F < 1$. Although younger and older children liked piano melodies more than vocal melodies, item analyses revealed that liking ratings were not correlated with recognition for either the younger or the older children, $ps > .4$.

The results provide evidence that recognition processes in young children (ages 5–6) are affected by the voice without generating a voice advantage. Inherently amplified attention to the voice may generate feelings of familiarity and the observed response bias. In any event, the findings reveal that the memory advantage for vocal melodies, as measured here, emerges between 6 and 7 years of age.

General Discussion

Children 9 to 11 years of age who were exposed to novel vocal, piano, banjo, and marimba melodies subsequently recognized the vocal melodies better than the instrumental melodies (Study 1), like adults do (Weiss et al., 2012). Melodic memory was also better for 10- and 11-year-olds than for 9-year-olds, just as memory for nonmusical materials improves with age (Picard et al., 2012; Yim et al., 2013), but the magnitude of the voice advantage did not change with age. Liking did not account for the observed vocal advantage because children liked the vocal versions less than the instrumental versions, perhaps because of the repeated syllable *la* instead of conventional lyrics.

Children 5 to 8 years of age who were exposed to vocal and piano melodies also differentiated the target melodies from foils at above-chance levels (Study 2). The 7- to 8-year-olds exhibited a memory advantage for vocal melodies, but younger children did not. Instead, younger children had higher false-alarm rates for vocal than for piano melodies—mistakenly designating them as old when heard for the first time—perhaps reflecting feelings of familiarity for vocal melodies despite their unusual rendering without words. As with older children in Study 1, 5- to 8-year-olds rated vocal melodies less favorably than instrumental melodies. In general, greater perceptual fluency generates more positive evaluations of stimuli (Reber, Winkielman, & Schwarz, 1998). For music, familiarity increases liking (Schellenberg, Peretz, & Vieillard, 2008; Szpunar, Schellenberg, & Pliner, 2004), so 5- to 6-year-olds' higher familiarity judgments for novel vocal than novel instrumental melodies is at odds with their lower liking ratings of vocal melodies. Because of their difficulty encoding contextual details at exposure (Brainerd et al., 2012; Pirogovsky et al., 2006), they may misinterpret altered arousal to vocal melodies as familiarity.

The present investigation provides the first evidence that children's memory for music is influenced by a biologically significant timbre, the voice, although the consequences differ for younger and older children. Vocal materials may evoke automatic increases in attention and arousal, generating greater depth of processing (Craik & Lockhart, 1972). Increased attention or arousal to vocal sounds could arise from specialized neural responses (Belin et al., 2002; Lévêque & Schön, 2013) or from subvocal premotor responses (Lévêque, Muggleton, Stewart, & Schön, 2013). These mechanisms could enhance memory for children 7 years of age or older. For younger children, the same mechanisms could enhance perceptual fluency, resulting in a mistaken sense of familiarity and consequent interference with memory processes. Younger children's immature episodic (Picard et al., 2012; Raj & Bell, 2010) and source memory (Foley, 2014; Roberts, 2002) and their limited implicit knowledge of music (Trainor & Hannon, 2013; Trainor & Trehub, 1994) are also likely to be implicated.

Different methods are likely to be necessary for identifying the mechanisms underlying the vocal memory advantage in children and adults (Weiss et al., 2012). For example, physiological indexes of attention and processing difficulty, such as pupil dilation (Goldinger & Papesh, 2012), may prove useful because of their applicability to young children. Dynamic changes in the vocal signal, including natural pitch and amplitude fluctuations, may also elicit increased attention compared to instrumental timbres with less pitch and amplitude variation, a hypothesis that could be evaluated with electronic manipulations of vocal and instrumental timbres.

The current investigation does not provide definitive evidence that species-specific differences in signal processing underlie the vocal melody advantage. Nevertheless, it encourages the pursuit of this question, perhaps by including other vocal timbres—for example, male as well as female voices—and instrumental timbres with more voice-like properties. Gender of singer could affect memory for melodies, especially with younger children who have greater exposure to female voices (Trehub et al., 1997; Vongpaisal, Trehub, Schellenberg, van Lieshout, & Papsin, 2010). The current timbres were selected to vary in familiarity (decreasing familiarity for voice, piano, banjo, and marimba), amplitude envelope (slow onset and variable amplitude for the voice; rapid onset and low amplitude variability for the instruments), and pitch fluctuation within notes (greater for vocal than instrumental timbres). Because instruments such as the violin and saxophone have some of the acoustic dynamics of the voice (e.g., variable amplitude envelope), a memory advantage for vocal over violin or saxophone timbres would add support to the notion that biologically based signal processes rather than signal dynamics are implicated.

The current results also reveal age-related improvement in the ability to distinguish recently heard melodies from novel melodies, which is consistent with developmental changes in episodic memory (Picard et al., 2012; Yim et al., 2013). The stimulus melodies may have exacerbated young children's difficulties because they were drawn from a common genre—British and Irish folk songs—sharing similarities in style (e.g., Western tonality, major or minor modes, simple metrical structures) despite differences in detail. Because novel stimuli that are similar to those experienced previously increase the incidence of false recognition (Brainerd, Reyna, Wright, & Mojardin, 2003), the use of more distinctive melodies could generate better recognition.

Single exposure to the melodies in Study 2, in contrast to two exposures in Study 1, may have been particularly disadvantageous for the youngest children. Keeping the duration of test sessions within manageable limits may necessitate reduction in the number of melodies and increased exposure for younger children. Altering task difficulty is likely to affect performance, but the critical issue is the voice advantage. As a practical matter, young children's familiarity bias for vocal melodies may facilitate learning of song melodies and words.

Finally, our finding of differential cognitive processing of vocal and nonvocal melodies in childhood calls into question the almost exclusive use of instrumental music in studies of children's perception of musical structure (Corrigall & Trainor, 2010; Hannon & Trehub, 2005; Krumhansl & Keil, 1982; Stalinski & Schellenberg, 2010; Trainor & Trehub, 1994) and its emotional implications (Dalla Bella et al., 2001; Hunter et al., 2011; Mote, 2011). In the single study with vocal and instrumental materials, young children more readily discerned the emotional intentions from vocal renditions (Dolgin & Adelson, 1990). It is not surprising that vocal materials are used extensively in therapeutic interventions involving music (e.g., Loewy, Stewart, Dassler, Telsey, & Homel, 2013), when participants' engagement is crucial. Listeners' engagement may be equally critical in laboratory studies of perception and memory, especially those involving challenging tonal or harmonic distinctions. In fact, the use of ecologically valid stimuli is likely to accelerate progress in our understanding of music processing in childhood. The melodies of songs with lyrics may be even more memorable than the melodies in the present investigation, which were based on songs but presented without lyrics. In any case, the use of vocal music is likely to uncover more parallels between music and language acquisition than those noted to date (e.g., Brandt et al., 2012; McMullen & Saffran, 2004).

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