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For 5-Month-Old Infants, Melodies Are Social

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Abstract

For 1 to 2 weeks, 5-month-old infants listened at home to one of two novel songs with identical lyrics and rhythms, but different melodies; the song was sung by a parent, emanated from a toy, or was sung live by a friendly but unfamiliar adult first in person and subsequently via interactive video. We then tested the infants' selective attention to two novel individuals after one sang the familiar song and the other sang the unfamiliar song. Infants who had experienced a parent singing looked longer at the new person who had sung the familiar melody than at the new person who had sung the unfamiliar melody, and the amount of song exposure at home predicted the size of that preference. Neither effect was observed, however, among infants who had heard the song emanating from a toy or being sung by a socially unrelated person, despite these infants' remarkable memory for the familiar melody, tested an average of more than 8 months later. These findings suggest that melodies produced live and experienced at home by known social partners carry social meaning for infants.

Keywords
music, social cognition, memory, infant development, open data, open materials

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Music is a putative human universal (Brown, 1991) that is ancient (Conard, Malina, & Münzel, 2009), highly variable (Lomax, 1968), and captivating throughout the life span, including in infancy (Patel, 2008; Trehub, 2003). Human infants learn and remember melodies (Trainor, Wu, & Tsang, 2004), are sensitive to rhythmic detail (Winkler, Háden, Ladinig, Sziller, & Honing, 2009), and move spontaneously to music (Zentner & Eerola, 2010). Parents sing frequently to their infants and children (Custodero & Johnson-Green, 2003; Mehr, 2014), in a style that is identifiable across many cultures (Trehub, Unyk, & Trainor, 1993). Why do parents sing to their infants? Why do infants engage with songs sung by their parents? These questions echo long-standing debates over music's psychological functions in modern environments and origins in human ancestry (e.g., Darwin, 1871; James, 1890; Spencer, 1857). Here, we explore the hypothesis that melody—a salient feature of vocal music—conveys social information to infants.

As do adults, infants regularly choose whether and how to engage with other individuals, selectively attending to novel people who look at them (Farroni, Csibra, Simion, & Johnson, 2002), produce infant-directed speech (Schachner & Hannon, 2011), or speak their parents' language (Kinzler, Dupoux, & Spelke, 2007). Such people are likely members of an infant's social group, and infants might be sensitive to this information as a result of innate dispositions, early learning, or both. We therefore examine whether infants selectively attend to novel singers of melodies learned in social settings.

Melody could signal social affiliation for two reasons. First, before the advent of sound recordings, melodies were learned only from other people. Because melodies are complex and highly variable, members of disjoint groups are unlikely to invent the same melodies. The ability and propensity to sing a familiar song could therefore carry social information: A novel person who sings a known melody is more likely to be connected to one's social group than is a novel person who sings an unknown melody. Second, in many cultures, people sing together in social contexts (Savage, Brown, Sakai, &

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Currie, 2015). Infants may be attentive to this fact, and these social experiences may lead them to endow music with social meaning.

Thus, we hypothesized that infant-directed songs convey social meaning to infants. In the experiments reported here, we examined infants' preferences for novel individuals, one who had sung a familiar melody and another who had sung an unfamiliar melody. The infants were familiar with one of the songs as a result of exposure to it in one of three forms: (a) live song from a parent in the home, (b) recorded song emanating from a toy presented and activated by a parent in the home, or (c) live song presented by a novel adult both in person in the lab and via live, interactive video at home.

These three forms of song exposure have different social implications. A musical toy presented by a parent divorces the source of music from the source of social interaction, while maintaining a socially engaging context provided by the parent, who activates the toy and modulates the infant's engagement with it. Live, interactive song presented by an unfamiliar adult involves social interaction between the singer and infant but divorces the source of music from any history of social interaction; when the singing episodes occur at home over interactive video, they are also divorced from other social interactions in the home.

Nevertheless, each of these forms of song exposure may carry social meaning. Infants reliably learn from both musical recordings (e.g., Trainor et al., 2004) and socially contingent nonmusical video interactions (e.g., Roseberry, Hirsh-Pasek, & Golinkoff, 2014). Many infants in modern societies encounter music produced by sound recordings as frequently as music produced by a parent (e.g., Mehr, 2014). Indeed, parents may believe that recordings provide higher-quality musical experiences than their own singing, given widespread beliefs that music listening and music education can have a positive influence on cognitive skills (see Mehr, 2015). Thus, we tested for social effects of music under all three learning conditions and investigated whether the magnitude of these effects varied by condition.

The infants in our experiments learned one of two lullabies that were adapted to equate their rhythms and lyrics; they differed only in melody and sounded highly similar (see Fig. 1a and Videos S1 and S2 in the Supplemental Material available online). The infants were randomly assigned to a 1- to 2-week familiarization with one song or the other, presented by one of the methods just described. At test, we measured the duration of the infants' looking at two novel people before and after they each sang one of the songs. If melodies convey information about social affiliation, then the infants would be expected to attend selectively to the new singer of the familiar song.

Experiment 1

Method

In Experiment 1, parents with little or no musical expertise learned to sing one of the two songs. They sang that song to their infants on a regular basis and visited a Web site where they could listen to the song, to help them faithfully reproduce it at home. To maximize ecological validity, we instructed the parents to "sing the song to your baby as much as you like." After 1 to 2 weeks of song exposure, the infants returned to the lab for a selective-attention test (described later in this section). Finally, the parents were recorded as they sang to their infants, so that expert raters could judge their pitch accuracy.

Participants. We recruited 38 full-term infants and their parents from the greater Boston area. The parents were given a $5 travel reimbursement at each lab visit, and the infants were given a toy or other small reward after completing the study. All testing took place at the Laboratory for Developmental Studies at Harvard University. Data from 6 infants were excluded because they were fussy (n = 1) or inattentive (n = 1), or because their parents failed to produce a recognizable song (n = 4). Thus, analyses included 32 infants (17 females; mean age = 5.61 months, SD = 0.31, range: 5.06–6.11). Typically, the infants were brought to the lab by one parent, who participated in the experiment; when both parents were present, one elected to serve as the participating parent, who completed all surveys, was given the music lesson, and sang to the infant at home and in the lab. Participating parents were predominantly female (26 female). Some parents reported that other adults learned the song and sang it to their infant as well.

Statistical power. The target sample size of 32 was determined before the experiment began, to ensure adequate power to detect a positive selective-attention effect. A similar experiment testing effects of language rather than music (Kinzler et al., 2007) obtained an effect size (d) of 0.54, and a sample of 32 had .84 power to detect an effect of this magnitude.

Musical content. We adapted two obscure lullabies from folk repertoires ("Babushka Baio" and "Shady Grove, My Little Love"; Feierabend, 2000) to create two songs with identical rhythms and lyrics but different melodies (see Fig. 1a for the music notation and Videos S1 and S2 in the Supplemental Material for the performances of the songs used in the selective-attention test). In pilot testing, the ratings of approximately 30 adults demonstrated that the songs were equally pleasant; half preferred one song, and half preferred the other. Additionally, twelve 5-month-old infants in a pilot study attended

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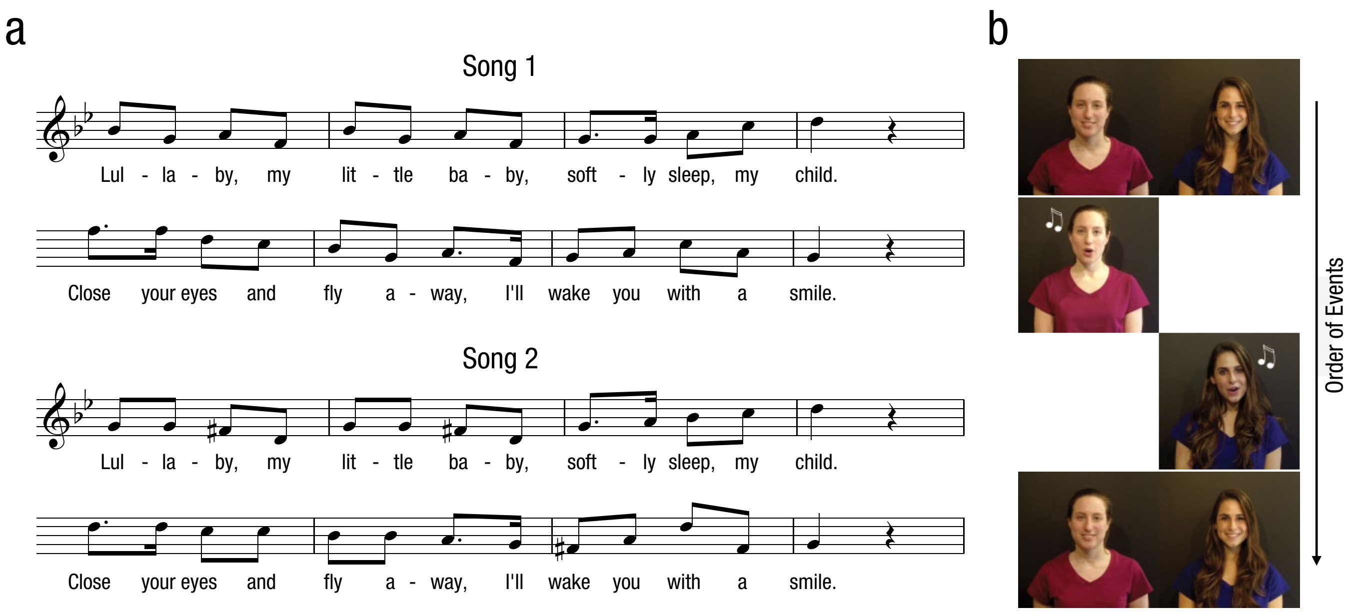

Fig. 1. The lullabies (a) and testing procedure (b) used in Experiments 1 through 3. During the baseline trial of the selective-attention test, two novel individuals stood silently smiling, directly gazing at the infant, for 16 s. Next, during the two familiarization trials, each individual sang one of the two lullabies in turn while gazing at the infant (22 s per trial; i.e., one person sang the lullaby that was familiar to the infant, and the other sang the unfamiliar lullaby). Finally, during the test trial, the two individuals again stood silently smiling, directly gazing at the infant.

comparably to videos of novel individuals singing the two songs.

Music instruction and assessment of music aptitude. At the first lab visit, each participating parent was randomly assigned to learn one or the other song (using the True Random Number Generator at www.random.org) and was given a 10- to 30-min music lesson, conducted without music notation and with the aid of a keyboard. The lesson concluded when the parent indicated that he or she felt confident in being able to reproduce the song without assistance (for an example of a parent singing to her infant, see Video S3 in the Supplemental Material). Parents were given access to a Web site that provided two recordings of their song (with and without lyrics), as well as the printed text of the lyrics; they were encouraged to practice by singing along with these recordings, but were also told that their infant should hear the song only from live individuals (i.e., that they should never play the recorded music on the Web site to their infants or record their own voice and play the recording for their infants). Compliance with these instructions was high: Thirty-one of the 32 parents visited the Web site at least once and spent enough time on the site listening to the song, on average, to listen to it a total of approximately 15 times over the course of the study. Total time spent on the site listening to the song was comparable across the two song conditions (Song 1: M = 5.73 min, SD = 5.62; Song 2: M = 5.23 min, SD = 6.02), $t(29.9) = 0.24$, $p = .81$ (Satterthwaite's t test). Thus, the two songs appear to have been comparably easy for untrained musicians to learn.

Parents also completed a standardized assessment of auditory perception skill, the Advanced Measures of Music Audiation (AMMA; Gordon, 1989), so that we could test for effects of parents' music aptitude on their infants' behavior.

Assessment of singing accuracy. At the second lab visit, we recorded the parents singing the song from the experiment to their infants during a free-play session. The audio recordings were presented to three professional musicians, who independently judged the number of accurate pitches (of 25 total pitches) in each performance. Interrater reliability (computed from the raw number of accurate pitches) was high (Cronbach's α = .90). When any one rater was unable to identify the song from a parent's performance, the data from the parent and infant were excluded from analyses. This occurred in four cases. With the exception of these participants, parents' pitch accuracy (proportion of correct pitches) was comparable across the two song conditions (Song 1: M = .87, SD = .13, range: .56–1; Song 2: M = .83, SD = .15, range: .52–1), $t(29.7) = 0.76$, $p = .45$ (Satterthwaite's t test).

Survey. After the first lab visit, we e-mailed parents daily with a brief survey, in order to determine the approximate number of times each infant heard the song each day. The rate of survey completion was high

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(92.3%). To estimate the amount of the infants' song exposure, we took the mean of each parent's responses to the question "About how many times did you sing your new lullaby to your baby today?" and multiplied it by the number of days of that family's participation in the study. These estimates thus accounted for both incomplete survey responses and variability in study length across participants.

Selective-attention test. At the second lab visit, we tested each infant's attention to two novel individuals, one who sang the song that was familiar to the infant and another who sang the unfamiliar song. The infant sat on his or her parent's lap, approximately 5 ft away from a 55- × 40-in. projection screen. The parent closed his or her eyes and wore noise-canceling headphones that played masking music throughout the experiment. The selective-attention test had four trials (see Fig. 1b). First, the infant viewed side-by-side high-definition video recordings of the two unfamiliar individuals, smiling with direct gaze at the infant, for 16 s (baseline trial). Then, the infant viewed, in turn, one 22-s video of each of the two individuals singing one of the two songs while continuing to look and smile at the infant (familiarization trials; see Videos S1 and S2). Finally, the infant viewed a silent 16-s test trial that was identical to the baseline trial. A looming object with an attractive sound effect brought the infant's eyes to the center of the screen before the baseline and test trials.

The videos were dubbed so that the two unfamiliar individuals sang in the same voice, to control for potential differences in singing quality across the two song conditions. The song-to-singer pairing, order of the familiarization trials, and presentation location (left or right side of the screen) were fully counterbalanced. Each infant's gaze in each of the four trials was recorded with a hidden high-definition camera and was coded frame by frame, at 30 frames per second, by a coder who was blind to which song the infant was familiar with and to the presentation location of each song. A second person recoded gaze for all the infants, and interrater reliability (computed by correlating the raw proportion of looking toward the singer of the familiar song) was high ($r = .91$). The coders viewed the baseline and test trials before the familiarization trials, so that no differences in the infants' behavior during the singing could influence the coding of attention to the individuals during the test trial.

Results

No variables differed between infants exposed to Song 1 and those exposed to Song 2 (ps > .1); thus, we present the data in aggregate. In the selective-attention test, the infants showed no preference for either individual at baseline. The proportion of time that they looked toward the person who sang the familiar song did not differ from chance (.5; $M = .521$, $SD = .177$, 95% confidence interval, or CI = [.457, .585]), $t(31) = 0.67$, $p = .51$ (one-sample t test; see Fig. 2a). Moreover, the infants attended highly and equally to the two singers during the familiarization trials, as each singer appeared by herself and sang a song (duration of looking toward the singer of the familiar song: $M = 15.6$ s, $SD = 5.07$; duration of looking toward the singer of the unfamiliar song: $M = 15.3$ s, $SD = 5.10$), $t(31) = 0.28$, $p = .78$ (paired t test). At test, however, the infants selectively attended to the now-silent singer of the song with the familiar melody; the proportion of time during which they looked toward her was greater than chance (.5; proportion of looking: $M = .593$, $SD = .179$, 95% CI = [.529, .658]), $t(31) = 2.96$, $p = .006$, $d = 0.52$ (one-sample t test), and greater than the proportion at baseline (difference in proportion of looking: $M = .072$, $SD = .169$, 95% CI = [.011, .133]), $t(31) = 2.42$, $p = .022$, $d = 0.43$ (paired t test; see Fig. 2a).

We used simple linear regression to investigate whether the degree of infants' increase in attention to the singer of the familiar song from baseline to test depended on their level of in-home exposure to that song. Parents reported singing regularly to their infants (median of 9 performances per day, interquartile range = [4, 11]; estimated total number of song performances: $M = 76$, $SD = 56$). After a $\log_2$ transformation (because of strong curvature), song exposure was a significant predictor of the within-subjects main effect (Fig. 2b), $\chi^2(1) = 7.53$, $p = .006$, $R^2 = .14$ (Wald test).[1] A doubling of the approximate number of parental performances corresponded to an estimated 0.37-SD increase in attention to the novel person who sang that song.

We also tested the predictive power of two characteristics of parents' musical abilities: the objective accuracy of their song performances (proportion of correct pitches, as judged by the expert raters) and their music perception skills (as measured by the AMMA). Both measures showed considerable variation across the parents in the sample, but neither predicted infants' attentional preferences—singing accuracy: $\chi^2(1) = 0.25$, $p = .61$; music aptitude: $\chi^2(1) = 0.85$, $p = .36$ (Wald tests).

Discussion

The infants selectively attended to the novel person who previously sang the song they had learned from their parents, and the amount of in-home exposure to the song predicted the size of this effect. In Experiment 2, we asked whether infants would show a similar effect if their parents presented them with a novel melody via a sound recording, emanating from a toy—that is, when the source of the melody was not a known social partner.

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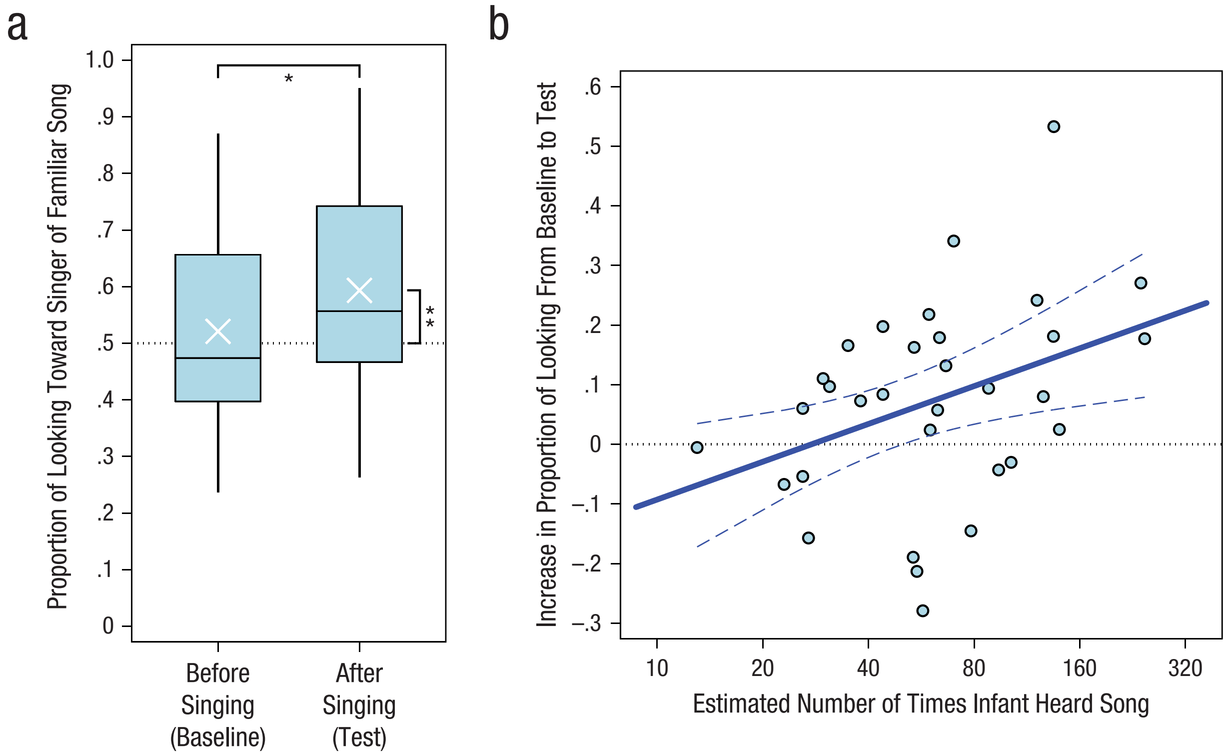

Fig. 2. Main effects in Experiment 1. The box plots in (a) show the proportion of time in the baseline and test trials during which the infants looked toward the singer of the familiar song. The dotted line indicates chance level (.5), the *X*s indicate the means, the horizontal lines indicate the medians, the boxes indicate the interquartile ranges, and the vertical lines indicate the full ranges. Asterisks indicate significant differences (*$p < .05$, **$p < .01$). The scatterplot in (b) shows each infant's increase in proportion of looking toward the singer of the familiar song from baseline to test, along with the predicted effect of the amount of song exposure on this within-subjects main effect, from a bootstrapped model with 40,000 replications. The dashed lines represent ±2 bootstrap standard errors, and chance (0) is indicated by the dotted line. Note that the *x*-axis is displayed on a $\log_2$ scale.

Experiment 2

Method

We repeated Experiment 1 with a second cohort of infants, altering the means of song exposure. In Experiment 2, parents were instructed never to sing the song to their child; instead, they were given a stuffed animal that produced music. When a parent squeezed this toy, it played a recording of an expert vocalist singing one of the two songs in an infant-directed fashion. Thus, song exposure in Experiment 2 was highly compelling and occurred in a social context, but the source of the song was an inanimate object. The procedure for recruiting participants, target sample size and statistical power, musical content, daily surveys (with minor changes in wording to account for the difference in exposure type, and a comparably high completion rate of 90.6%), selective-attention test, and analyses were the same as in Experiment 1. Thus, only the type of song exposure differed: In lieu of taking a music lesson in the lab and then singing the song in the home, parents in Experiment 2 were given a musical toy in the lab and used it with their infants at home. (Parent's pitch accuracy and music aptitude were not measured, because the parents in this experiment never sang the song to their infants.)

Participants. We recruited 35 full-term infants. Data from 3 infants were excluded because they were fussy ($n = 1$), failed to attend to the test stimuli ($n = 1$), or had prior familiarity with an actor in the test stimuli ($n = 1$). Analyses included 32 infants (18 females; mean age = 5.49 months, $SD = 0.31$, range: 4.99–6.14). Participating parents were predominantly female (27 females).

Song exposure: musical toy. We adapted an age-appropriate stuffed animal (Jellycat Inc., London, United Kingdom) to play a recording of the song (for an example of a parent playing the toy for her infant, see Video S4 in the Supplemental Material). The toy was no longer publicly available for purchase, and no parent indicated that his or her infant was familiar with the toy at the outset of the experiment. We removed stuffing from each toy and inserted a sound module (Invite By Voice LLC, Eden Prairie, MN) that played a recording of the song when the

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toy was squeezed. The recorded singers were two professional vocalists (gender matched to the participating parent), instructed to sing in an infant-directed fashion; neither vocalist was the singer in the selective-attention test. The toy played the song at approximately 55 dB at a distance of 5 in., a comfortable volume comparable to that of other commercially available musical toys intended for young infants. The infants lacked the dexterity to activate the toy themselves, and thus required a parent or another individual to do so. As in Experiment 1, the infants were randomly assigned to learn one song or the other.

At the first visit, we introduced the infants and parents to the musical toy and demonstrated its use. We instructed parents to "treat the toy as if you purchased it and use it as much as you like," indicating that the amount of song exposure and the nature of the infants' toy-directed actions were at the parents' discretion. Parents were instructed never to sing the song to their infants, and to relay this instruction to any other individuals who would come into contact with the toy. Compliance with this instruction was high. We asked parents at the second lab visit if they had sung the song during the exposure period. At most, parents reported a total of three or four instances of singing or humming the song, usually "by accident." Parents completed online surveys to report the amount of the infants' song exposure, as in Experiment 1.

Selective-attention test. Parents returned the toys to the lab at the second visit, when the infants participated in a testing session identical to that of Experiment 1. Interrater reliability, computed in the same fashion as in Experiment 1, was high (r = .96).

Results

Main analyses. The infants' degree of song exposure was comparable across the two experiments: The estimated total number of song performances was similar in Experiment 1 (M = 76.3, SD = 56.2) and Experiment 2 (M = 81.8, SD = 50.5), t(61.3) = 0.41, p = .68 (Satterthwaite's t test), and the exposure periods were of comparable duration (in both experiments, Mdn = 7 days, range: 7–14). Given that a song performance lasted 22 s, we estimated that the infants in Experiment 2 received about 30 min of song exposure, on average; this was more than the exposure in a previous study showing that 6-month-olds remembered songs presented to them via audio recordings (21 min in Trainor et al., 2004).

In the selective-attention test, the infants looked equally toward the two unfamiliar adults at baseline. The proportion of time that they looked toward the person who sang the familiar song did not differ from chance (.5; M = .512, SD = .175, 95% CI = [.449, .575]), t(31) = 0.39, p = .70 (one-sample t test; see Fig. 3a). In addition, the infants attended equally to the two singers during familiarization (duration of looking toward the singer of the familiar song: M = 16.2 s, SD = 5.18; duration of looking toward the singer of the unfamiliar song: M = 15.2 s, SD = 6.69), t(31) = 0.95, p = .35 (paired t test). The levels of attention to the two novel adults in Experiment 2 were comparable to the levels in Experiment 1 both during the baseline period, t(62.0) = 0.20, p = .84 (Satterthwaite's t test), and during the familiarization trials—familiar song: t(62.0) = 0.49, p = .63; unfamiliar song: t(57.9) = 0.06, p = .95 (Satterthwaite's t tests).

Despite the high appeal of the toy and professional quality of the singing, the selective-attention effects found in Experiment 1 were not present in Experiment 2. At test, the proportion of time during which the infants looked toward the singer of the familiar song (M = .537, SD = .181, 95% CI = [.472, .602]) did not differ from chance (.5), t(31) = 1.17, p = .25 (one-sample t test), or from the proportion at baseline (difference in proportion of looking: M = .025, SD = .165, 95% CI = [−.034, .085]), t(31) = 0.86, p = .40 (paired t test). Further, the amount of song exposure did not predict the infants' change in attentional preference toward the new individual who sang the familiar song (Fig. 3b), $\chi^2(1)$ = 0.01, p = .92 (Wald test).

Comparison with Experiment 1. We used multiple regression to test the effects of exposure type (via a parent, in Experiment 1, vs. via a toy, in Experiment 2) and amount of song exposure on the within-subjects increase, from baseline to test, in looking toward the singer of the familiar song. As in Experiment 1, we performed a $\log_2$ transformation on the parents' self-reported number of song performances. We used no-constant models because the population intercept is known to be 0: If infants have never heard either song (i.e., 0 song performances), on average, they should not show any increase in looking toward either singer from baseline to test. Model building began with a simple no-constant model predicting the overall increase in looking from exposure quantity only; we then added the predictor of exposure type, and finally an Exposure Type × Exposure Quantity interaction.

The final model was statistically significant, $\chi^2(3)$ = 12.0, p = .0076, R^2 = .16 (Wald test), as was the Exposure Type × Exposure Quantity interaction, b = 0.059, 95% CI = [0.014, 0.105], z = 2.53, p = .011 (z test of the bootstrapped regression coefficient). The inclusion of exposure type and the interaction term significantly increased model fit, $\chi^2(2)$ = 6.63, p = .036 (nested test). At the grand mean of exposure quantity (79 song performances), infants in Experiment 1 showed a larger increase in attention toward the singer of the familiar song from baseline

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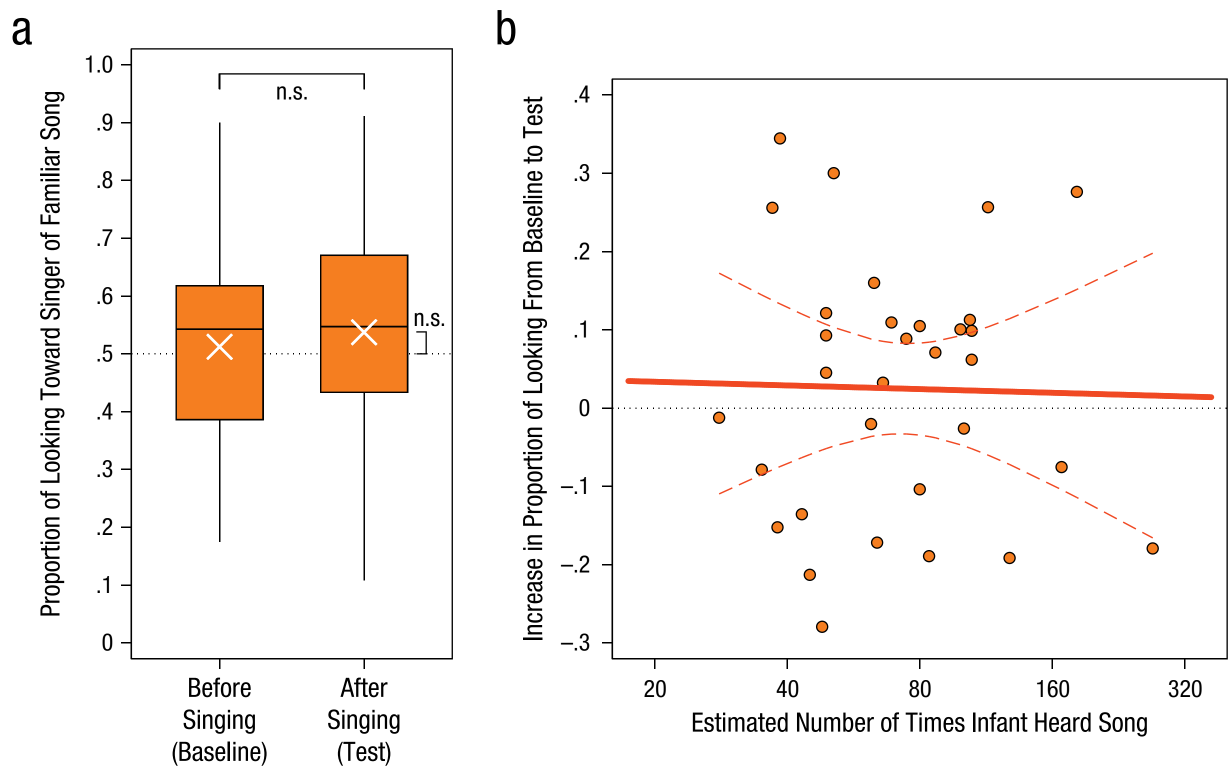

Fig. 3. Main effects in Experiment 2. The box plots in (a) show the proportion of time in the baseline and test trials during which the infants looked toward the singer of the familiar song. The dotted line indicates chance level (.5), the *X*s indicate the means, the horizontal lines indicate the medians, the boxes indicate the interquartile ranges, and the vertical lines indicate the full ranges. The scatterplot in (b) shows each infant's increase in proportion of looking toward the singer of the familiar song from baseline to test, along with the predicted effect of the amount of song exposure on this within-subjects main effect, from a bootstrapped model with 40,000 replications. The dashed lines represent ±2 bootstrap standard errors, and chance (0) is indicated by the dotted line. Note that the *x*-axis is displayed on a $\log_2$ scale.

to test than did infants in Experiment 2, $b = 0.072$, 95% CI = [−0.013, 0.156], $z = 1.67$, $p = .047$, $\beta = 0.43$ (general linear hypothesis test, one-tailed). At the 75th percentile of exposure quantity (101 song performances), the difference between the two experiments was larger, $b = 0.093$, 95% CI = [−0.001, 0.187], $z = 1.95$, $p = .025$, $\beta = 0.55$ (general linear hypothesis test, one-tailed).

Discussion

Despite the use of recorded music, a common form of musical exposure for infants, the results of Experiment 2 differed markedly from those of Experiment 1. Infants selectively attended to a novel singer of a song originally sung by a parent, but not to a novel singer of a song originally played via a musical toy. This contrast suggests that infants do not prefer novel individuals who are associated with *any* familiar melody presented in a positive social context, despite long-standing findings that people prefer familiar sounds, objects, and patterns over unfamiliar ones, in both adulthood (Zajonc, 2001) and infancy (Bornstein, 1989).

Live and recorded singing differ in many respects, however. Although parents in Experiment 2 activated the toys, the toys themselves were inert: Unlike live singers, they did not interact contingently with the infants, vary the style and content of their song production, fine-tune their singing to the infants' affective state, or move in synchrony with their singing. In Experiment 3, we presented infants with singing that incorporated these characteristics, but the source of the song was an unfamiliar adult who sang to the infants primarily over live, interactive video.

Experiment 3

Method

We repeated Experiment 1 with a third cohort of infants, again altering the means of song exposure. As in Experiment 2, parents were asked never to sing the song to their infants, but the parents and infants were introduced to a friendly adult (a university student with musical training) who sang the song to the infants in the lab. Parents then

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were given an iPad, by means of which this adult interacted daily with the infants, using interactive video chat (Skype). The procedure for recruiting participants, sample size and statistical power, musical content, daily surveys (with minor changes in wording to account for the difference in exposure type, and a comparably high completion rate of 90.0%), and selective-attention test were the same as in Experiment 1.

Participants. We recruited 39 infants. Data from 7 infants were excluded because they were fussy (n = 1), failed to attend to test stimuli (n = 1), or did not complete all the interactive video sessions (n = 2), or because of experimenter error (n = 3). Analyses included 32 infants (12 females; mean age = 5.82 months, SD = 0.49, range: 5.03–6.47). Participating parents were predominantly female (24 females).

Song exposure: interactive video sessions. Parents were provided with an iPad equipped with the Skype application and a flexible stand, a carrying bag, and a charger, all of which they kept for the duration of the study. At the first lab visit, the infants met the new adult, who played with them and sang the song directly to them six to eight times. The adult and parents then scheduled daily appointments for singing over interactive video. The parents were asked to choose times during which they expected the infants to be comfortable and attentive; across the cohort, appointment times were spread throughout the day, but within subjects they tended to occur consistently at the same time (e.g., every day after breakfast). The adult kept in regular contact with each parent via e-mail so as to ensure that the infant and parent were both present for each video appointment.

The infants participated in 6 to 11 interactive video sessions at home (Mdn = 7), each lasting roughly 10 min, during which the singer sang the song 4 to 11 times (Mdn = 7). Because the singing was live, there was natural variability in performance both within and between sessions. When the adult was not singing, she talked to the infants and parents. At the beginning of each session, she confirmed that the infant could see and hear her, and during the session, she asked the parent to reposition the iPad to maintain the infant's line of sight, as needed. The parents were invited to use their discretion in positioning the infants; we chose to encourage this because, during pilot testing, we determined that most families were already accustomed to using interactive video with their infants; indeed, 86% of the infants in Experiment 3 had previously used Skype, FaceTime, Hangouts, or some other form of interactive video chat before participating in the study. Thus, there was variability in the infants' positioning during the sessions: Some infants sat in a parent's lap, others sat in a high chair with the iPad on the stand, and so on.

The infants were randomly assigned to learn one song or the other, and the parents were instructed that they should never sing the song to their infants and should relay this instruction to other individuals who were present during the video sessions (who might learn the song incidentally). Compliance with this instruction was high, with only two parents in the study reporting any live singing of the song.

Selective-attention test. Parents returned the iPad to the lab at the second visit, when the infants participated in a selective-attention test identical to that of Experiment 1. Interrater reliability, computed in the same fashion as in Experiments 1 and 2, was high (r = .95).

Assessment of the infants' responses to song exposure. The presentation of songs via interactive video allowed us to analyze the infants' responses to song exposure in a fashion that was not possible in Experiments 1 and 2: In Experiment 3, all video sessions were recorded (for a typical song performance, see Video S5 in the Supplemental Material). These videos enabled us to compare the infants' responses to the song and speech in a natural setting and to test for the relation between the infants' engagement with the song during learning and their selective attention to a novel singer at test.

We analyzed three video sessions per infant, from the beginning, middle, and end of the exposure period. Videos in which the infants were fussy were not used (exclusion decisions were made before any coding was performed, to avoid confirmation bias). Two coders viewed the videos at 10 frames per second and recorded the durations of four categories of events: infant smiling, infant gazing toward the screen (where the adult was always visible), adult singing, and adult speaking. One of the three videos from each infant was randomly selected for double coding, and interrater reliability (computed as the frame-by-frame percentage of agreement across the two coders) was high (82%–99%).

Although infants' reactions to songs performed via video chat have never been systematically assessed, infants find singing highly enjoyable (for a review, see Patel, 2008). We expected that if the infants were sufficiently engaged with the adult during the interactive video sessions, they would smile more and attend longer to her when she was singing than when she was speaking.

Results

Main analyses. Parents' estimates of the total number of song performances (M = 47.7, SD = 17.0) were slightly lower than the actual number, as determined from the

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recorded video sessions (M = 48.7, SD = 16.9); this difference was not significant, t(31) = 0.59, p = .56 (paired t test). The total duration of song exposure (M = 17.5 min, SD = 6.23; extrapolated from the three videos that were coded for singing duration) was slightly lower than in a previous study in which 6-month-old infants were taught songs and subsequently remembered them (21 min; Trainor et al., 2004). Parents reported significantly less song exposure in Experiment 3 than in the other two experiments—comparison with Experiment 1: t(36.6) = 2.75, p = .009; comparison with Experiment 2: t(38.0) = 3.6, p = .001 (Satterthwaite's t tests)—although the study duration was comparable across all three experiments (Experiment 1: Mdn = 7 days, range: 7–14; Experiment 2: Mdn = 7 days, range: 7–14; Experiment 3: Mdn = 7 days, range: 7–12). We address possible bias in these reports later in this section.

In the selective-attention test, the infants showed no preference for either of the two unfamiliar adults at baseline. The proportion of time that the infants looked toward the person who sang the familiar song did not differ from chance (.5; M = .479, SD = .183, 95% CI = [.413, .545]), t(31) = 0.64, p = .53 (one-sample t test; see Fig. 4a). Similarly, the infants attended equally to the two singers during the familiarization trials (duration of looking to the singer of the familiar song: M = 18.4 s, SD = 4.75; duration of looking to the singer of the unfamiliar song: M = 17.2 s, SD = 4.93), t(31) = 1.28, p = .21 (paired t test). The infants in Experiments 1 and 3 exhibited comparable levels of attention during the baseline period, t(61.9) = 0.93, p = .36, and during the familiarization trial for the unfamiliar song, t(61.9) = 1.47, p = .15. However, the infants in Experiment 3 attended longer to the familiarization trial for the familiar song than did the infants in Experiment 1, t(61.7) = 2.26, p = .027 (all Satterthwaite's t tests).

The selective-attention effects found in Experiment 1 were not present in Experiment 3. The proportion of time that the infants looked toward the novel person who sang the familiar song did not differ from chance (.5; M = .488, SD = .232, 95% CI = [.404, .571]), t(31) = 0.30, p = .77 (one-sample t test), or from the proportion at baseline (difference in proportion of looking: M = .009, SD = .198, 95% CI = [−.063, .080]), t(31) = 0.24, p = .81 (paired t test; see Fig. 4a). Further, the amount of song exposure did not predict the infants' change in attentional preference toward the new singer of the familiar song (Fig. 4b), $\chi^2(1)$ = 0.46, p = .50 (Wald test).

Comparison with Experiment 1. Because parents may have paid greater attention to songs they themselves sang than to songs sung by a toy or another person, their reports of song exposure may have been depressed in Experiment 3, relative to Experiments 1 and 2. For this reason, we used somewhat different methods to compare the results of Experiments 1 and 3 than we used to compare the results of Experiments 1 and 2. We began by testing for differences between the experiments (exposure type) without adjusting for differences in the amount of song exposure. Then we proceeded with a regression model that differed in one respect from that used to compare Experiments 1 and 2: Instead of predicting selective attention from the estimated total number of song performances, after a $\log_2$ transformation, we standardized those values by dividing them by the standard deviation in each experiment in an effort to reduce the differences in parents' self-reporting bias across the two experiments. The predictor can thus be interpreted as standard-deviation units of song exposure.

Both approaches revealed differences between the two experiments. The first showed that at test, the infants attended significantly longer to the singer of the familiar song in Experiment 1 than in Experiment 3, t(58.2) = 2.04, p = .046 (Satterthwaite's t test). The difference between the experiments in the increase in proportion of looking toward the singer of the familiar song from baseline to test was smaller, but in the same direction, t(60.5) = 1.39, p = .086 (Satterthwaite's t test, one-tailed). We continued with the second approach, which included the standardized measure of song exposure as a predictor. The model's omnibus test yielded a significant result, $\chi^2(3)$ = 11.0, p = .01, R^2 = .14 (Wald test), as did a test of the Exposure Type × Exposure Quantity interaction, b = 0.061, 95% CI = [0.006, 0.115], z = 2.18, p = .029 (z test of the bootstrapped regression coefficient). The inclusion of exposure type and the interaction term significantly increased model fit, $\chi^2(2)$ = 6.87, p = .032 (nested test). Thus, although the comparison of the experiments was complicated by the introduction of bias in the measure of song exposure, the infants' behaviors at test clearly differed between Experiments 1 and 3.

Infants' responses to song and speech presented via interactive video. Across the three sessions that were coded for each infant, we computed four variables: duration of smiling while the adult sang, duration of looking at the video screen while the adult sang, duration of smiling while the adult spoke, and duration of looking at the video screen while the adult spoke. Each variable was computed as a proportion of singing time or speaking time. We then used planned comparisons to test whether the infants smiled and gazed at the video differentially, within subjects, depending on whether the adult was singing or speaking.

When the adult sang, the infants smiled at nearly twice the rate (M = .098, SD = .106, 95% CI = [.059, .136]) that they did when she spoke (M = .054, SD = .062, 95% CI = [.032, .077]), t(31) = 2.85, p = .008 (paired t test). Likewise,

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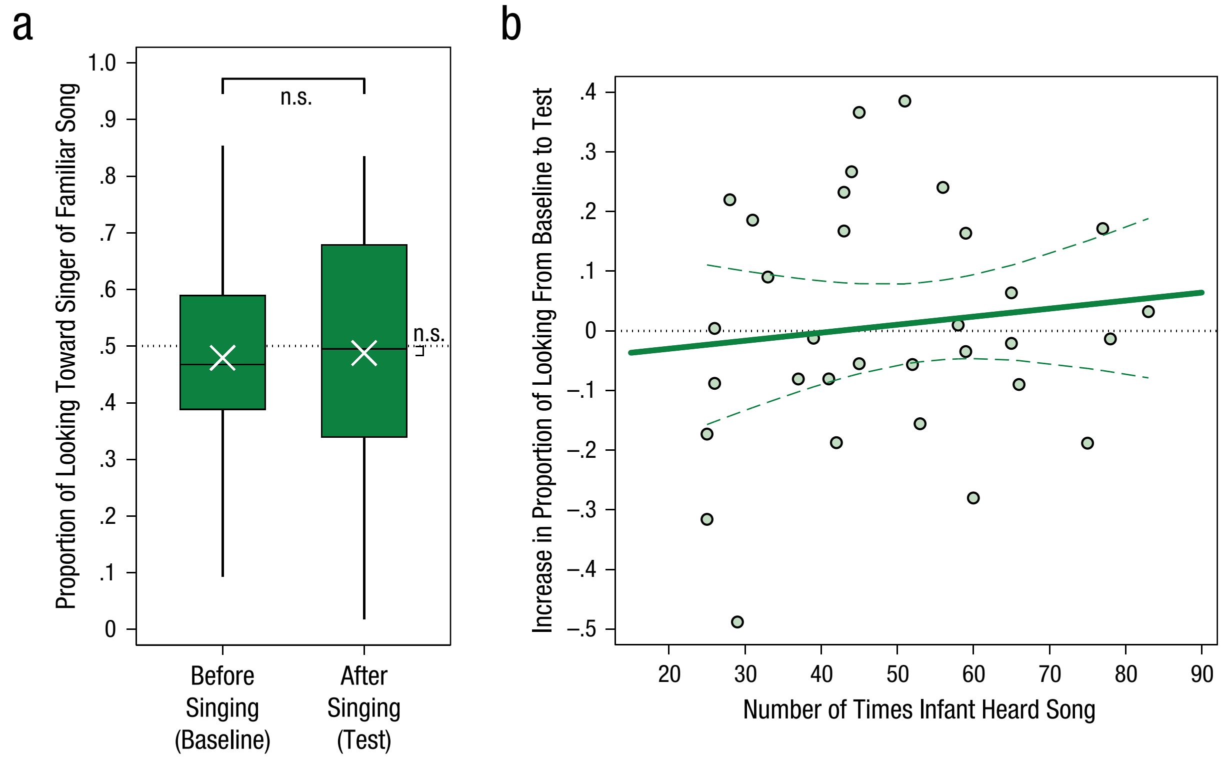

Fig. 4. Main effects in Experiment 3. The box plots in (a) show the proportion of time in the baseline and test trials during which the infants looked toward the singer of the familiar song. The dotted line indicates chance level (.5), the *X*s indicate the means, the horizontal lines indicate the medians, the boxes indicate the interquartile ranges, and the vertical lines indicate the full ranges. The scatterplot in (b) shows each infant's increase in proportion of looking toward the singer of the familiar song from baseline to test, along with the predicted effect of the amount of song exposure on this within-subjects main effect, from a bootstrapped model with 40,000 replications. The dashed lines represent ±2 bootstrap standard errors, and chance (0) is indicated by the dotted line.

they attended to the screen at a significantly higher rate during her singing (M = .623, SD = .184, 95% CI = [.557, .689]) than during her speaking (M = .547, SD = .130, 95% CI = [.500, .594]), $t(31)$ = 4.02, p = .0003 (paired t test).

Given that these positive responses might reflect differences in infants' experiences during song exposure between Experiments 1 and 3, we conducted two exploratory analyses to test whether these measures predicted the infants' preferences regarding the novel individuals at test. The results were negative: The rate of smiling during singing episodes were not related to the within-subjects main effect, $\chi^2(1)$ = 0.23, p = .63 (Wald test), and neither was the rate of looking during singing episodes, $\chi^2(1)$ = 0.50, p = .48 (Wald test). Thus, although the infants responded more positively to songs than to speech, as evidenced by two measures, the magnitude of these positive responses to the singing did not predict the infants' attentional preferences between the novel singers at test.

Discussion

The contrasting findings of Experiments 1 through 3 suggest that parents' singing has different effects on infants than do either musical toys or singing by a minimally familiar adult over interactive video. Did these differing effects stem from infants' differential attention to and learning of the songs in the three conditions? Although we know that the infants in Experiment 3 were highly attentive to the singer, the infants in Experiments 2 and 3 might have failed to learn the song well enough to recognize it at test.

The best test of this possibility would be to compare the infants' later memory for the melody across the three experiments, but this comparison was not possible. Many of the parents in Experiment 1 continued to sing the song after the experiment ended,[2] whereas the return of the toy at the end of Experiment 2 and the return of the iPad at the end of Experiment 3 made it unlikely that the infants heard the song again. Thus, in Experiments 4 and 5, we investigated long-term retention of the melody among the participants from Experiments 2 and 3, respectively.

Three to 12 months after the conclusion of those experiments (more than 8 months later, on average), we tested whether the infants could discriminate the familiar melody from the other melody while listening in the

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same context in which they had originally learned the song. In Experiment 4, we tested infants' attention to two visually identical toys from Experiment 2; one toy played the familiar song, and the other played the unfamiliar song. In Experiment 5, we tested infants' attention to two videos of the singer from Experiment 3; she sang the familiar song in one video and the unfamiliar song in the other.

Experiment 4

Method

Participants. We attempted to test all 32 infants from Experiment 2, but we failed to reach three families, two families declined to participate, and one family had moved away; in addition, 4 infants participated but were excluded because they were fussy during the lab session. Thus, our analyses included 22 full-term infants (11 females; mean age = 13.9 months, SD = 1.50, range: 10.8–17.1), who were tested an average of 8.63 months after they had last heard the recorded song in Experiment 2 (SD = 1.51, range: 5.82–11.6 months). During this interim, some of these infants had returned to the lab for unrelated experiments, but none had received any additional exposure to the toy or the recording of the familiar song. We asked the parents if they had sung the toy's song after the original study ended. Parents of 5 of the 22 infants reported singing the song "once or twice" during the weeks following Experiment 2, but not afterward.

Procedure. The infants sat in a high chair while we presented them with toys from Experiment 2, at a distance of approximately 26 in. Parents sat next to their infants, facing away from the toys, and wore noise-canceling headphones that played masking music for the duration of the experiment. The experiment comprised four trials. On each trial, the experimenter, who was unaware of which song had been presented to the infant during the original experiment, placed a toy to one side in front of the infant. He said, "Look at this toy, [baby's name]!" and activated the song (see Fig. 5a). The trials alternated between two visually identical toys, one that played the song the infant had heard in Experiment 2 and one that played the other song used in Experiment 2, which the infant had never heard except during the selective-attention test in that experiment. Thus, each infant heard the familiar song twice and the unfamiliar song twice. A given song was presented on the same side both times.

On each trial, we measured the infant's gaze toward the toy during the singing (22 s) and afterward in silence (16 s). The recordings were identical to those used in Experiment 2, and did not differ in lyrics, rhythm, or the identity of the singer. Because the two toys were visually identical, the only basis for distinguishing between them was the melodies they played. The order of presentation (familiar vs. unfamiliar song first) and the location of each toy (left side vs. right side) were counterbalanced, though lower-than-expected recruitment led to a slight imbalance in presentation order, such that 13 infants heard the familiar song on Trials 1 and 3, and 9 heard it on Trials 2 and 4 (we report a test for order effects in the next section). Each infant's gaze was recorded with a hidden high-definition camera and coded at 30 frames per second by an experimenter who was blind to the infant's song familiarity. A second experimenter recoded the videos of all participants, and interrater reliability (computed by correlating raw looking times, four trials per infant) was high (r = .97).

Results

Despite the lengthy delay between initial song exposure and test, the infants looked longer, on average, at the toy that played the song they had heard at home more than 8 months earlier than at the toy that played the unfamiliar song. This effect was strongest during the first phrase of the songs (Fig. 5b; difference in looking time: M = 0.815 s, SD = 1.61, 95% CI = [0.10, 1.53]), $t(21)$ = 2.38, p = .027 (paired t test), which is consistent with findings in a previous study of musical memory (Saffran, Loman, & Robertson, 2000), but it remained marginally detectable over a longer interval (first half of the songs; difference in looking time: M = 1.28 s, SD = 3.66, 95% CI = [−0.35, 2.90]), $t(21)$ = 1.63, p = .059 (one-tailed). The first-phrase effect was no larger for the 5 infants whose parents reported singing the familiar song after Experiment 2 than for the 17 infants whose parents did not report such exposure (mean difference = 1.46 s, 95% CI = [−1.00, 3.91]), $t(5.13)$ = 1.51, p = .19 (Satterthwaite's t test). The size of the main effect did not vary with presentation order (familiar vs. unfamiliar song first; mean difference = 0.95 s, 95% CI = [−0.53, 2.43]), $t(16.0)$ = 1.37, p = .19 (Satterthwaite's t test). In an exploratory analysis, we tested whether the amount of song exposure in Experiment 2 predicted the strength of the memory effect in Experiment 4. The result was negative: Infants with more song exposure were no more likely, on average, to show a greater preference for the toy playing the familiar song over the toy playing the unfamiliar song, $\chi^2(1)$ = 0.51, p = .47 (Wald test).

In sum, Experiment 4 provides evidence that the infants in Experiment 2 learned the song from the toy, discriminated that song from a song with identical lyrics and timing but a different melody, and retained this distinction between the two highly similar songs for 6 to 12 months (M > 8 months).

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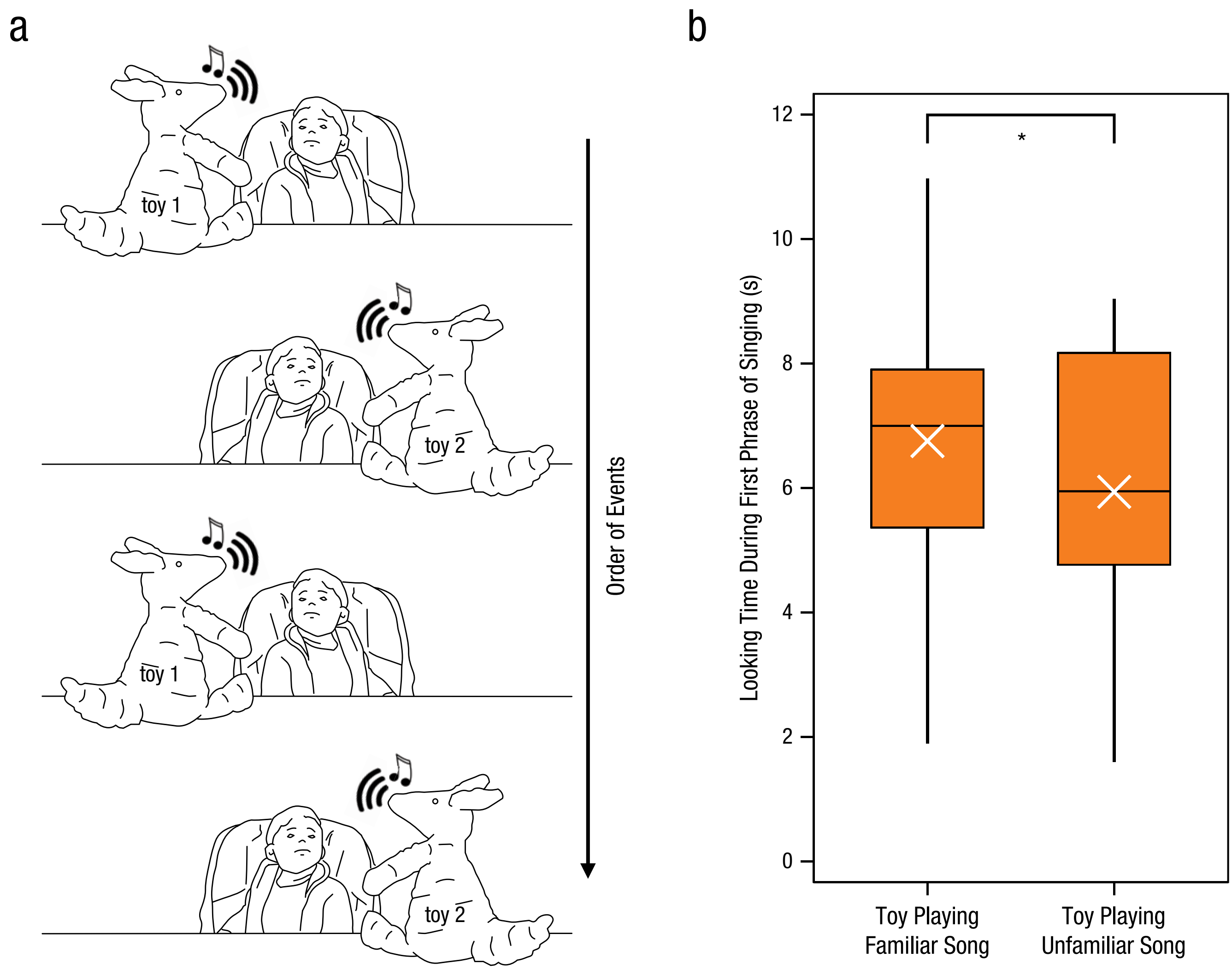

Fig. 5. Procedure and results of Experiment 4. On each of four trials (a), one of two visually identical toys was presented to one side in front of the infant for the duration of one performance of either the familiar or the unfamiliar song and during a 16-s delay afterward. The two songs were presented in alternation. The box plots (b) show the duration of looking toward each of the toys during the first phrase of the song. The *X*s indicate the means, the horizontal lines indicate the medians, the boxes indicate the interquartile ranges, and the vertical lines indicate the full ranges. The asterisk indicates a significant difference ($^*p < .05$).

Experiment 5

Method

Participants. We attempted to test all 32 infants from Experiment 3, but we failed to reach six families, and three families declined to participate. The sample comprised 23 full-term infants (8 females; mean age = 5.86 months, SD = 0.50, range: 5.03–6.47), who were tested an average of 8.48 months after they had last heard the familiar song from Experiment 3 (SD = 2.91, range: 2.99–12.1). During the interim, some of the infants had returned to the lab for other experiments, but none had received any additional exposure to the familiar song from either the singer or interactive video. Parents of 6 of the 23 infants reported singing the song during the first weeks following Experiment 3, but not afterward. Thus, exposure conditions in Experiment 5 were comparable to those in Experiment 4.

Procedure. The infants sat on the lap of a parent, who had closed eyes and wore noise-canceling headphones that played masking music for the duration of the experiment. They viewed high-definition videos of the adult singer from Experiment 3. On four alternating trials, she sang the familiar and unfamiliar songs (Fig. 6a). Because the same person sang both songs, the familiar song was

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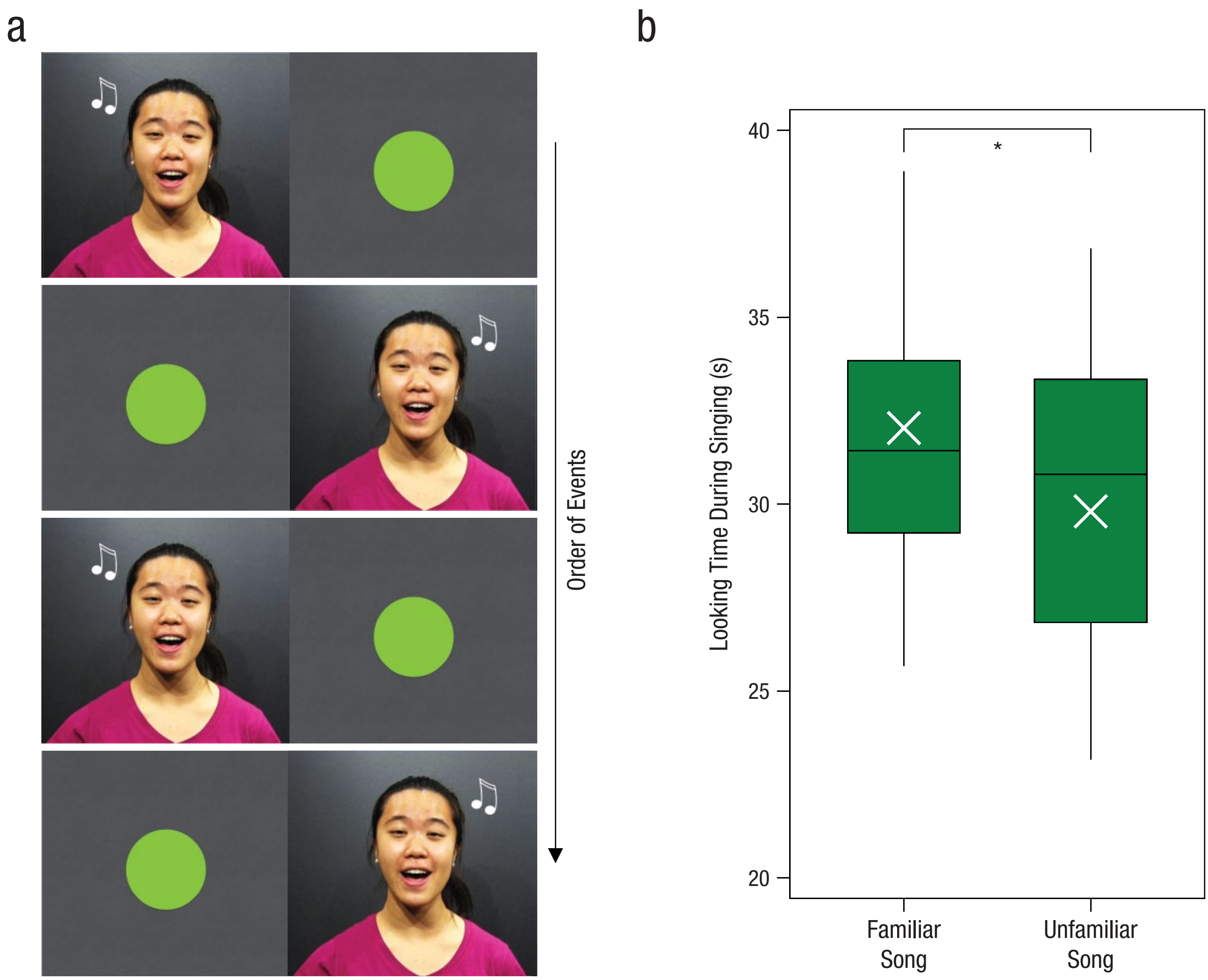

Fig. 6. Procedure and results of Experiment 5. On each of four trials (a), the infants viewed a video of the person who had previously Skyped with them. She sang either the familiar or the unfamiliar song (on alternating trials) and appeared alongside a green looming object. The box plots (b) show the duration of looking toward the videos of the singer while she sang the familiar song and while she sang the unfamiliar song. The *X*s indicate the means, the horizontal lines indicate the medians, the boxes indicate the interquartile ranges, and the vertical lines indicate the full ranges. The asterisk indicates a significant difference ($^*p < .05$).

not identifiable from the identity of the singer's voice. Because infants are highly attentive to videos of singing, we presented each song video alongside a video of a looming object that moved out of synchrony with the song, so as to avoid ceiling effects on the infants' gaze toward the face of the singing adult. The order of the songs (familiar vs. unfamiliar song first) and location of the singer (left vs. right side) were fully counterbalanced. The infants' gaze was recorded with a hidden high-definition camera and coded at 30 frames per second by two experimenters, both of whom were unaware of which song was familiar to each infant. Interrater reliability (computed by correlating raw looking times, four trials per infant) was high ($r = .93$).

Results

The infants attended longer to the video of the adult when she sang the same song as in Experiment 3 than when she sang the other song (Fig. 6b; difference in looking time: $M = 2.23$ s, $SD = 4.80$), $t(22) = 2.27$, $p = .033$ (paired *t* test). Preferential looking on familiar-song trials was no higher for the 6 infants whose parents reported singing the familiar song than for the 17 infants whose parents did not report such exposure (mean difference = 2.67 s, 95% CI = [−2.78, 8.12]), $t(7.89) = 1.13$, $p = .29$ (Satterthwaite's *t* test). Thus, these findings provide evidence that the infants in Experiment 3 learned the song via interactive video, discriminated that song from a song with identical lyrics and timing but a different melody,

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and retained this distinction for more than 8 months, on average.

In contrast to Experiment 4, Experiment 5 revealed a memory effect that was not largest in the first phrase of the song. Instead, effects were detectable through the entirety of the song. In addition, the latter two of the four trials (Trials 3 and 4) drove the overall difference in attention to the singing of the familiar versus unfamiliar song (mean difference between Trials 3 and 4 = 2.18 s, 95% CI = [0.47, 3.89]), $t(22) = 2.61$, $p = .015$ (paired *t* test). This difference between the effects observed in the two experiments is likely due to differences in the format of the memory test: In Experiment 4, the toy never moved on its own, and its recorded song was always performed identically. Visual attention to the toy therefore dropped off quickly after the beginning of each test trial. In contrast, in Experiment 5, the infants viewed videos of the person who had previously sung to them in a variable context, and whose behavior varied throughout the test; thus, their attention was better sustained throughout each trial.

In an exploratory analysis, we tested whether the amount of song exposure in Experiment 3 predicted the strength of the memory effect in Experiment 5. As we found in the corresponding analysis in Experiment 4, the result was negative: Infants with more song exposure were no more likely, on average, to show a greater preference for the video of the adult singing the familiar song over the video of her singing the unfamiliar song, $\chi^2(1) = 0.04$, $p = .84$ (Wald test). Finally, we tested whether a relation between song exposure and strength of the memory effect might be obtained by collapsing across the two experiments. In a simple logistic regression, the likelihood of a difference in looking time between the two songs was unrelated to the degree of prior song exposure, $\chi^2(1, N = 45) = 0.08$, $p = .77$ (Wald test). Thus, the degree of exposure did not contribute to the size of the memory effects in Experiments 4 and 5.

Because song exposure was video-recorded in Experiment 3, we were able to test whether the infants' levels of engagement while they learned the song in that experiment predicted their memory in Experiment 5. We computed the size of the memory effect in Experiment 5 as the raw difference in duration of looking toward the person singing the familiar song and duration of looking toward the person singing the unfamiliar song; we tested for relations between this measure and the measures of smiling and looking during song exposure in Experiment 3. No model showed a clear predictive relation—smiling only: $\chi^2(1) = 1.32$, $p = .25$; looking only: $\chi^2(1) = 2.31$, $p = .13$; both smiling and looking: $\chi^2(2) = 2.28$, $p = .32$; smiling, looking, and their interaction: $\chi^2(3) = 1.62$, $p = .66$. Although the infants remembered the song from Experiment 3 after a long delay, their levels of engagement while they learned the song did not predict the degree of the memory effect.

General Discussion

Infants selectively attended more to a novel individual who sang a song learned from a parent's singing than to a novel individual who sang a contrasting song with the same words and rhythms but a different melody. Infants displayed no such preference when they learned the song from a recording emanating from an inanimate toy or from live video interactions with a singing adult whom they had met only briefly.

Strikingly, the infants in the latter two conditions remembered the melody to which they had been exposed for an average of more than 8 months, in sufficient detail to discriminate it from a second, highly similar melody (see Fig. 1a and Videos S1 and S2 in the Supplemental Material). Moreover, analyses of video recordings of the infants as they learned the song in Experiment 3 revealed that they exhibited substantially more positive engagement with the adult while she sang than while she spoke. Thus, 5-month-old infants enjoy melodies that are sung by a variety of people under different conditions, and they show long-term retention of melodies learned from a variety of sources. Nevertheless, only a melody produced live by a parent leads infants to display an attentional preference for a new person who sings that melody.

The effect of parents' singing was robust to variation in their musical skills: Infants readily identified familiar melodies sung by novel individuals even when their parents' renditions of those melodies only roughly matched the new performances. This finding speaks to parents and early-childhood educators who favor high-quality, professionally recorded music as a source of infants' song exposure. Caregivers with low confidence in their musical abilities need not worry that the effects of their live singing are reduced by their lack of extensive musical training: In our experiments, we could not predict infants' behaviors at test from their parents' musical abilities.

Our findings suggest an early link between live song and social engagement that is independent of songs' semantic content: Social responses were driven by melody alone. This link may be attributable to the early experiences of infants within their families, evolved predispositions to view songs as signals of a social connection, or both; our experiments do not distinguish between these interpretations.

Moreover, the present experiments do not reveal whether the selective-attention effect found in Experiment 1 was driven by the song being sung by a parent or by its being sung in person. It is possible that infants show social preferences for new singers of familiar songs only when those songs have been learned from family

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members. Alternatively, infants may show social preferences for new singers of songs learned from any friendly adult, but only when the adult sings to them in person. Further experiments using the same general methods as the present experiments could distinguish between these possibilities. For example, might infants display social preferences for novel singers of songs learned from family members who sing only over interactive video? We predict that they will. If so, further analyses of singing over live video could then determine the particular performance features that elicit social interpretations of music. For example, songs may convey social information to infants more effectively the more the singers are attuned to the infants' affective states, varying their singing style in a fashion coordinated with the infants' responses.

Whatever the findings of such studies, the present research demonstrates that the social information conveyed by a melody depends on its original source. We found that a melody conveys social information about its singer when it is sung by a parent, during the course of parent-infant interactions. In contrast, such social information is not conveyed when the melody is produced by a musical toy, even if the parent is highly engaged with the infant while playing with the toy, or when the melody is sung by an interactive but socially unrelated adult, even if the infant is highly engaged with that adult in interactive video sessions.

Why might melodies serve a social function? In small-scale human societies, child rearing is conducted by multiple individuals who communicate with one another, sharing language and music (e.g., Hrdy, 2009). Infants might do well to identify individuals who could care for them when a parent is not available, and attending to other people's speech and singing might facilitate such identification. Indeed, some researchers have proposed that the human music faculty evolved in the context of child rearing (e.g., Trehub, 2003). Our studies did not test any particular evolutionary theory, but this speculative interpretation of our findings is consistent with the possibility that in ancestral environments, infants' caregivers reliably produced melodies, and infants reliably listened to and remembered them.

Author Contributions

S. A. Mehr and E. S. Spelke designed the research. S. A. Mehr collected the data for Experiments 1, 2, 4, and 5. L. A. Song collected the data for Experiment 3, under the supervision of S. A. Mehr and E. S. Spelke. S. A. Mehr analyzed the data. S. A. Mehr and E. S. Spelke wrote the manuscript.

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Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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Supplemental Material

Additional supporting information can be found at http://pss.sagepub.com/content/by/supplemental-data

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Notes

1. All regressions reported in this article were bootstrapped with 40,000 replications and subsequently validated with sensitivity analyses, to ensure that their results were not attributable to the presence of influential observations.
2. Parents volunteered this information when they returned to our lab to participate in unrelated studies.

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