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Melody recognition by two-month-old infants

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Abstract: Music is part of an infant's world even before birth, and caregivers around the world sing to infants. Yet, there has been little research into the musical abilities or preferences of infants younger than 5 months. In this study, the head turn preference procedure used with older infants was adapted into an eye-movement preference procedure so that the ability of 2-month-old infants to remember a short melody could be tested. The results show that with minimal familiarization, 2-month-old infants remember a short melody and can discriminate it from a similar melody.

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1. Introduction

Although 6-month-old infants do not demonstrate knowledge of culturally specific characteristics of either musical pitch structure (Lynch *et al.*, 1990; Trainor and Trehub, 1992) or metrical structure (Hannon and Trehub, 2005), their perception of melody is adult-like in many ways. They can remember musical pieces for weeks (Ilari and Polka, 2006; Trainor *et al.*, 2004; Saffran *et al.*, 2000), discriminate single note changes to a short melody (e.g., Trehub *et al.*, 1985; Trainor and Trehub, 1992), and recognize melodies in transposition (e.g., Chang and Trehub, 1977; Trainor and Trehub, 1992; Plantinga and Trainor, 2005). The presence of these skills early in development suggests that humans begin life with a predisposition to process music. However, little is known about the music processing abilities of infants younger than 5 months, although experience with sound begins before birth and very young infants are exposed to music through infant-directed singing, the musical qualities of infant directed speech, and music in the general environment (from television, radio, etc.). The ability of 2-month-old infants to remember a short melody immediately following familiarization was tested in this study.

At birth or soon after, infants appear to have the perceptual capabilities required to process the pitch and timing information necessary for the perception of music. With respect to pitch, by 35 weeks gestational age (GA), the fetus responds to pure tones at frequencies ranging from 100 to 3000 Hz (Hepper and Shahidullah, 1994). At birth infants can discriminate upward from downward pitch contours (Carral *et al.*, 2005). By 2 months after birth, infants show cortical EEG responses to a change of one semitone in the pitch of piano tones (He *et al.*, 2007). By 3 months, frequency resolution approaches that of adults for all but high frequencies (Werner and VandenBos, 1993) and is finer than is required for musical purposes (Trehub, 2001). With respect to timing, at 2 months infants can discriminate tempo changes to an isochronous tone sequence (Baruch and Drake, 1997) and can discriminate simple rhythmic patterns (Demany *et al.*, 1977).

Further evidence that in the first months after birth infants have the prerequisites to perceive music comes from auditory research using speech stimuli. At birth, infants are sensitive to pitch contours in speech and can use contour information to categorize words (Nazzi *et al.*, 1998). Neonates can use prosodic information (characteristic pitch and rhythm patterns) to distinguish between their native language and an unfamiliar one with different prosodic structure (Mehler *et al.*, 1988; Moon *et al.*, 1993). Third trimester fetuses

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(DeCasper *et al.*, 1994) and neonates (DeCasper and Spence, 1986) can recognize a poem or story that their mothers read repeatedly during the last trimester of pregnancy.

The present study examines whether 2-month-old infants can remember a brief melody after a short familiarization of 15 repetitions. A conditioned head-turn procedure is often used to test older infants, but 2-month-olds do not have good control of head movements (Kemler-Nelson *et al.*, 1995). For the present study, an eye-movement preference procedure was developed in which infants controlled how long they listened to the familiarized melody and how long they listened to a novel melody through their eye movements rather than their head movements. Memory for the familiarized melody was expected to manifest as a preference for that melody over the novel melody on the basis of previous studies with speech stimuli (De Casper *et al.*, 1994; De Casper and Spence, 1986; Moon *et al.*, 1993; Mehler *et al.*, 1988).

2. Method

2.1 Participants

Sixteen healthy full-term infants (eight females, eight males) between 2 and 3 months of age (average age 84 days) with no known hearing impairments participated in the study. Data from another 11 infants were not used due to low correlation between raters' judgments of looking behavior (six) or because the infants did not finish testing due to fussiness (five).

2.2 Stimuli and apparatus

The stimuli consisted of the first phrase of each of two old English folk songs, "Country Lass" and "Painful Plough," following studies using these as stimuli in 6-month-olds (Trainor *et al.*, 2004; Plantinga and Trainor, 2005). Both songs are simple in structure, but unlikely to be familiar to the infants, and both are in a similar folk song style. The excerpts were equated for number of notes (14) and playing time (5.8 s). The songs differ in meter (6/8 and 4/4) and mode (G major and G minor).

The stimuli were produced using the acoustic piano instrumentation in the Cakewalk program on a personal computer with a Sound Blaster AWE64 Gold sound card, and recorded using Cool Edit. For familiarization and testing, the sounds were presented by a Macintosh G5 computer, an NAD C352 stereo integrated amplifier, and two audiological GSI speakers. The speakers were located inside a large sound attenuating booth (Industrial Acoustics Co.).

2.3 Procedure

After the procedure was explained to the parent and a consent form was signed, the parent and the infant were taken into the sound-attenuating booth. The parent placed the infant in a car seat which was facing a 23-in. Apple flat computer screen. A camera located under the computer screen was connected to a Macintosh G4 computer so that the experimenters outside the booth could view an image of the infant. The parent was seated behind the infant in the booth so that he/she could remain with the infant, and wore headphones over which masking music was played during the entire procedure. Once the parent and infant were settled and comfortable, the experimenter left the booth and closed the door. During familiarization, the infant was presented with 15 repetitions of either the Country Lass phrase or the Painful Plough phrase, with random assignment to this familiarization melody. Then an eye movement preference procedure was used for testing the infant's memory. An animated stimulus appeared in the middle of the computer screen in front of the infant to attract the infant's attention. Two observers watched the infant on the computer screen outside the booth and independently judged where the infant was looking. Each observer had a keypad that was connected to the Macintosh G5 computer and was unaware of the response of the other observer. Once both observers judged that the infant was looking at the center of the screen (indicated independently with a key press on each key pad), the animated stimulus disappeared and a still visual target appeared on either the left or the right side of the computer screen. When both observers indicated by pressing a second key on each pad that the infant was looking at the visual target, the music for that trial began. Once both observers indicated that the infant had looked away (by releasing the key for more than 1 s), the

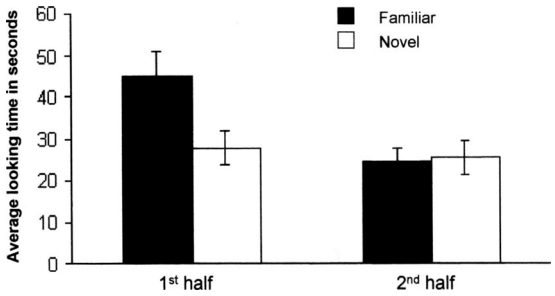

Fig. 1. Infants preferences as measured by the amount of time they chose to listen to the familiar compared to the novel melody. In the first half of the trials, infants preferred the familiar compared to the novel melody, indicating that they recognized the familiar melody. In the second half of the trials, looking times decreased overall, and the preference disappeared, suggesting that habituation had occurred.

trial ended, the music stopped, and the visual target disappeared. The animated stimulus reappeared in the center of the screen and the procedure was repeated, with the visual target appearing on the opposite side of the monitor screen from the previous trial. The infant was presented with the familiar melodic phrase on trials with the visual target on one side and the novel melodic phrase on trials with the visual target on the other side. First song (novel, familiar) and first side of presentation (left, right) were counterbalanced across participants. The observers were unable to hear the sounds, so they were unaware of which song was being presented on any particular trial. The experiment ended when 5 min had elapsed from the start of testing. The computer kept track of the time that each observer pressed the key for each trial, calculated the time the infant spent listening to each stimulus on each trial (the longer of the two observers' times), and calculated the correlation between the two raters' judgments of looking times over the experiment. The correlation between raters' judgments was required to be greater than 0.8 for the data from an infant to be included in the final sample.

3. Results

Infant preference shifts from familiar to no preference to novel with increased exposure to a stimulus (Rose *et al.*, 1982). To investigate whether this shift occurred over the trials of the testing, the looking time for each half of the total number of trials for each infant was computed and an ANOVA, with novel/familiar melody and test half as independent measures and mean listening times as the dependent measure, was performed. It revealed a significant effect of half, $F(1\ 15)=6.46$, $p=0.02$, with listening times decreasing from the first to second half. The only other effect was a significant interaction of novel/familiar × half, $F(1,15)=13.26$, $p=0.003$ (Fig. 1). Dependent-sample t-tests on novel and familiar listening times for each half showed that listening times to the familiar phrase were significantly greater than listening times to the novel phrase in the first half, $t(15)=3.42$, $p=0.004$, but not in the second half, $t(15)=0.21$, $p=0.83$ (Fig. 1). The disappearance of the preference in the second half is likely because by this time the "novel" phrase had been heard a number of times during the testing and was therefore no longer novel. Indeed, listening times decreased significantly from the first to second half, suggesting that the melodies were becoming less interesting in general with repetition.

4. Discussion

The prevalence across human cultures of singing to infants and talking to infants using "musical" infant-directed speech has been noted many times (e.g., Trehub, 2001; Trehub and Trainor, 1998; Trehub and Schellenberg, 1995; Trainor and Schmidt, 2003). The results of the present study show that infants as young as 2 months remember and discriminate a familiar from a novel melody after minimal exposure, so they are sensitive to the sequential pattern information in melodies.

The eye-movement preference methodology developed here provides a means with which to explore a number of critical aspects of infant musical processing. For example, after the minimal exposure to the melodies of the present study, infants showed a familiarity preference. However, after sufficient exposure, young infants would be expected to demonstrate a novelty preference, as is the case with older infants (Plantinga and Trainor, 2005). Determining the amount of exposure needed for familiarity and novelty preferences between 2 and 6 months of age would allow exploration of the development of musical memory across this age span.

Another critical question concerns relative pitch processing (i.e., the pitch distances between tones as opposed to the absolute pitches of the tones). A number of studies have shown that infants 6 months and older readily process relative pitch in that they recognize melodies when transposed to higher or lower pitch levels (Chang and Trehub, 1977; Plantinga and Trainor, 2005; Trainor and Trehub, 1992). At the same time, it has been suggested that only absolute pitch is available early in life, and that relative pitch develops with exposure to music (Saffran and Griepentrog, 2001; Sergeant and Roche, 1973). In order to understand the development of melodic pitch processing, it is therefore critical to test when infants are able to recognize melodies in transposition.

In summary, the present study developed a new methodology for testing discrimination in infants younger than 5 months of age and used this methodology to show that infants as young as 2 months can remember a short melody and can discriminate between the familiar and a novel melody.

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