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Brief article

Infant memory for musical experiences

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Abstract

Recent findings suggest that infants can remember words from stories over 2 week delays (Jusczyk, P. W., & Hohne, E. A. (1997). Infants' memory for spoken words. *Science*, *277*, 1984–1986). Because music, like language, presents infants with a massively complex auditory learning task, it is possible that infant memory for musical stimuli is equally powerful. Seven-month-old infants heard two Mozart sonata movements daily for 2 weeks. Following a 2 week retention interval, the infants were tested on passages of the familiarized music, and passages taken from similar but novel music. Results from two experiments suggest that the infants retained the familiarized music in long-term memory, and that their listening preferences were affected by the extent to which familiar passages were removed from the musical contexts within which they were originally learned.

Keywords: Infants; Music; Long-term memory

1. Introduction

Music and language are arguably the two auditory domains that most compellingly attract infant listeners. This is unlikely to be a coincidence; the prosodic patterns of language, which are of great interest to infants, are themselves highly musical. Across both domains, parents generate infant-directed signals which differ

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from adult-directed speech and music in their characteristic pitch and rhythmic structures, and which are preferred by infant listeners (e.g. Cooper & Aslin, 1990; Fernald, 1989; Masataka, 1999; Trainor, 1996; Trainor & Zacharias, 1998). Infants are also engaged in acquiring fine-grained information about how their native linguistic and musical systems work. To do so, infants must begin to extract and store particular exemplars from their auditory environment.

Little is currently known about the extent to which infants maintain specific auditory experiences in long-term memory. Jusczyk and Hohne (1997) found that after repeated exposure to words embedded in fluent speech, 7-month-old infants remembered the familiarized words for several weeks. Infant memory for musical stimuli may be equally powerful; when a particular musical selection is played in an operant conditioning paradigm, it serves as a powerful cue during later recall of the conditioned response (Fagan, Prigot, Carroll, Pioli, Stein & Franco, 1997). As yet, however, it is unknown whether infants remember music heard during passive listening experiences.

To ask whether infants show long-term memory for particular pieces of music, we adapted the methods used by Jusczyk and Hohne (1997). We first gave 7-month-old infants daily exposure to the slow movements from two Mozart piano sonatas. Then, following a 2 week retention interval during which the infants did not hear these pieces, we assessed infants' long-term memory for the sonatas using the head turn preferential listening procedure (e.g. Kemler Nelson, Jusczyk, Mandel, Myers, Turk & Gerken, 1995). The critical question is whether infants listen differentially to familiar and novel passages during testing due to their prior musical experiences. We predicted that the infants would prefer to listen to the familiar musical passages, analogous to the results from the Jusczyk and Hohne (1997) language study. To ensure that the experimental group's performance was not due to arbitrary musical preferences, we also tested a control group of infants without prior exposure to these pieces.

2. Experiment 1

2.1. Method

2.1.1. Participants

Eleven infants completed both the 2 week exposure and the laboratory testing phase (mean age at test 7 months 4 weeks (7:4), range 7:3–8:2). An additional four infants did not complete the laboratory testing phase due to fussiness (three) or listening times less than 3 s to one or both sides (one). Fourteen infants were assigned to the control group, and completed only the laboratory testing phase (mean age at test 8:0, range 7:3–8:2). An additional nine infants assigned to the control group did not complete testing due to fussiness (four) or listening times less than 3 s to one or both sides (five). All infants were free of ear infections for the duration of the study. Parental consent was obtained prior to testing.

2.1.2. Stimuli

The experimental stimuli were drawn from a Phillips CD recording of Mozart's first four piano sonatas (composed late 1774/early 1775, performed by Mitsuko Uchida). Two sonata movements (10 min of music) were recorded on audiotape for at-home playback to the infants: KV 281 (B-flat major, Andante) and KV 282 (E-flat major, Adagio). These two movements served as the stimuli for the 2 week exposure phase; their order was counterbalanced on the audio tapes.

Two different types of test passages were generated for the laboratory testing phase. The familiar test stimuli were 20 s passages taken from the two familiarized sonata movements. The passages were drawn from the middle of each piece, and were chosen to sound coherent when played in isolation. The novel test stimuli were also coherent 20 s passages taken from the same CD recording: KV 280 (F-major, Adagio) and KV 283 (G-major, Andante).

2.1.3. Procedure

During the exposure phase, infants in the experimental group listened to the two sonata movements at home, once a day, for 14 days. Parents were asked to play the music at a time when their child was quiet and alert. Each parent was given a log in which to record the time at which the recording was played each day, and to note the infants' activities while listening. Parents also filled out a musical background questionnaire for themselves and their infant. After the 14 days of daily listening, parents were asked to refrain from playing the recordings for their infant until their appointment for testing in the lab 2 weeks later.

During the testing phase, both the infants in the experimental group (who had participated in the exposure phase) and the infants in the control group (who had no prior exposure to these pieces of music) were assessed in the lab using the preferential listening technique. Each infant was tested individually while seated in a parent's lap in a double-walled sound-attenuated booth. An observer outside the booth monitored the infant's looking behavior on a closed-circuit TV system and coded the infant's behavior using a button-box connected to the computer. This button-box was used to initiate trials and to enter the direction of the infant's head turns, which controlled the duration of each test trial. Both the parent and the observer listened to masking music over headphones to eliminate bias. Twelve test trials were presented (three trials for each of the four test items, presented in random order). The four test items consisted of two 20 s passages from the familiar sonata movements and two 20 s passages from the novel sonata movements. Each test trial began with the blinking light on the front wall. When the observer signaled to the computer that the infant was fixating this central light, one of the lights on the two side walls began to blink and the central light was extinguished. When the observer judged that the infant had made a head turn of at least 30° in the direction of the blinking side light, a button press signaled to the computer that one of the test passages should be presented from the loudspeaker adjacent to the blinking light. The test passage was played until the conclusion of the passage, or until the observer coded the infant's head turn as deviating away from the blinking light for 2 s consecutively. When this look-away criterion was met, the computer extinguished

the blinking side light, turned off the test stimulus, and turned on the central blinking light to begin another test trial. The computer accumulated the total looking time to each test passage.

2.2. Results and discussion

Mean listening times for the familiar and novel musical passages were calculated for each infant (see Fig. 1). There was a significant difference in listening times for infants in the experimental group ($t(10) = 2.52$, $P < 0.05$). However, the direction of the preference was contrary to our prediction; ten of the 11 infants preferred the novel passages to the familiar passages. We also examined the performance of the infants in the control group, for whom all of the test passages were novel. These infants did not show a significant preference for either type of test passage (seven of the 14 infants tested preferred the novel passages to the familiar passages) ($t(13) = 0.55$, NS). An ANOVA contrasting listening time differences for the familiar versus novel test passages revealed a trend towards a significant difference between the experimental and control conditions ($F(1, 23) = 3.95$, $P < 0.06$).

Two interesting findings emerged from this experiment. First, the infants in the experimental group discriminated the familiar and novel test passages. Because the control group did not show a preference for either type of test passage, the results from the experimental group are unlikely to be due to the particular characteristics of the passages played during testing. Instead, these results suggest that infants in the experi-

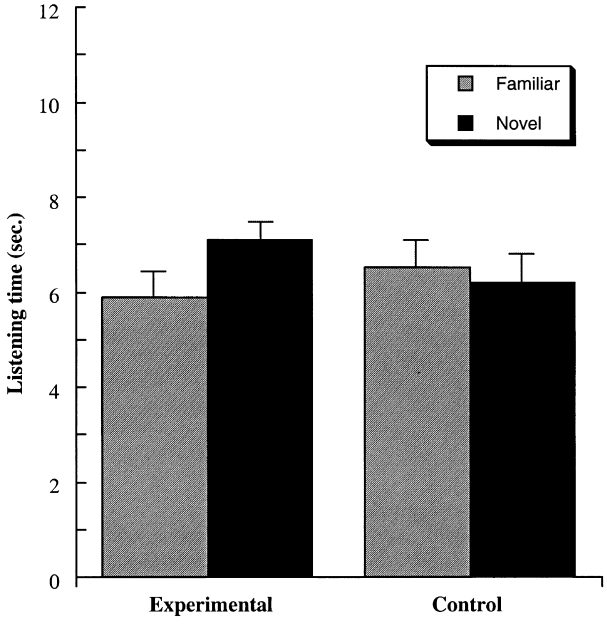

Fig. 1. Experiment 1: listening times for familiar and novel test passages for infants from the experimental (prior exposure) and control (no prior exposure) groups.

mental group recognized passages of music last heard 2 weeks previously in the context of the full sonata movement. The second finding pertains to the direction of infants' preferential listening response: infants in the experimental group preferred to listen to novel musical passages, rather than the passages from music with which they had been previously familiarized. These findings stand in contrast to the results from the linguistic long-term memory study by Jusczyk and Hohne (1997), in which infants preferred to listen to words drawn from familiar stories. While the test passages used in the current experiments were far longer than the test words used by Jusczyk and Hohne (1997), this factor is unlikely to explain the novelty preference that we observed, as other studies by Jusczyk and collaborators have elicited familiarity preferences with longer test passages (e.g. Jusczyk & Aslin, 1995).

Why did the infants prefer the novel musical passages? One hypothesis is that the infants had achieved mastery of the familiar music. Once a stimulus has been deeply encoded, its interest value may wane, such that stimuli that are less well encoded increase in their relative interest to the infant (e.g. Aslin, 2000). Factors shown to influence the shift from familiarity to novelty preferences include the number of exposures, age, and the complexity of the task (e.g. Hunter & Ames, 1988; Rose, Gottfried, Melloy-Carminar & Bridger, 1982; Wetherford & Cohen, 1973). Another factor, the amount of delay, predicts a shift from novelty to familiarity as more time intervenes between exposure and test (e.g. Spence, 1996); however, this factor would predict the opposite pattern of results from those we obtained.

The second hypothesis concerns the relationship between the sonata movements with which infants had been familiarized and the passages played during testing. The familiar test passages were drawn from the middle of each of the two sonata movements heard during the home-based exposure sessions. These passages may have sounded unnatural to infants in the experimental group because they were played out of musical context. That is, they were preceded by silence rather than by the first half of the sonata movement. As an analogy, consider a passage of text taken from a story. To a reader unfamiliar with the story, a passage taken out of context might seem perfectly coherent. However, for a reader who knows what typically precedes the passage, the text in isolation, while recognizable, might appear unnatural in the absence of the full story. Similarly, the familiar musical passages used in our test may have been perceived as relatively unnatural because they were taken out of the musical context in which they were learned. If this is the case, then the infants might have preferred the novel passages due to their relative naturalness when played in isolation (unlike the familiar passages, the infants were unaware of the musical contexts from which the novel passages were drawn). This hypothesis is consistent with prior research suggesting that infants prefer to listen to naturally segmented auditory stimuli (e.g. Hirsh-Pasek, Kemler Nelson, Jusczyk, Wright Cassidy, Druss & Kennedy, 1987; Jusczyk, 1997; Jusczyk & Krumhansl, 1993; Krumhansl & Jusczyk, 1990). It is thus possible that the pattern of results obtained for the experimental group reflects the removal of the familiar passages from their musical contexts. On this view, infants in the control group showed no such preference because they were unaware of the contexts from which the test passages were drawn, and the familiar and novel passages were thus perceived as equally natural.

The second experiment was designed to test these two hypotheses. A second group of 7-month-old infants was familiarized with the same two sonata movements, following procedures identical to Experiment 1. Following a 2 week retention interval, the infants were tested in the laboratory on two different types of *familiar* passages: passages taken from the middles of the sonatas (the familiar passages used in Experiment 1), and the beginning passages from the two familiarized sonatas. If the results of Experiment 1 reflected mastery as reflected by relative disinterest in the familiar music, then the infants should now prefer the *middle* passages, as the beginnings are presumably more memorable and should be more deeply encoded than the middle passages. However, on the musical context hypothesis, infants should prefer the familiar passages taken from the *beginnings* of the sonatas. Even in the context of the full sonata movements, the beginning passages were always preceded by silence. Thus, unlike the passages taken from the middles of the sonatas, the beginning test passages were not removed from their musical context when played in isolation.

3. Experiment 2

3.1. Method

3.1.1. Participants

Twelve infants completed both the 2 week exposure phase and the laboratory testing phase 2 weeks later (mean age at test 8:1, range 7:4–8:2). An additional three infants did not complete the laboratory testing phase due to fussiness (two) or equipment failure (one). Fourteen infants were assigned to the control group, and completed only the laboratory testing phase (mean age at test 8:0, range 7:3–8:2). An additional seven infants assigned to the control group did not complete the laboratory testing phase due to fussiness.

3.1.2. Stimuli

The stimuli for the exposure phase were identical to Experiment 1. For the test phase, the passages from the middles of the familiar sonata movements were the familiar passages from Experiment 1. Two additional 20 s passages were drawn from the beginnings of the two familiar sonatas.

3.1.3. Procedure

The procedure for both the exposure and test phases was identical to Experiment 1.

3.2. Results and discussion

As in Experiment 1, there was a significant difference in listening times for infants in the experimental group ($t(11) = 2.86$, $P < 0.05$) (see Fig. 2). The direction of the preference was consistent with the musical context hypothesis: 11 of the 12 infants preferred the passages from the beginnings rather than the middles of the familiar-

ized sonatas. The infants in the control group did not show a significant preference for either type of test passage, suggesting that the results from the experimental group are unlikely to be due to the particular characteristics of the passages played during testing ($t(13) = 0.98$, NS) (eight of the 14 infants preferred the passages from the beginnings of the sonatas). As in Experiment 1, an ANOVA contrasting listening time differences for the beginning versus middle test passages revealed a trend towards a significant difference between the experimental and control conditions ($F(1, 24) = 4.04$, $P < 0.06$).

The observed preference for the passages drawn from the beginnings of the sonata movements suggests that naturalness with respect to musical context affects infant preferential listening behavior. The beginnings of the sonatas are presumably encoded more deeply than the middles, suggesting the possibility of primacy effects. However, primacy effects are unlikely to explain the current pattern of results. If infants prefer musical passages which are deeply encoded over those which are less deeply encoded, the opposite pattern of results should have emerged in Experiment 1: infants should have preferred the familiar passages over the novel passages. Instead, infants preferred the novel passages. The results of Experiments 1 and 2, taken together, strongly suggest that infant listening preferences are influenced by the relationship between the tested musical passages and the musical contexts within which those passages were originally learned.

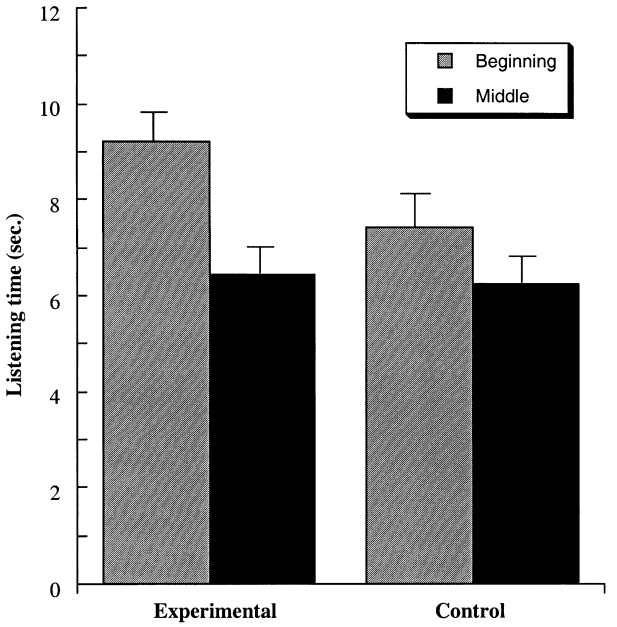

Fig. 2. Experiment 2: listening times for passages from the beginnings and middles of the familiar music for infants from the experimental (prior exposure) and control (no prior exposure) groups.

4. General discussion

The results of Experiments 1 and 2 support the hypothesis that infants remember the music that they hear, and can retain musical information over at least a 2 week delay following repeated passive exposure to complex pieces of instrumental music. Moreover, the results of Experiment 2, taken in concert with Experiment 1, suggest that the infants preferred musical passages that were not taken out of the musical context in which they were originally learned. Infants in the control group showed no such bias; the contexts from which these passages were drawn did not affect the listening preferences of infants who were unfamiliar with these pieces of music.

These results, along with other findings pertaining to infant short-term musical memory, discrimination abilities, and musical preferences (e.g. Schellenberg & Trehub, 1996; Trainor & Heinmiller, 1998; Trehub, Schellenberg & Hill, 1997; Zentner & Kagan, 1996), suggest that infants are sophisticated musical listeners. Their representations of music in long-term memory are not undifferentiated sequences of notes. Instead, passages are linked together to form coherent musical events. Future research will determine the basis upon which these musical links are formed (e.g. harmonic structure, melodic structure, rhythm), and the extent to which infant musical memory is enhanced by prior exposure to particular musical genres. The current results lend further support to an emerging picture of infants as remarkably adept at implicitly learning and remembering the structured information which characterizes the environment in which they develop (e.g. Gomez & Gerken, 1999; Jusczyk, 1997; Jusczyk & Hohne, 1997; Marcus, Vijayan, Bandi Rao & Vishton, 1999; Rovee-Collier, 1993; Saffran, Aslin & Newport, 1996; Saffran, Johnson, Aslin & Newport, 1999).

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