Infant-Directed Speech, not Melody, Facilitates Grammar Learning in Infants

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Abstract

Music can help both infants and adults learn a set of lyrics (Thiessen & Saffran 2009; Peretz, Radeau, & Arguin, 2004). Melodies may facilitate infants' lyric learning by eliciting their attention via notable pitch and rhythm variation. These characteristics are also representative of infant-directed speech, the sing-song language previously shown to facilitate language learning in infants. In this experiment, I investigated the ability of melody and infant-directed speech to facilitate infants' learning of linguistic information that is more complex than a simple set of lyrics. Fifteen-month-old infants were exposed to an artificial grammar, presented either in a singing voice paired with melodies or in infant-directed speech. The results show that melody's attention-eliciting ability is not sufficient to facilitate the learning of the grammatical patterns, while infant-directed speech successfully facilitates this learning. Infant-directed speech may be the speaking style best suited for the facilitation of complex linguistic learning in infants.

From lullabies to interactive toys, music fills infants' early experiences. One might assume that such musical input might be too complex for young infants to process. However, research has shown that infants display basic music processing abilities quite early. For example, six-month-olds attend to their mother longer when the mother is singing rather than speaking to them (Nakata & Trehub, 2004). Newborns and two-month-old infants also prefer to listen to consonant, rather than dissonant, pitch combinations, a preference that is maintained in adulthood (Butler & Daston, 1968; Masataka, 2006; Trainor, Tsang, & Cheung, 2002). Furthermore, American infants from the ages of four to eight months show a preference for the simple and regular meters of Western music over the irregular meters of Eastern European and African music (Soley & Hannon, 2010; London, 2005); this preference, like infants' preference for consonant pitch combinations, is also maintained in adulthood (Snyder, Hannon, Large, & Christiansen, 2006). Infants display a surprising depth of musical knowledge before they can speak, let alone sing.

Going beyond infants' musical preferences, researchers have investigated whether infants can use musical input as a learning tool. In one study, Thiessen and Saffran (2009) compared seven-month-olds' ability to learn a sequence of lyrics when they were presented with a consistent series of pitches (i.e., a melody) by a singing voice versus adult-directed speech (ADS). ADS is a speaking style characterized by a low fundamental frequency, and less variation in pitch and rhythm than is typically present in speech directed to infants. Generally, ADS does not facilitate learning in infants as well as other speaking styles (Thiessen, Hill, & Saffran, 2005). Thiessen and Saffran (2009) exposed infants to the lyric sequence (a set of numbers) in either ADS or with a melody and tested for their recognition of

the sequences in a listening preference test. In testing, infants who were presented with the sung lyrics listened longer to lyric sequences that violated the sequences they had previously heard than to the original lyrics, indicating that they had learned the lyric sequence. Infants presented with lyrics presented in ADS showed no difference in listening time. Moreover, the test items were all produced in ADS, potentially making the task harder for infants presented with sung stimuli. Infants could successfully generalize the lyric sequence to a different sounding voice. These results are remarkably similar to what has been observed in adults: research has shown that lyrics can aid in the recollection of a melody and, in turn, a melody can aid in the recollection of lyrics (Peretz et al., 2004).

A question that emerges from Thiessen and Saffran's (2009) findings is what characteristics of musical input make it possible for infants to connect a melody and a set of lyrics. Addressing this question, Thiessen and Saffran propose that musical stimuli may elicit infants' attention more effectively than ADS. Melody's ability to facilitate lyric learning may be attributed to the simple fact that infants like to listen to music (Trehub, 2006). For example, infants both display more positive affect and attend more while listening to consonant music, a music they prefer, than to music with many dissonant intervals (Trehub, 2006; Zentner & Kagan, 1998). Infants also fixate on their singing mothers and show a reduction of movement, a sign of deep engagement (Nakata & Trehub, 2004). When infants are attentive, as they would be to a melody, they may be better at learning the details of the stimuli to which they are attending.

Researchers have also proposed that other attention-eliciting stimuli may encourage learning in infants. Specifically, Thiessen et al. (2005) proposed that infant-directed speech facilitates language learning in infants in part because it is effective in maintaining infants' attention. Compared with ADS, IDS is distinguished by its higher overall pitch, slower rate of speech, greater pitch variation, and longer pauses between words. Thiessen et al. (2005) examined how IDS affects learning by presenting infants with novel words embedded in sentences spoken in either IDS or ADS. Infants were able to detect the words from sentences presented in IDS, but not those in ADS. Importantly, the stimuli were designed such that the IDS did not include any additional word boundary cues (e.g., pauses, word-final syllable lengthening, or emphasis). The authors proposed that infants may have learned from the IDS sentences more effectively because they found the exaggerated prosody and pitch variation of IDS more interesting and were better able attend to the stimuli; this increased attention to stimuli promoted the learning of its structure. Sung melodies share many characteristics of IDS, such as exaggerated pitch variation and word lengthening. Thus, Thiessen and Saffran's (2009) finding that melody facilitates infants' lyric learning could very well be explained by melody's ability to elicit attention more effectively than ADS.

With its attention eliciting abilities, can musical input facilitate other aspects of linguistic learning in infants? Lyric sequences are composed of linear strings of words; linguistic learning, however, involves more complex tasks. Grammar learning, for example, involves the recognition of complex word patterns (Gomez & Maye, 2005; Gomez & Gerken, 2000; Mintz, 1996). In the present experiment, we explored how melody affects the learning of grammatical information by comparing fifteen-month-old infants' learning of an artificial grammar when the sequences were paired to melodies and sung or presented in another attention-eliciting style,

IDS. Importantly, the sung sequence did not provide consistent musical cues to the grammatical information available in the spoken sequences. For comparison, a third group of infants heard the grammatical sequences in ADS. We used an artificial grammar to ensure that all infants had no prior experience with the language. This allowed us to measure what they learned during their time in the study, not what they already knew about their native language. The task is more complex than previous lyric learning tasks with younger infants (Thiessen & Saffran, 2009) and is better suited to examining effects on learning in infants at this age (Gomez & Maye, 2005; Gomez & Gerken, 2000). We predicted that the melodies would allow for stronger learning than ADS, because its pitch and rhythm variation should support infants' attention more effectively than ADS, and should therefore promote learning. We also predicted that IDS would promote learning when compared to ADS, similar to the findings of Thiessen et al. (2005). Finally, we predicted that the infants in the melody and IDS conditions would display similar levels of learning.

Methods

Participants

Thirty 15-month-old English-speaking infants participated in this study (Mean age= 14.9 months, range= 14.5-15.5). There were 10 infants in the ADS condition, 10 in the IDS condition, and 10 in the Sung condition. Infants had had fewer than five ear infections, limited second language exposure (less than 35%), and no history of hearing or visual impairments. Data from 22 additional infants were excluded due to fussiness (20) or experimenter error (2).

Stimuli

A female English speaker recorded syllable sequences following an artificial grammar, modeled after the stimuli used by Gomez and Maye (2005). The grammar was composed of two nonadjacent (aXb) grammatical patterns: *pel X rud* and *vot X jic*. The word *pel* always predicted the occurrence of the word *rud* after an intervening X element, and the word *vot* always predicted the occurrence of the word *jic* after an intervening X element. The twenty-four X elements were *balip, benez, chilla, coomo, deecha, feenam, fengle, gensim, gople, hiftam, kicey, laeljeen, loga, malsig, nilbo, plizet, puser, roosa, skiger, suleb, taspu, vamey, wadim, and wiffle* (Gomez, 2002). The exposure stimuli were composed of each X element inserted into each nonadjacent pattern, summing to 48 phrases total. The phrases were repeated twice during exposure. The phrases were presented in a pseudo-random order, with the constraint that no nonadjacent pattern could repeat more than three times consecutively. Previous work by Gomez and colleagues has shown that infants at fifteen months can learn these grammatical patterns when presented in speech with positive affect (similar to IDS). We selected this artificial grammar task because it is challenging for infants at this age, yet they are able to learn the patterns under some circumstances (Gomez & Maye, 2005).

The speaker recorded the phrases in 3 styles: 1) IDS, with exaggerated pitch variation, 2) ADS, with minimal pitch variation, and 3) sung to twenty-four specific pitch sequences (see Appendix, Table 1). In the Sung condition, the melodies were designed to avoid any pitch-related nonadjacent patterns; specifically, the phrases were randomly assigned to melodies, with the constraint that each nonadjacent

pattern was paired with any pitch sequence twice in the string of phrases. This eliminated the possibility of statistical redundancies, as each melody was equally likely to be paired with either grammatical pattern. Each exposure sequence was recorded at 92 beats per minute with 1 second of silence between the phrases. Each exposure section lasted 4 minutes and 17 seconds.

Based on the method used in Thiessen and Saffran's (2009) test of the effect of melody on lyric learning, a second female English speaker recorded the test stimuli, and all test trials were recorded in ADS so that the same test items could be used for all conditions. Recording the test stimuli in ADS allowed us a more conservative test for the IDS and Sung infants' learning of the grammatical pattern. Infants show difficulty displaying learning if the test stimuli differ significantly from the exposure stimuli (Hunter & Ames, 1988). If infants display learning across speaking styles, we can infer that they have securely learned the nonadjacent grammatical pattern and are able to generalize the pattern to speaking styles that differ from the speaking style of the exposure stimuli (Thiessen & Saffran, 2009). With the test items recorded in ADS, infants in the ADS condition had a simpler task than those of the IDS and Sung conditions, since the infants did not need to generalize the grammatical pattern to a different speaking style to display learning. Thiessen and Saffran (2009) addressed this problem by using a second speaker to record the test stimuli, ensuring that the test stimuli also differed from the ADS condition's exposure stimuli. We used this same technique to prevent infants in the ADS condition from possessing an undue advantage over those in the other conditions. Like the infants in the IDS and Sung conditions, the infants in the ADS condition had to generalize the grammatical pattern in some capacity to display learning. However, unlike the infants in the IDS and Sung conditions, they only had to generalize the pattern across speakers, not across speaking styles.

In testing, there were four familiar trials, which consisted of the same nonadjacent patterns present in the exposure stimuli, and four novel trials, in which the pairings of the *a* and *b* elements were switched across the patterns (*pel X jic* and *vot X rud*). The trials consisted of six sentences, with three X elements embedded into the two nonadjacent patterns (see Appendix, Table 2).

Procedure

Each infant was randomly assigned to the ADS, IDS, or Sung condition. They passively listened to the exposure stimuli in a soundproof room filled with age appropriate toys, supervised by a parent. To ensure the best environment for absorption of the material, the parent was instructed not to speak to the infant. We then moved the infant and his or her parent to the testing booth, where we tested recognition of the familiar grammatical pattern using the Listening Preference Procedure (based on the Headturn Preference Procedure; Aslin, 2000). Each infant was seated on its parent's lap in front of a large monitor. The parent listened to masking music through a set of headphones. The program Habit was used to display visual and auditory stimuli on the monitor. Because of the time lapsed as the parent and infant were moved to the testing booth, a 30-second segment of the exposure phrases was played for the infant as a brief refresher. We then played a pretest trial to familiarize infants with the visual stimulus of an orange spinning petal, which was paired with the audio stimuli during testing. The infants' attention to the audio stimuli was measured by the duration of their fixation to this visual

stimulus as it is paired with each test item. During the pretest trial, it was paired with repetitions of the word "look." We included the pretest trial because pilot testing indicated that infants' attention was inflated on the first trial in which the visual stimulus was presented. The pretest trial allowed the infants to become accustomed to the visual stimulus before listening to the test trials.

Each infant heard eight test trials, four containing the familiar nonadjacent patterns and four containing the novel nonadjacent patterns, in one of four randomized orders. A cartoon clip was used to bring the infant's attention to the monitor before each trial. Once the infant was fixated, the experimenter presented the test item. The test trial played as long as the infant attended to the screen. The experimenter recorded the duration of the infant's attention to each trial and advanced to the next trial once the infant looked away for more than 2 seconds. The dependent variable was the difference in listening time to the novel stimuli versus the listening time to the familiar stimuli. Discrimination of the sequences indicated that infants were sensitive to the nonadjacent pattern defined by the exposure stimuli. Therefore, infants who displayed a looking preference had developed this sensitivity.

Results

We performed a series of planned comparisons to examine infants' listening time to the familiar and novel test trials in each group (see Figure 1). For infants in the ADS condition, a paired samples *t*-test indicated that the looking times between the familiar and novel grammatical patterns was not significant *(t(*9) = .7, $p > .05$). Four of the 10 infants attended longer to the novel grammatical pattern than to the familiar pattern. For infants in the Sung condition, there was also no significant difference between familiar and novel patterns *(t(*9) = .3, $p > .05$). Four of the ten infants attended longer to the novel grammatical pattern than to the familiar pattern. In contrast, the paired samples *t*-test indicated that the looking times between the familiar and novel grammatical patterns of the infants in the IDS condition was statistically significant ($t(9) = 2.41$, $p < .05$). Eight of the ten infants attended longer to the novel grammatical pattern than to the familiar pattern.

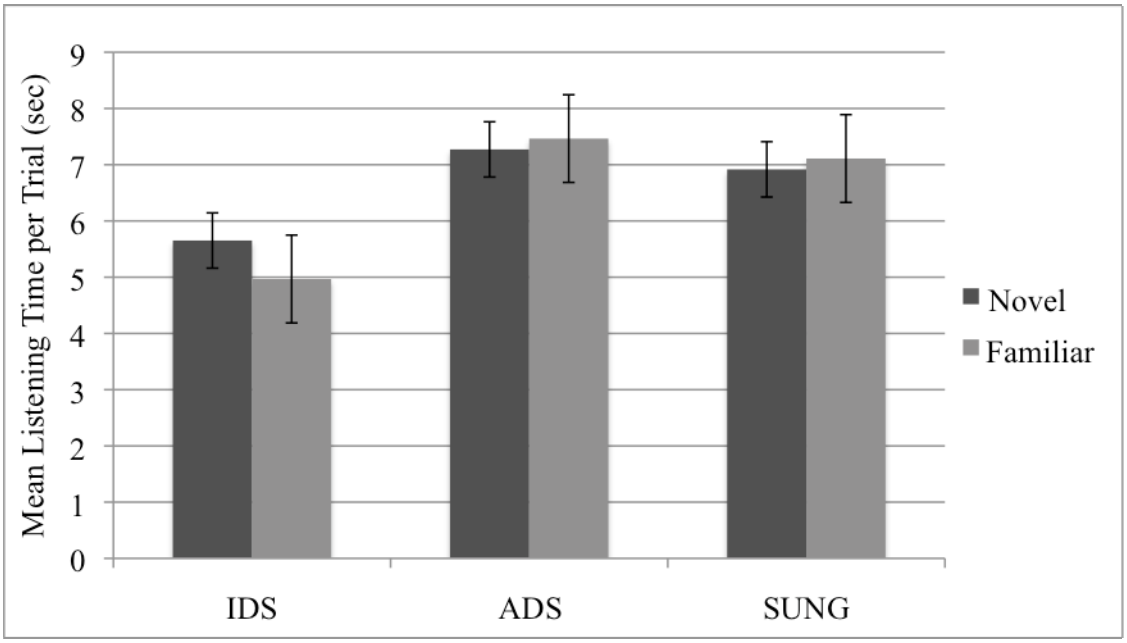

Figure 1. IDS infants showed a significant preference for the novel grammatical phrases, while Sung and ADS infants showed no significant preference. Only infants who heard the grammatical phrases in IDS displayed learning.

These results indicate that infants in the Sung and ADS conditions were not able to discriminate between the novel and familiar grammatical patterns, suggesting that they did not learn the grammatical pattern to which they were initially exposed. The infants in the IDS condition showed a significant preference for the novel stimuli, indicating that they had learned the familiar grammatical pattern.

Discussion

We found that infants learned the nonadjacent grammatical pattern if it was presented in IDS, but not in ADS or paired with melodies. This result suggests that musical stimuli do not readily help infants learn a complex grammatical pattern. We hypothesized that, much like the attention-eliciting characteristics of IDS, a melody would be able to fix infants' attention on the stimuli, thus facilitating learning. Our results, however, suggest that a melody's attention-eliciting ability is not sufficient to facilitate grammatical learning. On the other hand, IDS was able to facilitate learning of the grammatical pattern, despite the change is speaking styles from exposure to testing. The infants' ability to generalize across speaking styles suggests that IDS facilitated a high degree of learning. Infants who originally heard the stimuli in IDS recognized the pattern despite its presentation in ADS during testing, a conservative test of learning.

These findings are consistent with recent work investigating the ability of IDS to facilitate infants' language learning. Thiessen et al. (2005) found that infants can better segment words, or recognize individual words, from the stream of speech if the stream is presented in IDS. Graf Estes and Hurley (in preparation) found that IDS helps infants learn labels for objects when the labels are presented in isolation. Singh, Nestor, Parikh, & Yull (2009) found that IDS facilitates long-term word

memory in infants. Consistent with these findings, we found that IDS facilitates infants' learning of a complex grammatical pattern. Our work provides further evidence for the role of IDS as a strong facilitator of linguistic learning in infants. There is some debate among parents regarding whether "baby talk" is good for infants. Taken together, this research suggests that the sing-song speaking style of IDS can help infants learn about language and how it works.

We expected that melody, which is like IDS in its higher fundamental frequency and overall pitch variation, would function similarly. However, we observed no significant learning in the infants who heard the sung stimuli. This contrasts with the findings of Thiessen and Saffran (2009), who found that pairing melodies with lyrics facilitated the learning of those lyrics. One possible reason that our results differ from those of Thiessen and Saffran is that their Sung stimuli contained redundant musical cues that mirrored their lyrical pattern. That is, their stimuli provided overlapping sources of information that gave converging cues to the structure of the linguistic input. Research has shown that redundancies sometimes facilitate infants' ability to learn (Bahrick, Flom, & Lickliter, 2002; Gogate & Bahrick, 1998; Thiessen & Saffran, 2009). The cues, which are absent in more simplified input, provide infants with numerous within-stimuli regularities. An example of this pattern in music can be observed in the children's song "London Bridge Is Falling Down." The word *London* is always paired with the same notes and always comes before the word *bridge*. Therefore, the word *London* and its notes redundantly predict the occurrence of the word *bridge*. Similar redundancies have been shown to facilitate musical and lyrical pattern recognition in adults (Peretz et al., 2004; Trehub & Hannon, 2009). Therefore, Thiessen and Saffran's (2009) findings could be explained by the redundancies that a melody adds to a sequence of lyrics. Because we focused on the attention-eliciting aspects of melody, we carefully removed these cues, which may be a reason that the infants in the Sung condition failed to learn the grammatical pattern.

Perhaps the presence of non-redundant musical stimuli actively hindered the infants' ability to learn the grammatical pattern. It is possible that pairing a grammatical pattern with melodies that do *not* have redundant characteristics makes the stimuli *too* complex for the infants. In this case, the melody and the grammatical pattern do not overlap, and the infants may interpret each piece as two, unrelated pieces of stimuli as opposed to one cohesive unit. This complexity may therefore impede, rather than facilitate.

An alternate interpretation of our findings is that infants who heard the sung stimuli did learn the grammatical pattern, but were unable to generalize the learned pattern to ADS. Recall that infants struggle to recognize test stimuli that differ significantly from the exposure stimuli (Hunter & Ames, 1988). This generalization is a difficult task that requires infants to recognize a stimulus even when varied in its mode of presentation. In other words, generalization requires higher order learning than mere recognition. Perhaps the infants who heard the sung stimuli did absorb the grammatical patterns, but did not learn the pattern well enough to perform the more complex task of generalization, as they did in the IDS condition.

Finally, it may be that musical stimuli in general are a poor signal for complex linguistic information. Thiessen and Saffran (2009) successfully demonstrated that melodies facilitate infants' learning of a simple lyric sequence, or a linear progression of words. However, our stimuli were notably more complex than a

simple set of lyrics. They required detecting relationships across nonadjacent elements and detecting a higher order pattern. Additionally, in today's musical environment, melodies are not typically paired with linguistic information that is as complex as a nonadjacent pattern. IDS, on the other hand, acts as a good signal for linguistic information (Graf Estes & Hurley, in preparation; Thiessen et al., 2005; Singh et al., 2009). Melodies may not have facilitated learning of the grammatical pattern because they are not an appropriate medium for such complex linguistic stimuli.

Based on these interpretations of our findings, we propose the addition of two conditions to our current study. First, we will examine whether infants who hear the sung stimuli are able to display learning of the grammatical pattern if we eliminate their need to generalize the grammatical pattern to another speaking style. To do this, we will re-record the test stimuli to a series of sung melodies. In this condition, the speaking style of the exposure stimuli and the testing stimuli will be consistent. If infants display learning under these conditions, we will know that attention-eliciting melodies can facilitate the learning of complex linguistic information, though not as thoroughly as IDS.

Second, we will create an exposure condition that utilizes redundant melody sequences. This adjustment will more directly mirror the methods of Thiessen and Saffran (2009). In this condition, each grammatical pattern will be paired with a consistent musical pattern (e.g., *pel X rud* will be paired with the consistent pattern of high-low-high frequency, while *vot X jic* will be paired with the consistent pattern of low-high-low frequency). It is possible that when the melody contains redundant information, we will observe the learning of grammatical patterns, as Thiessen and Saffran (2009) observed with lyrical patterns.

The findings of this study provide additional support for IDS as a signal for complex information. Recent research indicates that IDS is better at facilitating infants' language learning than other speaking styles. Even melodies, which contain many of the characteristics of IDS, cannot encourage infants' learning to the same degree as IDS. Future research will be necessary to discover the conditions under which melodies facilitate language learning. However, it is clear that IDS remains a strong linguistic learning tool for infants.

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Appendix

Table 1.

24 pitch sequences and exposure pairings used in experiment.

Melody	*Pel X Rud* Phrases	*Vot X Jic* Phrases
G - F - Eb- D	pel skiger rud pel loga rud	vot chilla jic vot laeljeen jic
Bb - Bb - G - A	pel kicey rud pel coomo rud	vot wadim jic vot kicey jic
A - Bb - C - C	pel wadim rud pel chilla rud	vot taspu jic vot puser jic
D - C - C - Bb	pel suleb rud vot skiger jic	vot wiffle jic pel nilbo rud
Bb- C - D - D	pel malsig rud pel hiftam rud	vot deecha jic vot feenam jic
F - G – D - Eb	pel plizet rud pel fengle rud	vot feenam jic vot laeljeen jic
F - Eb - F - D	pel nilbo rud pel feenam rud	vot vamey jic vot roosa jic
G - Eb - G - F	pel balip rud pel taspu rud	vot deecha jic vot vamey jic
F - D – D - C	pel coomo rud pel roosa rud	vot gensim jic vot chilla jic
F - G - Bb - A	pel benez rud pel gensim rud	vot malsig jic vot benez jic
C - A - Bb - D	pel vamey rud pel taspu rud	vot taspu jic vot gensim jic
Bb - Bb - D - Eb	pel gensim rud pel laeljeen	vot fengle jic vot wadim jic
C - Bb - A - G	pel skiger rud pel wadim rud	vot plizet jic vot hiftam jic

C - A – D - Bb	pel roosa rud pel balip jic	vot balip jic vot roosa jic
Eb - F - Eb - D	pel gople rud pel deecha rud	vot fengle jic vot gople jic
A - G - Eb - F	pel puser rud pel laeljeen rud	vot nilbo jic vot wiffle jic
D - C - Bb - A	pel loga rud pel suleb rud	vot suleb jic vot malsig jic
F - A – D - C	pel fengle rud pel gople rud	vot coomo jic vot benez jic
D - C – G - G	pel benez rud pel hiftam rud	vot hiftam jic vot coomo jic
F - D – D - G	pel wiffle rud pel deecha rud	vot plizet jic vot loga jic
C - Bb - A - F	pel kicey rud pel wiffle rud	vot gople jic vot kicey jic
C - F – Bb - A	pel plizet rud pel malsig rud	vot loga jic vot skiger jic
D - F – Bb - C	pel feenam rud pel chilla rud	vot suleb jic vot nilbo jic
D - Bb – A - F	pel puser rud pel vamey rud	vot balip jic vot puser jic

Table 2. Test Phrases used in experiment.

Familiar Grammar Phrases	Novel Grammar Phrases
pel wadim rud	pel wadim jic
vot wadim jic	vot wadim rud