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Attention to Melodic versus Phonetic Cues in 8-Month-Old Infants

Alexandra M. Ryken
Huron University College, Western University, aryken@uwo.ca

ATTENTION TO MELODIC VERSUS PHONETIC CUES IN 8-MONTH-OLD INFANTS

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Alexandra M. Ryken

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Advisor: Dr. Christine Tsang

Reader: Dr. Mark Cole

The thesis by:

Alexandra M. Ryken

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Abstract

Infant listeners have very sophisticated auditory processing skills. In the music domain, infants as young as 6-months of age can recognize familiar and novel melodies (e.g., Trainor, Wu, & Tsang, 2004), and in the speech domain 8-month-old infants can use the statistical frequency of syllables to recognize familiar and novel nonsense words (e.g., Saffran, Aslin, & Newport, 1996). Though infants can process music and speech information when presented separately, there has been little research to date on whether infants can process information from both streams simultaneously. Auditory streams such as lullabies often contain both a melody and lyrics, but can infants process both at once? To test this, the present study familiarized 8-month-old infants to one of two melodies with nonsense lyrics. The lyrics were syllables arranged in a non-random order to form nonsense "words". Infants were then tested using a standard head-turn preference paradigm to determine whether they could recognize the melody or the "words". No significant main effects or interactions were found, but several interactions approached significance. The trends of this study suggest that infant listeners may have the cognitive resources necessary to process both music and speech information simultaneously. The trends also suggest that adding a lyrical component to a melody appears to facilitate memory for the melody. Possible reasons for these findings as well as implications and suggestions for future research are discussed.

Keywords: attention, lyrics, melody, facilitation, 8-month-old infants.

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Attention to Melodic versus Phonetic Cues in 8-Month-Old Infants

Language and music share many similarities. They are both forms of auditory input, and language and music are both composed of complex patterns of sounds governed by a rule-based system. They have a similar structure which varies over time. To adults, language contains additional semantic information and it would be difficult to confuse speech with music. To prelinguistic infants, neither speech nor music sounds have semantic meaning (Trehub, Trainor, & Unyk, 1993). Without semantic meaning to distract from the physical properties of language, the structural similarities between music and speech sounds are likely more apparent to young infants trying to make sense of what they hear (McMullen & Saffran, 2004). Despite these similarities, previous research has often examined infants' music and language processing separately from one another.

Music is arranged from a finite set of sounds, called notes or tones (McMullen & Saffran, 2004). The characteristics of musical arrangements can be divided into two categories based on the information they convey: surface characteristics and abstract structure (Trainor, Wu, & Tsang, 2004). Surface characteristics, also referred to as performance characteristics, include exact pitch, tempo, and timbre (Trainor et al., 2004). Pitch relates to the perception of the frequency of a note, for example "high" or "low". Tempo refers to the perceived temporal speed or pace of a musical piece. Timbre is the perceived quality or colour of a note, and is related to the interaction of static and dynamic acoustic features, differing depending on the instrument or voice used to create the sound. Surface characteristics are specific to a performance of a piece of music, but abstract structure requires more generalization. Abstract structure includes relative pitch which is the difference between the frequencies of notes regardless of their absolute pitch, and relative duration which is the amount of time a certain note is held in relation to other notes

(Trainor et al., 2004). Though awareness of surface characteristics allows for the identification of a specific musical performance, it is necessary to use absolute structural cues to identify the same melody across performances. Melody is a combination of pitch and rhythmic pattern, and can be best thought of as the foreground of a piece of music.

Studies have shown that infants are sensitive to the surface characteristics of music, and use them to discriminate between familiar and novel melodies. Trainor et al. (2004) found that infants as young as 6-months of age differentiate between familiar and novel melodies using the performance-specific characteristics of tempo and timbre. After familiarizing infants to a melody, a looking-preference paradigm was used to compare infants' looking times between the familiar melody and a novel melody. In one experiment, the tempo was 25% slower or 25% faster during the test phase compared to the familiarization phase. In another experiment, the familiar and novel melodies were presented in a different timbre during testing than during familiarization. In both cases, infants were unable to discriminate between the familiar and the novel melody. Infants preferred the novel melody when the timbre or tempo was kept the same, and the finding that this preference was lost when timbre or tempo was different suggests that infants store surface characteristics in long-term memory. Saffran, Loman, and Robertson (2000) did a similar study with 7-month-old infants. Infants were exposed to two Mozart sonatas each day for 14 days. Two weeks after this exposure period, the infants were tested on listening preference between segments from the middle of the familiar sonatas and segments from the middle of unfamiliar Mozart sonatas. Since all of the sonatas had similar features, infants had to remember specific surface characteristics to discriminate between the familiar and novel melodies. Infants who had been exposed to the Mozart sonatas prior to testing preferred to listen to the new music, showing that they could make this discrimination. A control group of infants

who had not been exposed to the sonatas prior to testing showed no preference between them, so it is unlikely that some segments were naturally more salient to infants. Instead, this result coupled with that of Trainor et al. (2004) suggests that infants can store the performance characteristics of music in long-term memory, and furthermore that prior experience influences later musical preferences.

The apparent ability of infants to track surface characteristics led Saffran and Gripentrog (2001) to suggest that statistical learning may be a possible mechanism for remembering melody. They investigated whether 8-month-old infants use relative pitch (abstract structure) or absolute pitch (a surface characteristic) as a cue when representing auditory experiences in memory. To test these cues, a statistical learning task was constructed. Infants were exposed to a stream of tones and then tested for preference between common and uncommon sequences from the longer tone stream. As in Trainor et al. (2004) and Saffran, et al. (2000), infants were more likely to use the surface characteristic which was absolute pitch when completing this task.

Other research has shown that infants are sensitive to abstract structure as well. Abstract structure relates more to relative cues and to relationships, for example relative pitch as opposed to absolute pitch. Plantinga and Trainor (2005) exposed 6-month-old infants to a melody each day for seven days. On the eighth day, they were tested on whether they preferred the familiar melody or a novel one. Infants preferred the novel melody over the familiar melody, even when the pitch of the familiar piece was transposed by a perfect fifth or a tritone. This suggests that infants could use the abstract cue of relative pitch to determine that the transposed version was the same melody they had been familiarized to. Interestingly, infants showed no preference between the original melody they had been familiarized to and the transposed version of the melody. The authors suggest that the infants might not have remembered absolute pitch in this

case or that the relative pitch cues had been more salient. As the results of Plantinga and Trainor show that the familiar melody and the transposed melody were not perceived as different by 6-month-old infants, this indicates that infants might have the ability to use abstract structural features, like relative pitch cues, to generalize across performances.

Like music, language is also generated from a finite set of sounds. Instead of notes, these are phonemes. All languages use a subset of possible phonemes, which are contrasts in speech sounds which change the meaning of a word and are perceived categorically by listeners (Younger, Adler, & Vasta, 2012). For infants, phonetic cues are cues about speech sounds. Speech sounds combine to form words with semantic meaning, but prelinguistic infants are not yet able to understand semantic meaning (Trehub et al., 1993), making speech perception during this period more similar to music perception. Despite the fact that semantic meaning is unavailable, studies have shown that infants are able to attend to and store individual words from speech. Jusczyk and Hohne (1997) exposed 8-month-old infants to a recording of a children's story for 10 days over a 2-week period. They were then tested for listening preference between words heard frequently in the story and words not heard in the story. Infants looked significantly longer at the words which occurred frequently in the story, suggesting that by 8-months of age infants are attending to individual words and storing the words in long-term memory.

Remembering individual words requires infants to first segment words from a continuous stream of speech. The results from Jusczyk and Hohne (1997) suggest that 8-month-old infants are capable of this, and another study from Saffran, Aslin, and Newport (1996) suggests a possible mechanism for this ability: statistical learning. Using a paradigm similar to the one used by Saffran and Gripentrog (2001) in their statistical tone study, Saffran, Aslin, and Newport (1996) familiarized infants to a continuous stream of speech sounds. Using relative frequency

between speech sounds as the only cue, infants were able to discriminate between "words" and "non-words" from the stream, even though such "words" were formed from nonsense syllables (Saffran et al., 1996). This suggests that sounds which are temporally correlated with each other are more likely to be perceived as words by infants. Infants in the Saffran et al. (1996) study preferred to listen to non-words, displaying a similar novelty preference to the one seen in the musical memory study by Saffran et al. (2000).

Infants' processing of melody and words is remarkably sophisticated when each is presented independently in controlled laboratory studies, but this separated exposure does not usually occur in the real world. It is important to note that language involves much more than speech sounds. On the suprasegmental level, prosody also plays an important role. Prosody involves rhythm and stress patterns in speech, and communicates additional information to listeners. In particular, natural speech and infant-directed speech contain rising and falling contours thought to reflect the affective state of the speaker (Trehub et al., 1993). Speech is rarely devoid of prosody, and as discussed above, infants are sensitive to the surface characteristics and abstract structure which make up prosodic features. Since prosodic features convey communicative intent to infants in a way which resembles musical melody, they are likely picking up on these features in both music and speech. The question of whether infants can simultaneously process melodic cues and phonetic cues then becomes very important for understanding what parts of speech infants may be attending to and learning from. A more obvious domain in which selective attention may be an issue involves sung songs. Infants are often exposed to sung songs like lullabies (Conrad, Walsh, Allen, & Tsang, 2011) which contain both melodic and lyrical components. But it is not clear whether infants are able to process both components at the same time or whether the melody and lyrics compete with each other for

priority. Such a task is extremely complex, and infants may not have the cognitive resources to fully process both at the same time. Without this information it is difficult to draw conclusions about what infants are learning from their auditory experiences.

Though evidence has shown that infants are sensitive to music and to speech, the two may not be equally salient. Tsang, Falk, and Hessel (2016) examined whether 6- to 10-month-old infants can discriminate between infant-directed speech and infant-directed song. Infant-directed speech contains more prominent tonal contours and rhythmic patterns than adult-directed speech, which gives it a more musical quality. However, infants were able to discriminate between infant-speech and infant-directed song, suggesting that the two types of stimuli (song and speech) are perceived as different by infants. Tsang et al. (2016) found that infants preferred to listen to infant-directed song over infant-directed speech, but other studies have found a preference for speech over other types of auditory stimuli. Saffran, Werker, and Werner (2007) demonstrated that by 6 months of age, infants prefer to listen to speech than to non-speech stimuli. They recorded looking times toward a target which was paired with a continuous stream of speech and to a target which was paired with white noise, and found that infants looked longer towards the target paired with speech. Nine-month-old infants will pull a lever more frequently to listen to a female voice singing a tune as opposed to solo musical instruments performing the same tune (Glenn, Cunningham, & Joyce, 1981). Vouloumanos and Werker (2004) created non-speech analogues which preserved the pitch contour of natural speech, and recorded looking time towards these non-speech analogues and to similar speech sounds. They found that infants between 2- and 7-months of age preferred to listen to speech sounds over non-speech sounds. Together, these studies suggest that infants devote more attention to language stimuli than to other auditory stimuli. Language may have special status to infants.

If language is special, will infants exposed to music and speech at the same time prioritize processing of the speech or phonetic cues? The current study was designed to provide an answer to this question by testing infants for recognition of melodies and lyrics in the context of sung stimuli. However, it will not be the first study to have done this. Lebedeva and Kuhl (2010) familiarized 11-month-old infants to a short song to determine which component of the song they found most salient: pitch or lyrics. A looking-preference paradigm was used to test discrimination between the familiar pitch sequence and a novel pitch sequence. When the familiarization song consisted of lyrics which were redundant syllables, infants were able to discriminate between the familiar and the novel pitch sequences. However, when the lyrics of the familiarization song consisted of varying syllables, infants were unable to discriminate between the same familiar and novel pitch sequences as they had in the previous condition. The conclusion drawn by the authors was that 11-month-olds cannot ignore phonetic stimuli and that this may interfere with the processing of pitch. Results from an unpublished preliminary study provided data which justified a similar conclusion. Infants exposed to familiarization stimuli containing a melody and stream of syllables as "lyrics" were able to differentiate between the familiar and the novel lyrics when tested later, but not between the familiar and the novel melody despite melody recognition presumably being the simpler task (Longfield, 2007; Myles, 2007). Both studies suggest that infants prioritize words or "lyrics" over melody.

However, there were some problems with the stimuli used by Lebedeva and Kuhl (2010) that limit the conclusions that can be drawn regarding infants' perception of lyrics and melodies. Detecting changes in pitch was much easier than detecting changes in lyrics, and infants were not actually able to discriminate between familiar and novel spoken lyrics when presented in isolation. In other words, infants could not remember the syllable of the song they had been

familiarized to even though the presence of such lyrics may have disrupted their processing of the melody. According to Saffran et al. (1996), infants should be able to make this discrimination by 8-months, and so the 11-month-old infants in this study should have had no trouble with the task. As a possible explanation, Lebedeva and Kuhl speculated that their spoken lyrics may have sounded less natural compared to their sung stimuli. In addition, the results of the study did not quite reach statistical significance ($p = 0.09$). Thus, to substantiate the claim that infants prioritize processing phonetic cues over melodic cues, it will be necessary to a conduct a similar experiment using more naturalistic stimuli.

In the current study, infants were familiarized to stimuli containing a melody and sequence of syllables forming nonsense "words" (the lyrics). They were then tested for discrimination between the familiar melody or familiar lyrics and a similar but novel melody or similar but novel lyrics using a standard looking-preference paradigm. This was similar to the approach of Lebedeva and Kuhl (2010), but more naturalistic stimuli involving a female vocalist had been created to test their conclusions. The pacing and tone of the vocalist while singing and speaking were similar to samples infants would experience outside of the laboratory environment, since they were not as heavily edited as the samples used by Lebedeva and Kuhl (2010). Infants in a control group were tested for discrimination between the familiar and the novel lyrics after exposure to the lyrics alone to confirm that they are able to remember which lyrics they heard. A second control group was tested for discrimination between the familiar and the novel melody. In the current study 8-month-old infants were tested because infants of this age are able to successfully use statistical learning to identify "words" in streams of syllables (as in Saffran et al., 1996), and should be able to perform both the melodic recognition and lyric recognition tasks.

If the present study reveals findings similar to those that emerged from the preliminary study and to those reported by Lebedeva and Kuhl (2010), this would provide greater support for the theory that music and language processing interfere with each other. Such an outcome would also suggest that infants have finite cognitive resources and must prioritize. Infants may be predisposed to pay attention to phonetic cues over melodic cues, and may choose to preferentially process language stimuli if they do not have the cognitive resources to process both. Another possible outcome is that infants may demonstrate differences in looking times on both the melody recognition task and the lyric recognition task, which would suggest that infants are able to process both melodic and phonetic cues concurrently. In this case 8-month-olds may have more cognitive resources than previously thought, or processing for melodic and phonetic cues may be somewhat integrated. Both findings would have important implications for language development and music learning, and would contribute to a larger understanding of how infants experience and process complex auditory stimuli.

Method

Participants

Thirty-five 8-month-old infants (17 females, 18 males) participated in this study (mean age = 256.66 days, range = 236 days - 287 days). Four additional infants were tested but excluded from the final analysis because of fussiness (3) and technical difficulties (1). According to parental reports, all participants were full-term births with no birth complications, were healthy at the time of testing, and had no reported history of hearing impairment. Participants were recruited from a developmental participant call list maintained by the Department of Psychology at Western University. The families of these infants had volunteered their contact

information and had given permission to be contacted regarding possible participation in developmental research.

Stimuli

Melody 1 and Melody 2 each consisted of 17 notes matched for pitch and rhythm. They were based on the stimuli used in Longfield (2007) and Myles (2007). Melody 1 was presented in the key of C major and Melody 2 was presented in the key of G minor. Each melody was 45 seconds long and was sung by the same female vocalist at a rate of 2 to 3 notes per second. There was no instrumental accompaniment.

Lyrics A and Lyrics B were each constructed from a string of 12 different spoken syllables based on Saffran et al. (1996). The syllables were structured so that four syllables were always presented sequentially, forming a consistent group or nonsense "word".

In addition to the two melody and two lyrics recordings, recordings combining one of the two melodies with one of the two lyrics were created. There were four possible combinations: Melody 1 – Lyrics A, Melody 1 – Lyrics B, Melody 2 – Lyrics A, and Melody 2 – Lyrics B. For each combination, the same female vocalist sung the "words" of the lyrics to the melody.

Apparatus

Testing was conducted in a quiet laboratory room. The infant sat on the parent/guardian's lap throughout the session. The parent/guardian sat in a chair arranged equidistant between two cabinets. Each cabinet held a 13-inch CRT computer monitor connected to a Power Macintosh G4 computer which was controlling the experiment via a wireless Mac keyboard. On the top of each cabinet was a Bose 201-V sound speaker. The experimenter sat behind a third cabinet facing the infant. See Figure 1 for the testing arrangement.

Figure 1. Head-turn preference procedure testing arrangement. Reprinted from "Infants' Sensitivity to Fine Durational Cues in Speech Perception" by A. K. Kuiack, 2015, *Undergraduate Honours Theses*, Paper 12. Copyright 2015 by Alyssa Kuiack. Reprinted with permission.

Procedure

Infants were tested using the standard head-turn preference paradigm outlined by Kemler-Nelson, Jusczyk, Mandel, Myers, Turk, and Gerken (1995). Testing involved two phases: the familiarization phase; and the testing phase. During both phases, the parent wore headphones playing masking music to ensure that he/she would be unaware of what their infant was hearing and could not influence their infant's responses. The experimenter also wore headphones during the testing phase. During the familiarization phase, the infant and their parent/guardian sat alone in the quiet testing room. The assigned familiarization stimulus was played for a total of 3-minutes. The specific stimulus to which the infant was familiarized depended on their assigned condition.

Two control conditions and two experimental conditions were tested. The first control condition, Melody Alone, involved familiarization to Melody 1 or Melody 2 and then tested for discrimination between the familiar and the novel melody. Based on results from previous studies (e.g. Saffran, et al., 2000; Saffran & Gripentrog, 2001; Trainor et al., 2004), 8-month-old infants were expected to be able to make this discrimination. The second control condition, Lyrics Alone, involved familiarization to Lyrics A or Lyrics B and then tested for discrimination between the familiar and the novel lyrics. Based on previous studies (e.g. Saffran et al., 1996), 8-month-old infants were expected to be able to make this discrimination as well. The purpose of these control conditions was to confirm that infants could discriminate between the specific stimuli used in this study. There were 8 infants tested in the Melody Alone condition and 7 infants tested in the Lyrics Alone condition.

The first experimental condition was the Melody Test condition. Infants in this condition were familiarized to one of the four combined melody-lyrics recordings, and were tested for

discrimination between the familiar and the novel melody. Similarly, infants in the second experimental condition, the Lyrics Test condition, were familiarized to one of the four combined melody-lyrics recordings and were tested for discrimination between the familiar and the novel lyrics. There were 9 infants tested in the Melody Test condition and 11 infants tested in the Lyrics Test condition. All conditions were counterbalanced for starting stimulus, starting side, and for which melody/lyric was familiar and which was novel.

For the testing phase, the experimenter came back into the testing room following familiarization. The infant stood or sat on their parent's lap, facing the experimenter. The experimenter brought the infant's attention to the center and initiated each trial by pressing a button when the infant was facing forward. Each trial began with the image of Mickey Mouse flashing on one of the side computer monitors to attract the infant's attention. When the infant made a 45 degree head turn towards the side with the flashing image, the experimenter pressed another button. The image became static and the auditory stimuli played from the accompanying speaker. The infant's looking time toward that side was recorded until the infant looked away (made a 45 degree head turn away) for at least 2 seconds. At this time, the trial would end and the experimenter would signal the monitor on the other side of the infant to begin flashing for the next trial. There were 20 trials in total with 10 on each side.

Results

To test the effectiveness of the counterbalancing efforts made in the current study, a 2x2x4 analysis of variance (ANOVA) was conducted with sex (female or male), starting side (left or right) and starting stimulus (Melody 1, Melody 2, Lyrics A, or Lyrics B) as between-subjects variables, and age (in days) as a covariate. The analysis revealed no significant main effects or interactions, indicating that the counterbalancing efforts were effective.

A 2x2x4 mixed variable ANOVA was then conducted with stimulus type (familiar or novel) as the first within-subjects variable, study half (Trials 1-10 or Trials 11-20) as the second within-subjects variable, and condition (Melody Alone, Melody Test, Lyrics Alone, or Lyrics Test) as the between-subjects variable. The dependent variable was infants' looking-time in seconds. There was no significant main effect of stimulus type, F (1, 30) = 0.99, p = 0.33, partial η^2 = 0.03, no significant main effect of study half, F (1, 30) = 0.67, p = 0.42, partial η^2 = 0.02, and no significant main effect of condition, F (1, 30) = 0.26, p = 0.86, partial η^2 = 0.03. No significant interactions were found. However, several interactions were trending toward significance. The first was Stimulus Type x Condition, F (3, 30) = 1.74, p = 0.19, partial η^2 = 0.14. The trends indicated that infants in the Melody Alone condition looked longer at the familiar stimulus (M = 49.96, SD = 6.00) than at the novel stimulus (M = 45.96, SD = 6.34). Infants in the Melody Test condition looked longer at the novel stimulus (M = 54.11, SD = 5.68) than at the familiar stimulus (M = 47.57, SD = 5.38). Infants in the Lyrics Alone condition looked longer at the familiar stimulus (M = 48.85, SD = 6.10) than at the novel stimulus (M = 41.15, SD = 6.44). Infants in the Lyrics Test condition looked longer at the familiar stimulus (M = 51.71, SD = 4.98) than at the novel stimulus (M = 49.57, SD = 5.26). The second interaction which trended toward significance was Stimulus Type x Study Half, F (1, 30) = 2.25, p = 0.19, partial η^2 = 0.06. The trends indicated that during the first half of the study, infants looked slightly longer at the novel stimulus (M = 50.13, SD = 3.55) than at the familiar stimulus (M = 48.90, SD = 2.66). In the second half of the study, infants looked longer at the familiar stimulus (M = 50.14, SD = 4.08) than at the novel stimulus (M = 45.27, SD = 3.69). The third interaction which trended toward significance was Stimulus Type x Study Half x Condition, F (3, 30) = 1.93, p = 0.16, partial η^2 = 0.15. The trends indicated that infants in the Melody Alone condition

looked marginally longer at the novel stimulus during the first half of the study (*M* = 52.92, *SD* = 16.44) than at the familiar stimulus (*M* = 50.65, *SD* = 16.74), and longer at the familiar stimulus during the second half of the study (*M* = 50.40, *SD* = 11.27) than at the novel stimulus (*M* = 43.27, *SD* = 20.04). Infants in the Melody Test condition looked marginally longer at the novel stimulus during the first half of the study (*M* = 48.77, *SD* = 28.85) than at the familiar stimulus (*M* = 47.52, *SD* = 20.98), and longer at the novel stimulus during the second half of the study (*M* = 59.09, *SD* = 36.71) than at the familiar stimulus (*M* = 47.52, *SD* = 35.57). Infants in the Lyrics Alone condition looked slightly longer at the familiar stimulus during the first half of the study (*M* = 50.01, *SD* = 9.43) than at the novel stimulus (*M* = 46.49, *SD* = 14.26), and longer at the familiar stimulus during the second half of the study (*M* = 47.54, *SD* = 12.65) than at the novel stimulus (*M* = 35.23, *SD* = 8.57). Infants in the Lyrics Test condition looked slightly longer at the novel stimulus during the first half of the study (*M* = 52.33, *SD* = 22.85) than at the familiar stimulus (*M* = 47.58, *SD* = 11.10), and longer at the familiar stimulus during the second half of the study (*M* = 55.19, *SD* = 22.47) than at the novel stimulus (*M* = 44.38, *SD* = 11.03). See Figure 2.

Discussion

Despite finding no significant main effects or interactions, the results of this study are promising and a follow-up study with increased statistical power would likely produce statistically significant effects. With only 35 participants in the current study there was a great deal of variation in the data, making any significant effect difficult to detect. Future extensions of this study should augment the sample size to reduce noise and increase statistical power. The age range in the current study was also very large (236 days - 287 days), and so narrowing the age range might also reduce noise if the study were to be replicated. Since the results did not reach

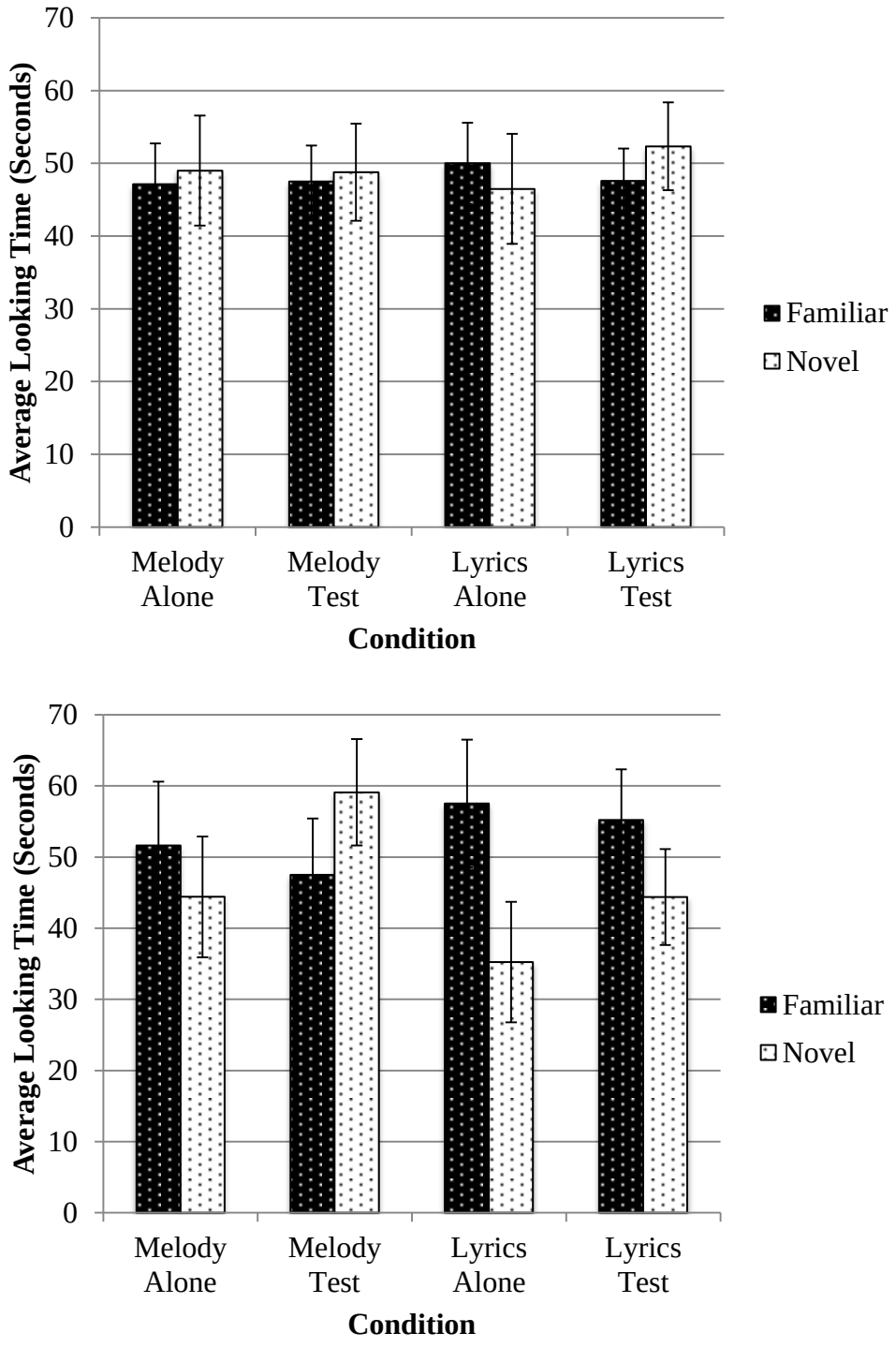

Figure 2. Average looking time in seconds towards the familiar and the novel stimulus for infants in each condition. The top graph shows average looking time for the first half of the study (Trials 1-10) and the bottom graph shows average looking time half of the study (Trials 11-20). Error bars represent the standard error of the mean.

significance, caution is advised when interpreting the results. However, the fact that three interactions are trending toward significance despite low statistical power is encouraging and suggests that the trends might become statistically significant given increased statistical power. If this is the case, findings would have important implications for our understanding of how infants process complex auditory streams. As such, a discussion of the preliminary trends is warranted.

Lebedeva and Kuhl (2010) found that infants cannot ignore phonetic stimuli and that this interferes with their processing of pitch. Like the current study, results from Lebedeva and Kuhl only approached significance ($p = 0.09$). With a sample size of only 40 infants, they likely experienced issues with statistical power as well. If the current study found the same trends, infants in the Lyrics Test condition would be expected to show a difference in looking times toward the familiar and the novel stimuli, but infants in the Melody Test group would not. Instead, the trends of the Stimulus Type x Study Half x Condition interaction (F (3, 30) = 1.93, p = 0.16, partial η^2 = 0.15) suggest that there may be a difference in the amount of time infants spend looking towards the familiar stimulus and towards the novel stimulus based on which of the four study conditions they are in (Melody Alone, Melody Test, Lyrics Alone, Lyrics Test) and based on which half of the study is being examined (Trials 1-10 or Trials 11-20). During the second half of the study infants showed longer attention to the familiar melody or pattern of syllables in the Melody Alone condition (familiar: M = 50.40 sec, SD = 11.27; novel: M = 43.27 sec, SD = 20.04), Lyrics Alone condition (familiar: M = 47.54 sec, SD = 12.65; novel: M = 35.23 sec, SD = 8.57), and Lyrics Test condition (familiar: M = 55.19 sec, SD = 22.47; novel: M = 44.38 sec, SD = 11.03). Infants in the Melody Test condition showed longer attention to the novel melody (familiar: M = 47.52 sec, SD = 35.57; novel: M = 59.09 sec, SD = 36.71). Though

not significant, all four conditions did demonstrate differences in looking times towards the familiar and the novel stimulus.

A difference in infant looking times towards the familiar and the novel stimulus provides two pieces of information. First, it indicates that infants can discriminate between the familiar and novel stimulus. Second, it indicates whether infants prefer to attend to the familiar stimulus or to the novel stimulus. Both discrimination and preference are important to the purpose of this study because they require infants to remember which stimulus was familiar and which was novel, indicating an ability to process that level of the auditory stream. Infants in the Melody Alone condition and the Lyric Alone condition were expected to show a difference in looking times since previous research has shown that infants are able to discriminate between familiar and novel melodies (e.g., Trainor et al., 2004) and between familiar and novel patterns of syllables (e.g., Saffran et al., 1996) when each stimulus level was presented alone. However, the results of the current study are different from the results of Lebedeva and Kuhl (2010) because infants in both the Melody Test condition and the Lyrics Test condition were also able to discriminate between the familiar and the novel melody/lyrics despite the stimuli being initially presented concurrently. Infants in the study by Lebedeva and Kuhl could not process the melodic level of an auditory stream when the phonetic level was present, but the trends of the current study suggest that infants are able to process both levels of an auditory stream at once.

A key difference between the current study and the study by Lebedeva and Kuhl (2010) is that the stimuli used in the current study were designed to be more naturalistic. Cues which are present in real-world auditory information may have been edited out in stimuli from Lebedeva and Kuhl. Infants may be sensitive to both the melodic and phonetic levels of the auditory stream as they are sung or spoken by a natural human voice. In real-world exposure, language often has

melodic qualities. This is especially the case with infant-directed speech, where rising and falling pitch often carries important information about the meaning of the speech and the affective state of the speaker (Trehub et al., 1993). Infants are often exposed to both melody and speech together in the context of song and in the context of speech, and may learn that attending to both components simultaneously is beneficial for learning to communicate.

Interestingly, infants' differences in looking times were larger during the second half of the study compared to the first half of the study. Typically infants habituate to the stimuli used in head-turn preference paradigms and exhibit lower looking times during the second half of the study. Preference is usually more pronounced in the first half of the study, but the opposite pattern emerged in the current study. For this reason, looking times were broken out by session half as well as by condition in Figure 2 to fully capture trends in infant looking time. In the second half of the study, three out of the four conditions showed longer looking times toward the familiar stimulus. The apparent delayed discrimination observed may be due to the complexity of the stimuli.

According to Hunter and Ames (1988), infants are more likely to demonstrate a familiarity preference when a stimulus is complex and a novelty preference when a stimulus is simple. Even when presented alone, both the melodies and the lyrics used in the study are quite complex. The melodies used in the current study involved 17 note patterns, which are long patterns to remember. The melodies also contained pitch information and tempo information. The 12 syllable patterns in the lyrics each contained a "word" structure, and required infants to segment the speech sounds using relative frequency. For both the melody and the lyrics stimuli, the female voice who sang/spoke the patterns provided timbre information as well. The auditory streams used included a great deal of information for infants to process, but the results show that

they were able to process both the melody and lyrics levels despite this complexity, albeit later than would be expected.

Infants in the Melody Test condition demonstrated longer looking times toward the novel stimulus, which is very interesting especially when compared to the Melody Alone condition in which infants demonstrated longer looking times toward the familiar stimulus. The only difference between the two conditions is that infants in the Melody Alone condition were familiarized to an audio stream containing only a melody, and infants in the Melody Test condition were familiarized to an audio stream containing both a melody and a lyrical component. Why would the addition of nonsense words as lyrics alter the nature of later melody preference in 8-month-old infants? If infants in the other three conditions demonstrate a familiarity preference because of the complexity of the stimuli, the infants in the Melody Test group may demonstrate a novelty preference because they perceive the melody paired with lyrics to be less complex. Is it possible that lyrics somehow facilitate the processing of melody?

There is a large body of literature suggesting that melody can facilitate language learning. For example, in the adult literature, melody has been used to improve language abilities in a wide variety of groups, from those learning English as a second language (Wolverton, 1991) to patients suffering from Broca's aphasia (Schlaug, Marchina, & Norton, 2008). In the infant literature, infant-directed speech (speech characterized by higher pitches and a more melodic tone) has been shown to assist in language acquisition by helping infants to segment words (Thiessen, Hill, & Saffran, 2005).

The findings of the current study suggest that melody learning may be facilitated by language as well. While fewer studies have examined this relationship, previous research has found similar results. Thiessen and Saffran (2009) found that infants between 6.5-months old and

8-months old learn melodies more easily when the melodies are paired with lyrics than when the melodies are presented alone. The presence of both a melodic and phonetic level in the auditory stream was beneficial even though the stream was objectively more complex than if there had been a single level. This conclusion was based on a novelty preference similar to the one found in the current study. Thiessen and Saffran suggest that redundant cues play a role in helping infants remember melody, but in the current study melody and lyrics were not correlated. Since the melody was 17 notes long and each nonsense "word" was 4 syllables, the melody and lyrics did not repeat at predictable times relative to each other. The results of this study suggest that the redundant cue explanation is incomplete, and that there may be another mechanism at work.

It should be noted that the longer looking times seen toward the familiar syllable pattern for infants in the Lyrics Test condition does not preclude the possibility that melody also facilitates language learning for 8-month-old infants. It is possible that remembering the melody and remembering the "lyrics" of the familiarization piece may not have been equivalent tasks. To recognize the pattern of syllables, infants in the Lyrics Alone and Lyrics Test conditions had to use statistical learning to segregate syllables into nonsense "words", presumably a more cognitively challenging task than recognizing the melody. For the Lyrics Test condition, lyrics were also sung during the familiarization phase and were spoken during the test phase. To recognize the sung syllable pattern as a spoken syllable pattern, more generalization would have been needed and infants in the Lyrics Test condition would have had to use abstract structure as a cue to recognize the lyrics. According to Saffran, et al. (2000), Saffran and Gripentrog (2001), and Trainor et al. (2004), infants are more likely to use surface characteristics such as absolute pitch rather than abstract structure, making the task more difficult. If melody facilitated infants'

memory for lyrics in the Lyrics Test condition, these gains may have been overshadowed by the difficulty of the task.

It would be interesting for future research to examine whether the trends found in the current study are present for auditory streams which are less complex. This can be examined by increasing familiarization time, using melodies with fewer note patterns, or using syllable patterns with fewer "words". Future research should also test different age groups to examine whether processing of different levels of an auditory stream changes throughout the first year of development. Lebedeva and Kuhl (2010) focused on 11-month-old infants whereas the current study focused on 8-month-old infants.

It should be noted that the trends of the current study suggest that infants may be able to process both levels of the auditory stream simultaneously, but it is possible that 8-month-olds infants and 11-month-olds have different attentional priorities. For example, 11-month-olds who have had more exposure to language may devote a greater proportion of resources to processing phonetic stimuli than 8-month-olds. The 8-month-old infants in this study have likely had less exposure to language, and may have divided cognitive resources between the melodic and phonetic components of the auditory stream such that they were able to recognize both during the testing phase. If the trends seen are the result of differences in resource allocation, this would have implications for language development. If infants develop a priority for phonetic stimuli over melodic stimuli as their experience with language increases, this focus would likely be beneficial for language development. However, the early facilitation between language and melody seen in 8-month-olds may be important to help younger infants make sense of what they hear so that this prioritization can develop.

Overall, the trends found in the current study are very interesting and further investigation is needed to better understand the trends observed in this study. The trends found contradict the findings of Lebedeva and Kuhl (2010) since they suggest that not only are infants capable of processing the phonetic level and the melodic level of an auditory stream concurrently, but for 8-month-old infants the phonetic level may facilitate learning of the melody instead of interfering with it. Though the results were not statistically significant, the design of the study was strong and the results add to literature on how music facilitates language by suggesting that language facilitates music as well. This is a very important issue which has applications in language development, second language learning, music learning, and memory. The results of this study provide important insights into how infants process different levels of complex auditory stimuli.

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Curriculum Vitae

Name:	Alexandra Marie Ryken
Place and Year of Birth:	London, Ontario, Canada, 1995
Secondary School Diploma:	Mother Teresa Catholic Secondary School London, Ontario, Canada
Post-Secondary Diploma:	Hons. Bachelor of Arts (Candidate), Huron University College, London, Ontario, Canada
Awards:	Prof. Mark Cole Prize in Experimental Psychology, 2016
	The Kevin M. Cunliffe Fourth-Year Scholarship, 2016
	Great Minds, Great Hearts Third Year Scholarship, 2015
	Great Minds, Great Hearts Second Year Scholarship, 2014
	Dean's Honour List, 2013-14, 2014-15, 2015-16
	The Huron Scholarship of Excellence, 2013-2016
Experience:	Centre for Vision Research (CVR) Summer School Student. York University, Toronto, Ontario, June 2016
	Data Collection Needs Assessment Team Member. Western University Community Engagement Program, London, Ontario, Fall 2016
	Infant and Child Development Laboratory Research Assistant. Huron University College, London, Ontario, 2015-2017
	Animal Behaviour Laboratory Student. Huron University College, London, Ontario, Fall 2015
Publications:	Ryken, A. M. (2016). The Effect of Fear Arousal on Recognition and Recall Memory for Subsequently Presented Stimuli. *The Huron College Journal of Learning and Motivation*, 54, 108-119