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Infants' Sensitivity to Fine Durational Cues in Speech Perception

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INFANTS' SENSITIVITY TO FINE DURATIONAL CUES IN SPEECH PERCEPTION

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Abstract

Previous research has indicated that infants as young as 3 days of age show sensitivity to prosodic stress patterns and can use this information to distinguish word boundaries (Christophe et al., 1994). Older infants have also exhibited an ability to use prosodic stress patterns to segment streams of speech (Echols et al., 1997) and have shown a preference for samples of speech with the patterns of prosody displayed by their native language versus the prosodic patterns typical of other non-native languages (Werker & Tees 1984, Juscyzk et al. 1993). Adults have demonstrated the ability of language discrimination based strictly on fine durational cues rather than a broad sensitivity to rhythm. The purpose of the current research was to investigate this ability in infants. Sixteen 6- to 10-month old infants were presented with two different trisyllabic non-words, consisting of three consonant vowel pairs varying in rhythmic duration, one with a rhythmic duration previously familiarized and one with a novel rhythmic duration. Infants were tested using a head-turn preference procedure. Results indicated that infants significantly preferred to listen to a novel durational pattern, which suggests that infants are able to rely entirely on fine durational cues to discriminate between speech samples.

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Infants' Sensitivity to Fine Durational Cues in Speech Perception

A major research question in the study of language development is how the human mind becomes capable of processing running speech into its meaningful components. This task is incredibly complex and difficult considering the speed and fluency of spoken language. For example, infants draw on multiple properties that may signal word boundaries. Some of these properties may include: prosodic patterns (e.g. rhythm, intonation and stress patterns in speech), phonotactic regularities (the set of allowed arrangements or sequences of speech sounds in a given language) and allophonic variations (the variations of speech sounds that represent a single phoneme) (Mattys & Jusczyk, 2001).

During the first year of life, infants' speech perception ability evolves from language general to language specific due to their increasing knowledge of and exposure to their native language (Nazzi, Jusczyk & Johnson, 2000). Werker and Tees (1984) reported that, by 10 months of age, an infant's ability to distinguish non-native consonant contrasts declines significantly. They compared groups of 6- to 8-month-olds, 8- to 10-month-olds, and 10-12 month olds on their ability to distinguish two different sound contrasts from non-native languages (Hindi and Salish). Werker and Tees found that most 6- to 8-month olds were able to discriminate both sets of non-native contrasts whereas by 8- to 10-months fewer infants were able to make this discrimination and by 10- to 12-months of age very few infants were able to discriminate between the samples in either contrast. Their results provided evidence for the decline in discriminative abilities of infants for non-native phonetic contrasts during the first year of life. Their results also indicated that, around 8 months of age, infants' abilities to discriminate between non-native contrasts begin to decline as their perceptual abilities narrow due to exposure to and expertise in their native language. At 8 months of age there appears to be a divide between infants who are sensitive to all aspects of prosody, regardless of language experience, and infants who are becoming increasingly specialized to properties of their native language in their speech processing abilities. There is also evidence that this native-language tuning process applies to elements of prosody as well. Mehler et al. (1998) reported that infants from 4 days to 2 months of age were able to discriminate between utterances of their native language and utterances from a non-native language using prosodic cues. Jusczyk & Thompson (1978) showed that 1- to 4-month-olds were able to discriminate changes in the stress patterns of words from their native language. Jusczyk et al. (1993) found that, by 9 months, native English hearing infants demonstrated a preference, by listening longer to lists of disyllabic items, for a trochaic (strong-weak) stress pattern compared to an iambic (weak-strong) stress pattern. Together, these studies indicate that, throughout the first year of life, an infant's ability to rely on prosodic cues when distinguishing between speech samples becomes increasingly complex and tuned to native language characteristics.

There is an expanding body of evidence suggesting that rhythmic factors in speech have great influence over the development of speech perception in infants. Furthermore, even newborn infants may be utilizing rhythmic cues to identify word-level units in speech (Jusczyk, Cutler & Redanz, 1993). Nazzi, Bertoncini and Mehler (1998) tested the hypothesis that infants are able to extract the rhythmic characteristics of different languages and use this information to sort these languages into different rhythmic classes. They found that French newborns were able to discriminate between two different foreign languages (each belonging to a different rhythmic class) but could not discriminate between two foreign languages from the same rhythmic class. Nazzi et al. (2000) provided further evidence that 5-month-old infants were able to successfully discriminate pairs of languages from different rhythmic classes. The infants were again unable to discriminate between two languages from within the same foreign rhythmic class. Their findings suggest that language discrimination within the child's native language rhythmic class is derived from the child's developing knowledge of the typical sound organization of the native language and that infants are sensitive by 5 months of age to stress-based rhythmic cues within a language.

For the young language learner, the ability to locate where spoken words, in a stream of fluent speech, begin and end is a challenging yet crucial step to language acquisition. From birth, infants are exposed to fluent language or speech occurring without pauses between words. Saffran, Newport and Aslin (1996) suggested that the same prosodic cues that allow infants to discriminate between languages of different rhythmic classes might also be useful when learning to segment words. Certain languages contain prosodic cues directly correlated to word boundaries. For example, the English language shows word-initial stressed syllables while the French language displays a word-final stress. Thiessen, Hill, and Saffran (2005) explained that, compared to adult-directed speech, the prosody of the English language is particularly well represented in infant-directed speech, or speech that is typically of a higher pitch, slower speed and increased enunciation. They exposed 7-month-old infants to either nonsense sentences with the intonation contours assessed, typical of infant-directed speech, or nonsense sentences with the intonation of adult-directed speech. The infants were only able to distinguish words from syllable sequences that spanned word boundaries after exposure to infant-directed speech, but not when previously exposed to adult-directed speech. These results suggest that the prosody of English infant-directed speech is particularly clear and this clarity directly aids in infants' discrimination of word boundaries.

During the first year of life, infants are exposed to and their listening preferences are influenced by the predominant prosodic patterns of their native language and these stress patterns are likely large contributors to infants' abilities to detect word-boundaries. Although there are many variables influencing the stress placement and overall rhythm in continuous English speech, the cues that infants are exposed to, based on the results of Jusczyk et al. (1993), should lead them to expect a word-initial stress pattern (Echols, Crowhurst & Childers, 1997).

Christophe, Dupoux, Bertoncini and Mehler (1994) further explored newborn infants' sensitivity to prosodic cues at word boundaries. They used a number of different disyllabic items, all with the simplest form of disyllabic structure of two consonant-vowel pairs. These items contained the same phonemic content (e.g., the word [mati]) extracted from a naturally produced sentence and differing only in the presence or the absence of a word boundary. Because the stimulus in this study was French, the disyllabic word [mati] would exhibit a weak-strong stress pattern typical of the French language. Therefore when the consonant-vowel pairings were separated and located on either side of a word boundary, the stress would be located on the first consonant-vowel pairing of /ma-/ which is not typical of standard French prosody in the word [mati]. They predicted that this sample should indicate a word boundary to infants. When the consonant-vowel pairings were located side-by-side without a word boundary present, prosodic stress would be placed on /-ti/, prosody to which infants would be familiar. Using a non-nutritive sucking procedure (sucking amplitude measured on a soother with attached measuring device) it was found that 3-day-old infants were indeed able to discriminate between the two samples. Adult French speakers were able to learn to categorize the same stimuli. These results suggest that sensitivity to prosodic cues that indicate word boundaries is similar in newborn infants as in adults (Christophe et al., 1994).

Echols, Crowhurst, and Childers (1997) tested infants' abilities, at 9 months of age, to segment a multisyllabic string of speech based on their exposure to their native language of English and thus trochaic, or strong-weak, stress patterns. Infants were familiarized to strings of test stimuli, one string of speech containing an embedded trochaic unit and another containing an embedded iambic, or weak-strong, unit. The stimuli were presented separately but an equal number of times. The test stimuli used were the trochaic (strong-weak) or iambic (weak-strong) units that the infant had been previously exposed to but, at test, these items were presented in isolation. Alternatively they were presented with a new trochaic or iambic "distractor" to which they had not been familiarized but which contained similar structure to the target items. The researchers found that infants preferred trochaic distractors compared to iambic distractors, which provided further support for Jusczyk et al.'s (1993) findings that infants significantly prefer to listen to disyllabic items exhibiting the trochaic pattern of prosody displayed by their native language. Furthermore, infants were able to successfully distinguish a trochaic sequence that had previously been embedded within a string of 4 syllables from a novel trochaic sequence. This finding suggests that infants were able to recognize this trochaic sequence to which they had been previously exposed. The infants failed to distinguish between the iambic sequence to which they had previously been exposed and the novel iambic sequence, which suggested that infants were biased to recognizing, extracting and remembering trochaic sequences given the exposure their native language provided.

Adult studies have indicated that the rhythm of a person's native language continues to directly influence speech processing later in life and that native speakers of French, English and Japanese appear to segment speech based on cues provided by the rhythmic units that exist in their native language (Werker & Tees, 1984). White, Mattys and Wiget (2012) further reported that adult listeners were able to distinguish between pairs of languages (e.g., English-Spanish or Dutch-Japanese) based on prosodic cues. The authors tested the hypothesis that adult perception of language differences is achieved as the result of the use of specific durational cues rather than just a broad sensitivity to rhythm class. Dauer (1983) stated that some languages (e.g., Dutch and English) are “stress-timed” and display, in unstressed syllables, the shortening of vowels and the clustering of consonants in the onset and the coda of stressed syllables. These findings lead to a high durational contrast between the stressed versus the unstressed syllables in these languages. He also found that languages like French or Spanish are considered “syllable-timed” and exhibit a low durational stress contrast. However he also noted that certain languages, like Polish, do not fit into either one of these categories. White et al. (2012) also added that there is a plethora of other cues that may be at work in distinguishing between languages. Given the range of these potential cues, the researchers decided to investigate which cues listeners were attuned to when categorizing speech. According to the *class discrimination hypothesis*, only languages from different rhythm classes should be distinguishable from one another whereas the *durational contrast hypothesis* suggests that languages differing substantially in contrastive rhythm should be distinguishable from one another regardless of which rhythm class (and patterns of stress distribution) the languages belonged. Twenty-four English speaking natives were able to distinguish between English and Spanish “flat” speech (speech in which only rhythmic cues are available). These experiments demonstrate that adult listeners are able to distinguish between languages based entirely on durational information rather than simply the broad sensitivity to rhythm that had previously been demonstrated.

Because infants have demonstrated the ability to utilize prosody as a cue in word boundary discrimination and because infants have also demonstrated their ability to discriminate between different languages that vary in prosodic features, the purpose of the current study was to examine infants' sensitivity to fine durational cues (an important element of prosody) and their ability to utilize these fine durational cues to distinguish between different samples of speech. Adults have demonstrated the ability of language discrimination based strictly on durational cues rather than broad rhythm sensitivity (White et al., 2012), but this ability has not yet been shown in infant participants. In the current study, infants will be familiarized to a trisyllabic non-word with a specific fine duration pattern. After familiarization, infants will be tested on discrimination for a novel trisyllabic non-word in two variations: one variation with the same fine durational cues as during familiarization and one with a novel pattern. If infants show a preference between the non-words they will have demonstrated the ability to recognize and rely on fine durational cues. The effects of age will also be investigated with respect to the findings of Werker and Tees (1984) that 8 months of age appears to represent a divide between infants that are sensitive to the features of all languages and infants that are becoming more and more specialized in recognizing and utilizing the features of their native language.

Method

Participants

Sixteen 6- to 10-month old infants (6 males and 10 females, mean age = 7.67 months, range = 3.2 months) participated in this study. Participants were recruited via telephone from the developmental research participant database maintained by the Department of Psychology at Western University. At the time of testing, infants were healthy and caregivers reported no history of ear infections or history of family hearing loss.

Apparatus

Testing was conducted in a quiet and well lit testing room. Caregivers were seated in a chair in the middle of the testing room with the infant seated, facing forward, on their lap. The infant was positioned directly across from the experimenter, who was seated behind a narrow black desk, at a distance of approximately 1.5 m. A wireless computer keyboard was used by the experimenter to control the presentation of the visual and auditory stimuli and was hidden from the infant's view behind the desk. Situated at 90-degree angles, to the left and to the right of the infant and the caregiver, were two identical black cabinets. Within each cabinet was a 13-inch standard computer monitor that was used to display the visual stimuli. On top of each cabinet was a black Bose 201-V sound speaker to present the auditory stimuli. Both the experimenter and the caregiver wore headphones and listened to masking music for the duration of the Test Phase (see Procedure) to ensure that they had no influence on the infant's head turn behaviour. See Figure 1 for the laboratory arrangement.

A Macintosh computer with customized software was used to control testing and record the looking times of the infant. This computer was located in the adjoining test room and connected to both the wireless keyboard, used during testing, and the amplifier, which controlled the stimuli presentation, through the two sound speakers.

Stimuli

The infant-directed stimuli in this study were trisyllabic non-words, consisting of three consonant vowel pairs varying in rhythmic duration. The same female speaker recorded all of the stimuli so that the voice was consistent across the presented non-words. The syllables used were /mi/ and /la/ of a shortened vowel duration or /mee/ and /laa/ of a lengthened vowel duration. Each non-word had an ABA syllable pattern and differed in the length of the vowels and the accent of the consonants. Stimuli were either "milami", with shortened or lengthened durations,

Figure 1. Head-turn preference procedure laboratory setting.

or “lamila”, with shortened or lengthened durations. The non-words presented during familiarization were either “milami” with shortened durations or “lamila” with lengthened durations. At test the shortened and lengthened duration of the opposite word was presented in alternating order. Each presentation, both during the Exposure Phase and the Test Phase, consisted of three slightly different versions of the same non-word presented in a quasi-random order that never repeated sequentially.

Procedure

Infants were tested individually using a head-turn preference procedure. There were two phases of this study: an Exposure (familiarization) Phase and a Test Phase. During the Exposure Phase, the caregiver and infant were brought into the test room. The caregiver was instructed to sit on a chair between two cabinets and facing the desk of the experimenter. The caregiver was fitted with headphones that played music to mask the sound of the stimuli and was informed that the experimenter would be wearing similar headphones during the testing procedure. The caregiver held the infant on his or her lap. The experimenter then left the room and played the familiarization stimulus for the infant on both speakers (the right and the left side) from iTunes on the computer in the adjoining test room. The infant listened passively to the stimulus, which consisted of one set of words with a specific rhythmic duration pattern (e.g., shortened duration) in which the three versions of the same word repeated in random succession for approximately 2 minutes. After the presentation of the auditory clip, the experimenter re-entered the test room, sat behind the desk directly across from the infant and began the Test Phase when the infant was facing forward and appeared to be attentive.

During the Test Phase, a standard head-turn preference procedure was used as described by Kemler Nelson et al. (1995). The Test Phase began with the image of Mickey Mouse flashing on a computer screen to one side of the infant. When the infant turned his/her head to look at the screen, the target image stopped flashing and remained on the screen as the experimenter pressed a key from behind the desk that prompted one of the sound stimuli to begin playing from the sound speaker located directly above that computer monitor. The key press, made by the experimenter, also initiated a timer for the looking-time behaviour of the infant for this particular trial. The stimulus that played had either the familiar durational pattern or a novel durational pattern, as determined by the Exposure Phase. For example, if “milami” of a shortened duration was presented during exposure, the infants was tested with the non-word “lamila” in shortened versus lengthened duration at test. The stimulus continued playing until the infant looked away (45 degree head turn for 2 seconds) at which time the experimenter released the key press, terminating the timer for this trial as well as extinguishing the auditory and visual stimulus. The next trial began with Mickey Mouse flashing on the computer monitor on the opposite side of the infant. When the infant focused on the other computer monitor the trial proceeded in an identical manner but presented a stimulus with the opposite durational pattern. This alternation of familiar and novel stimuli continued for 20 trials, such that each stimulus type was presented 10 times in total. The side of first presentation (left or right) was counterbalanced across participants. The first stimulus (varying in durational cues) was also counterbalanced across participants. The duration of testing was approximately 15-20 minutes.

Results

An initial 2x2x2 mixed variable Analysis of Variance was conducted to statistically test the effectiveness of the counterbalancing efforts made in the current experiment. The within-subjects variable in this analysis was stimulus (familiar versus novel). The first between-subjects variable was the side of first presentation (left versus right) and the second between-subjects variable was the durational cues of the first presented stimulus (long versus short duration). The analysis revealed no significant main effects or interactions, indicating that the counterbalancing efforts were effective.

A 2x2x2 mixed variable Analysis of Variance was conducted with stimulus (familiar versus novel) as the first within-subjects variable, half of the study (first half versus second half) as the second within-subjects variable, and age (under 8 month versus over 8 months) as the between-subjects variable. Infants' looking-time was the dependent variable. There was a significant main effect of Stimulus, F (1, 14) = 5.01, p = 0.04, partial η = 0.26. A paired-samples t-test revealed that, overall, infants looked longer towards the novel durational pattern (M = 0.54, SD = 0.07) than the familiar durational pattern (M = 0.46, SD = 0.07), t (15) = 2.43, p = 0.03). There was no significant main effect of Half, F (1,14) = 0.12, p = 0.74, partial η = 0.01.

There was a significant Stimulus x Half interaction, F (1, 14) = 9.68, p = 0.01, partial η = 0.41. A paired-samples t-test revealed that there was no significant difference between looking times towards the familiar stimulus (M = 31.37, SD = 11.25) and the novel stimulus (M = 31.80, SD = 10.72) during the first half of experimentation, t (15) = 0.20, p = 0.84. A second paired-samples t-test revealed that there was a significant difference between looking times towards the familiar stimulus (M = 25.34, SD = 7.60) and the novel stimulus (M = 36.03, SD = 17.93) during the second half of experimentation, t (15) = 2.94, p = 0.01. The differences between looking times (between the familiar versus novel stimuli) in the first versus the second half of experimentation are represented in Figure 2. Finally, the analysis found no significant Stimulus x Half x Age interaction, F (1, 14) = 1.94, p = 0.19, partial η =0.12.

Discussion

The results of the current experiment revealed that there was a significant main effect of stimulus type (novel vs. familiar). Overall, the infants showed preference for the stimulus with a novel durational pattern. These results indicated that infants were able to discriminate between two stimuli that differed in their fine durational properties. The results also revealed that there was a significant stimulus by half interaction such that looking times, towards the familiar versus novel stimuli patterns, during the first half of the experiment were virtually identical while looking times in the second half of the experiment were significantly different.

The finding that infants were sensitive to, and could use, fine durational cues for discrimination between two similar speech samples reinforces a plethora of literature demonstrating that infants are sensitive to prosody (of which fine durational cues are an important component) in speech and can use this information to perform a variety of tasks. Mehler et al. (1998) found that infants as young as 4 days old were able to discriminate between utterances of their native language and utterances from a non-native language using prosodic cues. Further research has provided evidence that prosody continues to be an important aspect in infants' discriminative abilities and aids in language acquisition. For example, infants have previously demonstrated the ability to extract rhythmic characteristics of different languages and sort these languages into their differing rhythmic classes (Nazzi et al., 1998; Nazzi et al., 2000). Infants have also shown a preference for disyllabic items with stress patterns typical of their native language compared to those with stress patterns typical of a foreign language (Jusczyk et al., 1993) and have exhibited the ability to use the prosodic cues that are typically found at word boundaries to segment streams of speech (Christophe et al., 1994). Infants have demonstrated, in a wide variety of tasks, that they are sensitive to prosody and are able to use this prosodic information to distinguish between speech samples. Thiessen, Hill, and Saffran (2005) explained that, compared to adult-directed speech, the prosody of the English language is particularly well represented in infant-directed speech because of the slow pace and clear articulation. It is reasonable to hypothesize that infant-directed speech in other languages emphasizes the same properties of speech and therefore, even after only several months of life, infants have had vast exposure to and experience with the prosodic cues typical of their native language. The current results provide further evidence that prosody is a particularly well-represented aspect of speech for infants and they are able to rely on prosodic cues when distinguishing between speech samples varying in rhythmic duration.

Adult listeners have demonstrated an ability, similar to infants, to rely on prosodic properties when discriminating between languages that differ in their rhythmic classes (Dauer, 1983). White et al. (2012) reported that, when distinguishing between various languages, there is a plethora of other cues available to aid in the discrimination process. The researchers tested English-speaking adults on their ability to discriminate between English and Spanish speech samples for which only rhythmic cues were available. Their results demonstrated that adult listeners were able to successfully discriminate between the two speech samples when only durational information was provided, indicating that adults are able to rely on specific durational cues rather than a more broad sensitivity to rhythm when discriminating between speech samples. This ability had not yet been demonstrated in infants even though, similarly, infants are exposed to a vast array of speech cues that aid in their growing ability to understand and break speech into its meaningful components. The current results provide evidence that fine durational information is sufficient for speech sample discrimination in infants as well, even when presented in isolation from other cues that interact with prosody and that are typically found in naturally occurring speech samples (e.g. phonotactic regularities, allophonic variations).

An unusual finding in the current results is that the novelty effect appears to be largely driven by differences in looking time in the second half of the testing session. Looking times towards the familiar versus novel stimuli patterns during the first half of the experiment were not significantly different (t (15) = 0.20, p = 0.84), suggesting that infants did not habituate to the stimuli despite a 2 minute exposure period and 20 trial test session. Thorpe (1963) defined habituation as the somewhat permanent waning of a response towards repeated stimulation. Habituation and the related dishabituation (the recovery of response towards a novel stimulus after habituation) have been demonstrated throughout the literature to be a typical finding in infant looking time research. However, the current results did not provide evidence for habituation. During the second half of the experiment, as seen in Figure 2, there was an overall decrease in looking times toward the familiar stimulus and an overall increase in looking times towards the novel stimulus. The observed novelty preference was not observed until the second half of the experiment.

There are a variety of factors that influence an infant's familiarity/novelty preference. Hunter, Ames and Koopman (1983) found that the complexity of the stimulus, relative to the age of the infant, interacts with the length of familiarization time in affecting infants' preferences for novelty versus familiarity. They also suggested that individual differences in personal processing speed might play an important role as well in determining an infant's preference. Evidently there are many factors in determining familiarity versus novelty preferences in infants and predicting which preference will be exhibited is a complicated and difficult task. It is reasonable to hypothesize that the observed results of the current experiment may be due to the limited 2-

minute familiarization time. Rose, Melloy-Carminar, Gottfried, and Bridger (1982) exposed infants to visual stimuli for varying durations of time (3.5, 4.5, and 6.5 seconds) and concluded that infants demonstrated a preference for the familiar stimulus after limited exposure whereas infants exhibited a preference for the novel stimulus with longer exposure. These results have been frequently replicated in both visual and auditory infant research and, although commonly observed, were not seen in the current results. There was never an observed preference for familiarity in the current results. The 2-minute familiarization time in the current experiment may not have been sufficient to provide infants with enough evidence to distinguish between the complicated yet similar stimuli. Looking times, during the first half of the experiment, being nearly identical may suggest that infants were learning about the stimuli during the first half of trials. The stimuli used in this experiment varied only in their fine durational cues, which overall are very subtle and create complicated stimuli. Infants, therefore, may have been equally interested in both stimuli because they still did not completely understand the durational properties of each stimulus. After 2 minutes of familiarization and, subsequently, 10 trials of exposure to the familiar stimulus, infants may have finally learned to distinguish between the familiar and novel patterns.

There are a variety of complex factors that contribute to familiar versus novel stimulus preferences and finding the point when this familiar-to-novel-preference shift occurs is a complex task. In the current study, there was a non-significant stimulus by half by age interaction, when the subjects were divided into two groups: infants over the age of 8 months and infants under the age of 8 months. A Chi-Square Test of Independence revealed that there was a significant relationship between the age of the infant (under 8 months versus over 8 months) and stimulus preference (familiar versus novel), $\chi^2(1, N = 16) = 5.33$, $p = 0.02$, Cramer's $V = 0.58$.

Overall, infants below the age of 8 months showed no preference for familiar versus novel (50% of infants showed preference for the familiar pattern and 50% showed preference for the novel pattern). Overall, infants over the age of 8 months preferred the novel stimulus (100% of infants showed preference for the novel pattern). Based on these findings, it is reasonable to predict that around 8 months of age infants' auditory processing and abilities to handle the complexity of this stimulus are advanced enough to allow the infants to habituate to the stimulus with familiar durational cues and show preference for the stimulus with novel durational cues. It is reasonable to hypothesize, based on the current study, that for fine durational cues (as an important element in prosody) and with the exposure time outlined by this experimental procedure, approximately 8 months of age is when this shift occurs. In future research, the effects of age in processing fine durational cues as well as different initial familiarization times in speech samples should be investigated.

Age has been shown, in various studies, to interact with other factors such as familiarization time and complexity of stimulus in affecting familiarity versus novelty preference in infant looking time procedures. Older infants have also proven to comprehend and process complex stimuli more easily than younger infants (Hunter et al., 1983). Jusczyk and Aslin (1995) and Saffran et al. (1996) conducted similar experiments involving infants' abilities to detect sound patterns of specific words in a stream of fluent speech. Although the studies varied in several ways, results from both studies indicated that infants of about 7.5 months of age were able to distinguish between speech samples that did or did not include a previously familiarized target word. Interestingly, Jusczyk and Aslin found a familiarity preference while Saffran et al. found a novelty preference. These results reflect a general finding that, overall, infants have been fairly divided in their novelty versus familiarity preferences. Commonly this division of preference has not been considered important and the conclusions drawn by most researchers have been that infants showing a preference, regardless of the direction, is the truly important result. In the future, and with a larger sample size, it would be interesting to investigate the effect that age plays in a discrimination task involving fine durational patterns. The current results indicate that, with a larger sample size, age may have an interaction with the other variables. Investigating the effects of age may also provide interesting insight into infants' developing understanding of fine durational patterns, throughout the first year of life, and into the course of the language acquisition process overall.

The present study did not gather information regarding the languages that infants were exposed to in the home environment. There is always a possibility that infants have been raised in a bilingual home and therefore exposed to the phonetic, allophonic and prosodic properties of more than one language at a time. Previous research has indicated that bilingualism begins to affect infants' language perception abilities late in the first year of life. Burns, Yoshida, Hill and Werker (2007) tested infants at 6- to 8-months of age, 10- to 12-months of age, and 14- to 20-months of age, from French-English or English-only home environments, on their ability to discriminate between a French and an English voice onset time distinction (the length of time that passes between the release of a stop consonant and the subsequent onset of voicing). They found that 6- to 8-month olds responded similarly to both French and English voice onset time distinctions regardless of being monolingual or bilingual. These findings are in line with research by Werker and Tees (1984) who reported that an infant's sensitivity to aspects of non-native speech does not significantly decline until approximately 10 months of age. Burns et al. (2007) also reported that groups of infants 10- to 12-months old and 14- to 20-months old displayed language-specific discriminative abilities. They found that monolinguals could discriminate only the English voice onset time distinction whereas bilingual infants were able to discriminate both distinctions. These results reinforce the findings that, towards the end of the first year of infants' lives, their ability to discriminate non-native speech contrasts declines. The researchers concluded that infants who, from birth, are exposed to two languages are equipped to process each language as a native language and are sensitive to the properties of both languages throughout the first year and onward. It is important to note that, late in the first year of life, when infants' language perception abilities are becoming less generalized and more tuned to the properties of their native language, bilingual infants are equipped with a more extensive repertoire of speech sounds.

Furthermore, Abboub, Bijeljac-Babic, Serres and Nazzi (2015) reported that French-learning infants have difficulty when processing non-native languages like English because the French language lacks lexical stress. They stated that these difficulties are commonly seen in infants of about 10 months of age (when their language processing abilities are becoming more exclusive to their native language) during tasks involving prosody (e.g. differentiating trochaic versus iambic patterns). Abboub et al. (2015) investigated the sensitivity to lexical stress contrasts of 10-month-old monolingual French infants and bilingual infants learning French as well as a second language with variable lexical stress patterns. The results indicated superior performance by bilingual infants in discriminating lexical stress patterns. These findings suggested that infants exposed to the lexical stress patterns of French and a language with stress-other patterns had increased prosodic discrimination abilities. Their findings also suggested that as little as 30% exposure to a language with different or variable lexical stress patterns might be enough for bilingual infants to learn to differentiate stress patterns in lists of varied pseudowords. Abboub et al. (2015) explained that these findings suggest that even limited exposure to a language during infancy can have a significant impact on how language processing develops and to which stress patterns infants develop sensitivity.

In collecting samples, especially from older infants (at 9- or 10-months of age), bilingualism is an important factor that must be considered. The effects of bilingualism on discrimination in fine durational cues would be an interesting extension to the current research that should be investigated in the future. In samples of older bilingual infants, it is reasonable to assume that bilingual infants would be equally sensitive to the prosodic features of two languages. This bilingualism especially for French, which lacks lexical stress patterns and is a language with variable stress patterns, could lead to increased sensitivity, overall, to prosodic features. Especially of interest, is the finding that even limited exposure to a second language can have an impact on the prosodic processing of infants. In future extensions of this study, information should be gathered as to an infant's exposure to various languages and the effects of a second language on fine durational pattern discrimination.

Finally, because White et al. (2012) found that adult listeners were able to successfully discriminate between the two speech samples when only durational information was provided (in flat sasasa" speech), adults should be presented with the stimuli used in this experiment to investigate if these abilities transfer to samples of speech currently used. The current stimuli uses rhythmic cues varying in fine duration presented within a trisyllabic non-word rather than fine durational cues presented alone as in "flat sasasa" speech. Because infants were successful at this discrimination task, adults' abilities should be investigated in future extensions of the current research.

Overall, the results of the current experiment revealed that infants were able to discriminate between two stimuli that differed only in their fine durational properties. This finding, that infants could use fine durational cues for discrimination between two similar speech samples, reinforces an abundance of literature demonstrating that infants are sensitive to prosody of which fine durational cues are a component. The current findings also extend research, by White et al. (2012), that adult listeners were able to distinguish between languages based entirely on durational information rather than simply a broad sensitivity to rhythm. Infants have demonstrated that they too are able to extract and rely entirely on fine durational patterns to discriminate between speech samples.

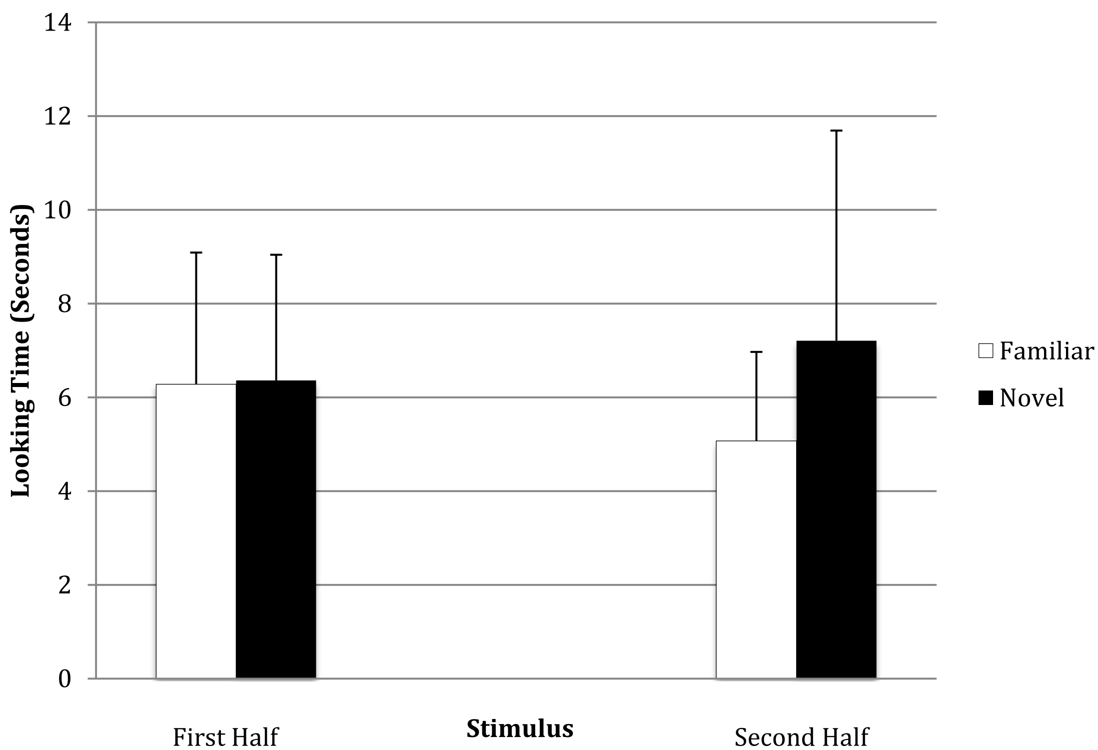

Figure 2. Average looking time per trial in seconds to familiar and novel stimulus across first half of trials and second half of trials. Error bars represent the standard error of the mean.

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