Maturation and Experience in Preterm Speech Perception

by

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Abstract

The present study examined the relative impact of maturation and experience on preterm and full term infant speech perception when learning about sounds that are unable to be heard in utero (i.e., fricative sounds). Our sample consisted of 7 (*N* = 49 full term, 9 preterm) 9 (*N* = 57 full term, 27 preterm), and 11-month (*N* = 68 full term, 25 preterm) gestationally corrected full term and preterm infants, with a follow-up at 18-months (*N* = 43 full term, 13 preterm). The headturn preference procedure was utilized to measure infants' perception of fricative sound pairs and vowel sounds at different ages by presenting infants with common versus uncommon sound pairings and measuring looking times for these sounds. I did not find evidence for preterm infants outperforming full term infants on the common versus uncommon sound discrimination task. This could be partially due to maturation playing more of a role than experience when infants are developing an understanding of the phonetic constraints surrounding fricatives in the English language. Specifically, preterm infants were not able to utilize the extra experience gained out of the womb with sound pairings involving fricatives, possibly due to a maturational restriction. Further, no relationship was found between MCDI scores and discrimination of common from uncommon fricative sound pairs, suggesting that when infants begin to gain an understanding of phonotactic properties in their language is not always indicative of their later language development.

Keywords: preterm infant, speech perception, language development, phonotactics

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Maturation and Experience in Preterm Speech Perception

It has consistently been shown that language development differs between preterm and full term infants after controlling for health and socioeconomic economic status (SES; e.g., Censullo, 1994). Preterm infants have a different sound experience compared to their full term peers. This is due to the developing fetus being exposed to limited sounds in the womb that preterm infants are removed early from (Gerhardt, Otto, Abrams, Colle, Burchfield, Peters, 1992). Research is mixed on whether gestationally matched preterm infants (i.e., corrected to 40-weeks gestation) are able to utilize their extra exposure to the full sound environment out of utero or if maturation inhibits this (e.g., Peña, Werker, Dehaene-Lambertz, 2012; Gonzalez-Gomez & Nazzi, 2012). An area of interest that has not been fully explored is sound combinations unable to be heard in utero--specifically, sound pairings involving fricatives. The current study sought to understand whether a maturational or environmental account of development best described how infants gain an understanding of fricative sound pairings.

Preterm Birth

Preterm infants are those who are born at less than 37 weeks gestation (World Health Organization, 2014). Over 15,000 infants are born in Manitoba each year, 8.3% being preterm (Heaman et. al, 2012). This rate is slightly higher compared to the national average of 7.8% (Statistics Canada, 2016). Research consistently shows that the preterm population is at risk for having less advanced cognitive development as well as language skill impairments by the second year of life (Bhutta, Cleves, Casey, Cradock, & Anand, 2002; Censullo, 1994; Charollais, Stumpf, De Quelen, Rondeau, Pasquet, & Marret, 2014; Foster-Cohen, Edgin, Champion & Woodward, 2007). Many of these delays, however, may be confounded by preterm infants who are multiple births or born with health deficits (e.g., Singer, Yamashita, Lilien, Collin, & Baley, 1997; Thorpe, 2006). Regardless of health or multiple birth status, preterm infants have a significantly different experience during development compared to full term infants, especially within the first year. This difference in development is due to preterm infants being removed from the uterine environment earlier than their maturationally matched full term peers.

Uterine environment

Sounds can be heard in utero by the end of the second trimester due to the development of neural pathways and the cochlea being operative (Abrams & Gerhardt, 2000; Moore, & Linthicum, 2007; Richards, Frentez, Gerhardt, McCann, & Abrams, 1992). Preterm infants are removed from their uterine environment early, meaning that they do not receive as much time listening to sounds in utero compared to their full term peers. Conversely, preterm infants, who were conceived at the same time as their full term peers but are born earlier, receive more out of utero experience. This is important due to the fetus not being exposed to the full range of sounds heard by infants who are outside of the uterine environment.

The fetus typically only hears sounds produced at a frequency below 300-400 Hz (Gerhardt, Otto, Abrams, Colle, Burchfield, Peters, 1992; Griffiths, Brown, Gerhardt, Abrams, & Morris, 1994). This is referred to as low-pass filtering, and occurs because the mother's abdomen and uterine tissues filter out higher frequency sounds, preventing these noises from being heard by the fetus (Abrams & Gerhardt, 2000). Fricative sounds occur at a relatively high frequency (i.e., greater than 400Hz) and are therefore unable to be heard in utero, vowels occur at a lower frequency and can therefore typically be heard in utero (Shadle, 1985).

To study what types of sounds are filtered into the uterine environment, research has been conducted on pregnant mammals. In a study conducted by Griffiths et al. (1994), pregnant sheep were examined. A hydrophone was placed on the sheep's fetus that then recorded sounds being presented from outside the fetus. When these recordings were then played back for judges, individuals made more errors in understanding recorded words that contained consonant sounds. Consonant sounds are produced at a higher frequency. This demonstrates that sounds produced at a low frequency are able to enter the uterine environment, while those produced at a higher frequency tend to be filtered out.

Knowing about the different sound exposure in utero is important because infants begin learning in this environment. For example, when learning about their language environment, infants first learn about the prosody of their native language (Mehler, Jusczyk, Lambertz, Halsted, Bertoncini, Amiel-Tison, 1988). These melodic characteristics of language pass into the womb (Kisilevsky, Hains, Jacquet, Granier-Deferre, & Lecanuet, 2004).

Mampe, Friederici, Christophe, and Wermke (2009) studied infants' retention of sounds that they were exposed to in utero by examining the cries of French and German healthy newborns. It was found that the majority of French newborns produced cries with rising contours (typical of the French intonation), while the majority of German newborns cried with falling contours (typical of the German intonation). Because infants in this study were only two to five days old, this suggests that they were most likely exposed to the intonational characteristics of their language in utero, which influenced the crying noises they produced. This demonstrates that infants are able to learn from their environment while developing in the womb.

Similarly, DeCasper and Spence (1986) determined that infants are influenced by speech heard during the third trimester, and are also capable of remembering these sounds. In this study, newborns' preference for auditory stimuli that had been heard in utero was examined. By examining infants' reactions to excerpts that were read by the mother while in utero, it was discovered that infants found the stories heard in utero more reinforcing compared to those that were not. These results suggest that the fetus is not only hearing but also retaining information heard in the womb. These findings are important due to the fact that preterm infants are removed from this environment early, therefore receiving a different experience compared to their full term peers who are still developing in utero.

Infant Speech Perception

Studies have shown that infants are capable of discriminating and categorizing speech sounds by the age of one month (Eimas, Siqueland, Jusczyk, & Vigorito, 1971; Jusczyk, 1997). The ability to discriminate speech sounds is at first broad, with infants being able to perceive the properties of many types of languages (Werker, Gilbert, Humphrey, & Tees, 1981). However, throughout the infants' first year, this capability narrows to only being able to discriminate contrasts in the infants' native language, and infants begin to have a difficult time discriminating sounds that are uncommon to the language they are typically surrounded by (Werker & Tees, 1984).

Werker and Tees (1984) examined the timeline of the regression of nonnative speech perception by presenting infants with both nonnative and native (i.e., English) speech sounds from ages 6-12 months. The non-native language sound pairings that infants were presented with were from the Thompson language (a language that uses non-English places of articulation) and the Hindi language (a language that has four places of articulation compared to English's three), as well as the English sound pairings. This study found that the older the infant group, the less discrimination between changes of sounds common to the foreign languages occurred. Specifically, infants 6-8 months in age, but not 10-12 months of age, were able to discriminate between changes of sounds in foreign languages. These findings demonstrate that there is a weakening in infants' capability to discriminate contrasts in nonnative speech sounds between the ages of 6-12 months. These results also provide evidence that infant speech perception is shaped by the environment.

The narrowing of language discrimination occurs because infants initially have certain sensitivities to their perception of acoustics, which are shaped by being exposed in their direct environments to the auditory applications of different sounds (Aslin & Pisoni, 1980). Cristia (2011) examined how certain exposure to sounds shapes infants' perceptions of these sounds. Infants' ability to discriminate the similar sounding /s/ from /ʃ/ (with /s/ as a target category and /ʃ/ as the habituation category) was assessed using a visual habituation procedure (Werker, Shi, Desjardins, Polka, & Patterson, 1998). Overall, it was found that how prominent caregivers' pronunciation of /s/ was from /ʃ/ determined how likely their infants were able to discriminate these sounds from one another. These findings show that the way in which infants learn to perceive sounds is guided in part by the way in which they experience these sounds in their environment.

Phonotactics

Phonotactics describe the combinations of sounds (phonemes) that are permissible or impermissible in a given language as well as common or uncommon. For example, the sound combination /vr/ is not permissible in the English language, but /sl/ is. Gaining knowledge of phonotactics is crucial for infant speech development, as it is a building block for the eventual understanding and production of words (Werker & Yeung, 2005).

Jusczyk, Luce, and Charles-Luce (1994) examined infants' knowledge of phonotactica in their English-speaking environment by playing sound combinations that were both typical (i.e., likely consonant-vowel-consonant phonemic patterns, such as "riss") and atypical (i.e., unlikely consonant-vowel-consonant phonemic patterns, such as "yowdge") and examined which sounds infants preferred based on listening time. The strategy of measuring listening time when sounds are played was used because infants who have knowledge about a regularity in their language will listen longer to sounds that contain this regularity (Jusczyk, Cutler, & Redanz, 1993). Nine-month, but not six-month, infants looked significantly longer for the common sound pairs compared to the uncommon sound pairs.

Friederici and Wessels carried out a similar study in 1993 that examined infants' phonotactic understanding with word boundaries (i.e., the beginning and ending of words). Phonotactic characteristics within languages exist that indicate word endings and beginnings. Therefore, determining at what age infants began preferring licit from illicit word onset and offset combinations in the English language would indicate when an understanding for this specific phonotactic regularity occurs. The authors examined infants from Dutch-speaking families at 4.5, 6, and 9 months and presented them with licit and illicit word onset and word offset combinations using the headturn preference procedure. Similar to results found by Jusczyk et al. (1994), 9-month infants spent significantly more time attending to the licit strings of word onset and offset strands compared to the ilicit strands. The results from the outlined studies indicate that typically developing infants begin to prefer listening to common sound pairings roughly by 9-months of maturational age, indicating that it is within this time frame that they are gaining an understanding of the phonotactics of their native language.

Maturation and Experience

The maturational account of development was described by Gesell (1929) as being due to genetic sequencing independent of learning and life experiences. In terms of infant speech development, the maturational theory would predict that infants develop language differently in part due to their different biological makeup (e.g., their neural growth independent of experience). Conversely, experiential theory states that humans learn and develop from what is presented to them in their environments, specifically the individual experiences they have (Dewey, 1958). The experiential approach would therefore focus on infants' different levels of experience and exposure with speech stimuli when acquiring speech. Development cannot be explained exclusively by one framework (i.e., maturation or experience) because they are interwoven with each other throughout the developmental process. However, it is important to determine whether maturation is inhibiting the use of experience in a given area of development, such as speech perception.

Compared to full term infants of the same maturational age, preterm infants not only have less in utero exposure to low-pass filtered sounds, they also have more out of utero sound experience with the full acoustic environment. For example, a preterm infant who was in utero for 30 weeks and out of utero for 30 weeks is of the same maturational age as a full term infant who was in utero for a full 40 weeks and out of utero for 20 weeks, but has had an extra ten full weeks out of utero as well as less time in utero. Although the full term infant has spent more time in utero and less time out of utero, the two infants still have the same maturational time frame with different amounts of experience with different sounds.

Research varies on whether a maturational account of development is driving infants' understanding of certain phonetic rules in their native language, or whether in some cases maturation is not overriding experience, allowing experience to be utilized (Bosch, 2011). Specifically, findings have differed on whether or not preterm infants perform similarly to or outperform their full term gestational age matched peers. We might expect preterm infants to outperform their full term gestationally age matched peers because preterm infants are born earlier, thus being exposed to the full acoustic environment earlier. This means that preterm infants gain more experience with certain properties of their language compared to full term infants, who are still developing in the womb. Preterm infants, in some cases, may be able to use this extra experience to their advantage. To compare gestational age matched infants, we correct for preterm age by subtracting the infants' date of birth from their 40 weeks gestation due date and subtracting this number from their current chronological age. For example, if a preterm infant was born eight weeks early (32 weeks gestation), and they were born nine months ago, their corrected age would be seven months. Essentially, gestationally age matched preterm and full term infants were conceived around the same time period, but the preterm infant was born earlier.

Correcting infants to a 40-week gestational age allows researchers to match preterm and full term infants so that both groups are of the same maturational age. This allows us to examine how infants in both preterm and full term groups are performing on certain tasks in comparison to each other. If both groups are performing similarly at the same maturational age, this would suggest maturation is the driving force for the task being examined (e.g., speech discrimination). If groups do not perform similarly (e.g., preterm infants are outperforming full term infants), this would suggest experience is being utilized due to maturation not inhibiting infants from using the experience presented.

Some key studies examining the current issue of maturation versus experience in infants' language development have suggested a maturational account for speech development in preterm infants. A study conducted by Peña, Pittaluga, and Mehler (2009) examined pre and full term infants' ability to distinguish their own language from other rhythmically similar and dissimilar languages. The researchers exposed healthy preterm and full term infants to their native language (Spanish), a similar rhythmic language to their native language (Italian), and a distant rhythmic language to their native language (Japanese). By measuring infants' gamma-band power (increased levels indicate recognition) while being exposed to the different language recordings, it was found that preterm infants performed similarly to their corrected age matched full term controls. That is, preterm infants' levels of recognition was similar to full term infants' when they were exposed to their native language. Although preterm infants had been born earlier and in turn had more experience with the full range of their native language's sounds, they were not able to use this to their advantage because they did not have the neural maturation to do so. However, results supporting experiential effects have been found when examining phonotactic acquisition in sounds that are not well perceived in utero.

Gonzalez-Gomez and Nazzi (2012) examined whether phonotactic perception in French healthy preterm and full term infants was restricted by maturation, or whether experience also played a role. The researchers presented the preterm and full term infants with labial coronal (LC, more common in the French language) and coronal labial (CL, uncommon in the French language) pairings. Coronal consonants are sounds that are articulated by the front part of the tongue, while labial consonants are articulated with the lips. Compared to, for example, vowels, these LC and CL phonotactic pairings are not as well passed through into the uterine environment. This means that compared to full terms of the same corrected age, preterm infants would have had more exposure to these sounds because they were born earlier. Thus, the researchers predicted that the preterm infants' extra experience with these sounds (in comparison to their full term peers) would enable them to utilize this experience, and they would in turn outperform the full term infants of the same maturational age to them.

It was found that preterm infants who were matched by birth date (therefore having the same amount of out-of-womb experience with the sounds) to the full term controls performed similarly when presented with the common and uncommon sound pairings. However, when the same infants were gestationally age matched to 40-weeks, it was found that preterm infants (who had the same maturational development as the full term infants but more experience with the sound pairings) recognized common sounds at seven months, while the full term infants could only do this at ten months. Because preterm infants had been exposed to these sounds longer than full term infants and recognized their distinctions earlier, this indicates that maturation was not inhibiting preterm infants from utilizing this extra experience when gaining knowledge for this specific phonetic sound pairing. This finding suggests that experience is not hindered by maturation when it comes to learning about sounds that cannot be heard in utero. However, in order to test this claim, more sound pairings need to be examined.

Current Study

In order to study at what corrected age infants seem to gain an understanding of phonotactics involving fricative and vowel sounds, relative interest between common versus uncommon fricative sound pairs and common versus uncommon vowel placements was compared in infants at 7, 9, and 11 months. Both common versus uncommon fricative pairs and vowel placements were studied in order to examine differences between when infants begin to gain understanding for sounds that are perceived both in (i.e., vowels) and out (i.e., fricatives) of utero. Whether maturation or experience was driving the development of speech perception was observed by comparing looking times of fricative sound pairings for both the preterm and full term groups at 7, 9, and 11 months. Preterm and full term infants were compared based on their maturational (corrected to 40 weeks gestation) ages. Therefore, preterm and full term infants in the study were similar in terms of maturation, but preterm infants had more experience with fricative sounds compared to full term infants. Because preterm infants on average had more time spent listening to fricative sound pairings compared to their gestationally matched full term infants, this allowed me to examine whether experience had a significant effect on infants' understanding of fricative sound pairings, or if maturation inhibited the utilization of this extra experience.

Separate comparisons were made to determine whether health status at birth or multiple birth status (i.e., twin births) were factors in infants' ability to discriminate sound pairings. First, infants who were defined as unhealthy at birth were removed from both preterm and full term fricative analyses. Next, infants who were multiple births were removed from the preterm fricative analysis (no full term infants within the study were multiple births). The same was done with only those infants who were not a multiple birth. This was done after null results were obtained for differences in looking times between common and uncommon sound pairings in the 9-month preterm group. Finally, to determine whether the ability to discriminate fricative sound pairings predicted performance on the MCDI, infants' caregivers completed an MCDI at an 18-month follow up appointment and MCDI scores were compared to looking times for the common versus uncommon fricative sound pairings at 9-months.

As previously noted, infants who have developed an understanding of the phonotactic properties of their language should prefer to listen to common over uncommon sound pairings (Jusczyk, Cutler, & Redanz, 1993). Therefore, if infants spend significantly more time listening to common sound pairings compared to uncommon sound pairings, they most likely have an understanding of the phonotactic properties in their native language that are being played to them.

As mentioned previously, sounds involving fricatives occur at a relatively high frequency (i.e., greater than 400Hz) and are therefore unable to be heard clearly in utero, while sounds involving vowels occur at a lower frequency and can therefore typically be heard in utero (Shadle, 1985). Sounds involving fricatives and vowels were played for infants and interest in listening to these sounds was measured.

Purpose Statement

The purpose of this study was to examine the developmental trajectory of phonotactic acquisition, specifically involving vowel and fricative sounds, from 7-11 months in full term infants in comparison to preterm infants. This was done to determine whether maturation was inhibiting preterm infants' utilizing their extra experience when gaining knowledge on phonotactic characteristics that can only be heard out of the womb (i.e., fricative sounds). The questions that this study addressed were:

1) At what age do typically developing infants gain an understanding of phonotactics involving fricative and vowel sounds?

2) Do we see differences between preterm and full term infants' knowledge of phonotactics? If so, do these differences support an experiential hypothesis? In other words, do corrected age matched preterm infants outperform corrected age matched full term infants on the perception of fricative sounds?

3) Does health or multiple birth status confound potential differences between preterm and full term infants' knowledge of phonotactics?

4) Does ability to discriminate fricative sound pairings predict performance on the MCDI?

Hypotheses

1) Typically developing infants will gain an understanding of the phonotactic rules for fricative and vowel sounds by nine months of age. This was hypothesized based on previous studies that have found similar findings on when typically developing infants are gaining an understanding for phonetic rules in their environments (e.g., Friederici & Wessels, 1993; Jusczyk, Luce, & Charles-Luce, 1994).

2) Differences will be seen between preterm and full term infants of the same maturational age in terms of phonotactic knowledge with fricatives. Specifically, preterm infants who are matched for corrected age to full term infants (and thus have more experience with fricatives) will outperform full term infants by discriminating between common versus uncommon fricative sound pairs at an earlier age compared to full terms. Therefore, I hypothesized that preterm infants would be able to utilize their extra experience with fricative sounds and that maturation would not inhibit this.

3) Because my sample consisted of mainly healthy infants, I hypothesized that health would not play a role in these potential differences. I did not have a specific prediction regarding multiple births, as this question was exploratory in nature.

4) Ability to discriminate fricative sound pairings will predict performance on the MCDI. This was hypothesized because infants who learn about the phonotactic regularities of their language earlier will be at an advantage in learning language (as measured by the MCDI).

Methods

Participants

Participants consisted of healthy (at the time of study) preterm and full term infants from Manitoba. Infants were from monolingual environments, with no more than 20% of a language other than English occurring in their daily environments. In regards to the current study, preterm was defined as an infant born at a gestational age less than 37 weeks, with full term infants being born at 37 weeks gestation or later. “Healthy”, in terms of the current study, was considered infants who did not require any medical testing or specific examination or pediatric appointments during the time of participation.

For the current study, infants were recruited at 7, 9,11, and 14 months specifically. Infants were also asked to participate in an 18-month follow up to complete a BSID. It is important to note that this study was semi-longitudinal in nature, meaning that some infants participated in more than one age group (i.e., at 7-months and again at 9-months).

Infants in both groups (i.e., preterm and full term) were corrected to a 40-week gestational age in order to be compared at maturationally similar ages at 7, 9, and 11-months. Doing this allowed for comparison of preterm and full term infants who were maturationally similar ages but differed experientially (i.e., preterm infants having more experience with fricative sound pairs). To correct for age, the number of days early the infant was born is subtracted from their due date. This means that if an infant was born at 32 weeks and has been out of the womb for 16 weeks, their corrected age would only be 8 weeks.

Research Design

This was a combined within and between subjects, experimental study. The independent variables of this study were gestational age at birth (between variable, preterm vs. full term), chronological age (within variable, 7-months, 9- months, 11-

months), and type of phonological pairings being presented (within variable, common or uncommon sounds for both vowels and fricatives). As an additional independent variable for the fricative analyses, I also examined /s/ and /ʃ/ separately as development of these two phonemes may occur at different time points. The dependent variable was the infant's preference (i.e., looking time) between vowel and fricative common versus uncommon sound pairings.

It is important to note that this study is a portion of a larger study. Therefore, data was also collected for some infants at 5 and 7 months for a separate study involving different dialects, as well as 14-months. In terms of the 14-month infants in the current study, the only data that was utilized were Bayley Scales of Infant and Toddler Development scores (i.e., if the infant had participated in the 7, 9, or 11-month age group but completed a BSID at 14-months instead of 11), but the data collected on looking times between common and uncommon sound pairings was not. This 14-month data was not used in the current study due to null results that did not provide further information to the developmental trajectory of when infants are gaining an understanding for the phonetic rules involving fricative and vowel sounds. Another MCDI is also being mailed out to parents at 24-months, and although not included in the current study will be analyzed once collected.

Instruments and Materials

Bayley Scales of Infant and Toddler Development. The Bayley Scales of Infant and Toddler Development, third edition (BSID; BSID, 2006a; BSID, 2006b) was administered to infants participating in the current study typically at the ages of 7, 11, and 18 months. Scores were used to determine whether full term and preterm infants in the study were a comparable group in terms of cognitive, fine motor, and gross motor skills. The BSID was ideally to be conducted at 18 months due to the knowledge that scores of infant abilities at 18 months are a more valid indicator of abilities compared to younger ages (Mccall, Hogarty, Hurlburt, 1972). However, infants were also given a BSID assessment at their first visit (typically 7 months) as well as their 11-month or 14-month visit. This was done for two reasons: 1) there was low retention for the 18-month follow-up visit due to mothers going back to work – collecting the earlier measure ensured that we had a data point for every participant, and 2) to determine whether our preterm and full-term samples were homogeneous across the different age groups. The BSID is a standardized assessment used to examine cognitive, fine motor, and gross motor skills among infants from ages 1-41 months (other modules exist within the BSID but were not used in this study).

During the BSID, infants are tested on a wide range of items that typically involved some type of play-like interaction. If the infant completes a desired task, (e.g., putting a desired number of blocks into a plastic drinking cup) they are given a score of one. If they do not complete the desired task, they are given a score of zero for that specific test item. For most infants, testing was conducted with a primary assessor who conducted the assessment with the infant, and an observer who watched from behind the infant. Scores were compared between the assessor and observer after the participant had departed. Discrepancies or ambiguities were resolved by discussion and consultation with the manual. This assessment tool was selected for use due to its high rates of internal consistency as well as validity (Albers & Grieve, 2007) and its widespread use in the clinical and research fields.

MacArthur-Bates Communicative Development Inventory (Second Edition). The MacArthur-Bates Communicative Development Inventory (MCDI) is a self-report, standardized assessment for parents to complete on their child's language abilities (Fenson, Bates, Dale, Marchman, Reznick, & Thal, 2007). Parents of infants involved in the current study were asked to complete the MCDI at 18 months. For the purposes of the current study, Part A, which involves a 680-word checklist of words that their infant was able to produce, was examined. The MCDI has shown to be both reliable (in terms of internal consistency and test-retest reliability) as well as valid, making it a logical choice for assessing infants' current language abilities (Volkmar, 2013). MCDI scores were used as an outcome variable to determine if the preterm and full term samples were similar in terms of speech production. These scores were also used to compare preterm and full term infants' level of speech production to their ability to discriminate common versus uncommon fricative sounds at 9-months. This was done to determine whether a relationship existed between infants' language development (as measured by the MCDI) and infants' understanding of phonotactic sound pairings (as measured by presenting them with common versus uncommon fricative sound pairs).

Questionnaire. Parents of all infants who participated in this study completed a questionnaire related to health of the infant, ethnic background, household SES, parent education level, child care arrangements, etc. (see Appendix A). For the specific study, information that was used was: SES information, health information (both at birth and currently), and whether or not the child was a multiple birth. Gathering information on health and multiple births allowed us to examine whether differences were seen in healthy versus unhealthy preterm and full term samples, as well as twin versus non-twin samples. Parents were told that they were not obligated to provide any information they were not comfortable sharing.

Recruitment

Infants were recruited primarily through a blind mail-out via Manitoba Health. Mothers of infants born in Manitoba were contacted through Manitoba Health and provided with information regarding the study. If parents were interested in having their preterm or full term infant take part in the study, they were encouraged to contact our lab directly via telephone or email. Other forms of recruitment were through hospitals, community centers, parenting tradeshows, infant groups, as well as pediatricians' offices. These locations were provided with pamphlets as well as information posters with the Baby Language Lab's contact information and a brief overview of the study. All distributed information illustrated the fact that participation was voluntary. For each appointment an infant attends, a toy was given as a gift for participating and parking or bus fare was paid for the participant. All toys cost roughly five dollars or less.

Procedures

Parents who were interested in having their child participate were invited to our Baby Language Lab at the University of Manitoba. They were asked to read through and complete the consent and questionnaire forms, and the headturn preference procedure and BSID were then explained to them. For the purposes of my study, infants who chose to participate were invited to come to the Baby Language Lab twice per age group for 7, 9 and 11 months (i.e., once for vowel sounds in the headturn preference procedure, once for fricatives in the headturn preference procedure). Infants were asked to participate in all three age groups but were not required to do so. Infants were also invited to come into the lab at 18 months to complete a BSID assessment as well as take home a MCDI-II for the parent(s) to fill out and return via postage-paid mail. BSID assessments were also completed at the infant's first appointment, as well as either 11 or 14 months during one of the two appointments per age group. See Figure 1 for a study timeline.

In order to measure level of interest in common versus uncommon fricative pairs and vowel placements, the headturn preference procedure was utilized, which is a commonly used technique of measuring infants' perceptions of sound (Kemler Nelson, Jusczyk, Mandel, Myers, Turk, & Gerken, 1995). Infants tend to look towards the source of the sound that they are listening to (Kemler Nelson, Jusczyk, Mandel, Myers, Turk, & Gerken, 1995). Therefore, a colorful checkerboard that appeared on a screen directly above the speaker that sounds were being played out of provided infants with a visual stimulus to attend to while listening to different speech sounds. In the first session, infants listened to either fricative or vowel common and uncommon sound pairings using the headturn preference procedure. In the second appointment, they listened to the sound pairings not heard in the first appointment. The order in which the appointments occurred were counterbalanced.

For all of the 7, 9, and 11 month sessions, the headturn preference procedure consisted of twelve trials of sound combinations being played for the infant: 6 common and 6 uncommon sound pairing trials for fricatives, and 6 common and 6 uncommon placements for vowels. Common fricative pairings were the sounds /shr/ and /sl/ (as in shriek, sleep) and uncommon pairings were /sr/ and /ʃl/ (as in "srep" [unattested], and "schlep"). These sounds were presented as nonsense syllables during the headturn preference procedure. A speaker whose first language was English recorded all sounds.

The same sounds were played for each infant for the entirety of the study. See Table 1 for a listing of all fricative sound pairings that were presented during the study. Common vowel placements were made up of two stop consonants (e.g., sounds like /b/, and /k/) at the beginning of the non-words, and tense vowels (e.g., sounds like /i/ as in "bead") at the end of the non-words to create single syllable common sounds (e.g., /mow/). These are common placements of vowels because tense vowels can occur at the end of single open syllables in the English language. Uncommon vowel placements were made up of two stop consonants at the beginning of the non-word and lax vowels (e.g., "ε" as in "bed") at the end of the non-word to create single syllable uncommon sounds (e.g., /bε/). These single syllable sounds are uncommon in the English language because lax vowels do not occur at the end of open single syllables. See Table 2 for a listing of all vowel sound placements that were presented during the study

During the headturn preference procedure, parents/caregivers sat in a booth with their child on their lap while researchers measured the child's looking time when either common or uncommon vowel or fricative sounds were played for them. Three computer screens mounted to the walls were utilized: one computer screen directly in front of the child (approximately 91.5cm away from the parent's chair), and two on either side of the child (approximately 50.5-51.5cm from the parent's chair). A video camera was also connected to the center monitor (i.e., in front of the child) and a monitor in the adjacent room to the booth that the researcher was situated in so that looking times could be recorded. Before the beginning of each trial, a yellow circle flashed on the center screen. Once the child attended to this screen, a yellow circle then flashed on either the right or left screen. Which side the circle flashed on was in a random order. Once the child looked at this circle, it was replaced with a picture of a colourful checkerboard, and the experimenter played the sounds for the child by clicking a mouse that was connected to the speakers (to see images of this procedure please see Figure 2). This sound only played contingent upon the infant looking at the screen. If the infant looked away from the screen, the researcher lifted the mouse and the sound stopped playing until the infant looked back at the screen. To move to the next trial, the infant needed to look at the correct screen for a minimum of two seconds. If the minimum was not reached, the trial started over. If during a trial the infant looked away from the screen for less than or equal to two seconds, the same trial continued to be played upon looking back to the correct screen. If the infant looked away for more than two seconds, the trial ended and a new trial began with the yellow circle flashing on the center screen. If the maximum looking time of 20 seconds was met, a new trial began.

Both parents and researchers were kept blind to the sound pairings in order to not influence the infants' looking times. This was made possible by having parents listen to music through Aviator headphones while their child engaged in the headturn preference procedure. Sounds were not presented to researchers through the monitor that they were measuring infants' looking time through. The infant's interest (i.e., looking time) in the visual stimulus was used as a measure of relative preference (and thus, discrimination) for sounds being played.

At 18 months, interested parents again brought their infants who participated in the 7, 9, or 11-month portions of the study to complete a BSID assessment as well as an MCDI (see Instruments and Materials). Parents at this appointment again needed to provide consent and were asked to note any changes in their questionnaire responses that had occurred (e.g., a change in their child's health status)

Results

Sample Characteristics

All infants were born and currently living in Manitoba. Based on the information that parents chose to provide on the parent questionnaire response, the full term sample consisted of 56% female and 44% male. In terms of ethnicity and household income, the majority of the full term sample was White (79%), and the median household income was >$90,000 per year. In terms of the preterm group, the data from the parent questionnaire showed that 50% of the preterm sample was male and 50% female. The majority of the preterm sample also identified as White (80%), while the median household income per year was >$90,000.

Infants were categorized into 3 main groups: 7 month preterm and full term infants, 9 month preterm and full term infants, and 11 month preterm and full term infants. For a breakdown of total *N*'s for these three groups, as well as means and ranges of age, see Table 3. Overlap did occur between age groups in that some infants participated in more than one age group. In total, 35 full term infants participated in both the 9-month and 11-month groups. Two preterm infants participated in all three age groups, while 19 participated in two of the three age groups. In total, 25 full term and three preterm infants were discarded from the study. Discarded data was due to: technical problems (i.e., speakers not being turned on, $N = 4$; infant being run under the wrong study condition, $N = 4$; and issues with video recording, $N = 1$), infants being upset (i.e., crying or fussing, $N = 11$), the infant being inattentive ($N = 2$) or the infant being exposed to over 20% of a language other than English or accents other than

Canadian English (*N* = 6).

Eighteen month preterm (*N* = 13) and full term (*N* = 43) infants were assessed using the MCDI. BSID assessments were also given at the first visit, and at either 11 or 14 months. BSID data was grouped into infants who were between 5-7 months (preterm: *N* = 25, full term: *N* = 92), 11-14 months (preterm: *N* = 24, full term: *N* = 78), and 18 months (preterm: *N* = 14, full term: *N* = 39). BSIDs were occasionally conducted at 5 or 14 months because the current study was a part of a larger study, which involved infants coming into the lab at these time points as well.

Tests of Group Similarities

To check for homogeneity across preterm and full term groups, BSID scores (cognitive and motor) were compared between preterm and full term infants to see if scores on these measures were differing significantly between preterm and full term groups. Independent samples *t*-tests were conducted to compare cognitive and motor BSID scores between preterm and full term infants. These *t*-tests were conducted for three corrected age groups: 5-7 months, 11-14 months, and 18 months. Although some 5 and 14 month BSID scores were used in these analyses, these infants were also involved in at least one of the 7, 9, or 11-month corrected age groups. In total, six independent samples *t*-tests were conducted: 5-7 month preterm/full term motor, 5-7 month preterm/full term cognitive, 11-14 month preterm/full term motor, 11-14 month preterm/full term cognitive, 18 month preterm/full term motor, and 18 month preterm/full term cognitive. Out of these six groups, only significantly different motor scores were found in the 18-month preterm (M = 55.133%, SD = 26.207) and fullterm (M = 65.00%, SD = 18.48) group; $t(51)=1.558$, p = .04. See Table 4 for an overview of the cognitive

BSID results, and Table 5 for motor BSID results.

A second independent samples *t*-test was conducted to determine if any differences existed between preterm and full term groups in terms of MCDI scores. No significant differences in MCDI scores were seen between preterm (M = 36.00%, SD = 33.421) and full term (M = 34.302%, SD = 26.783) groups; $t(53)$, $p = .43$. See Table 6 for an overview of the MCDI collected data.

Developmental Trajectory of Phonotactics

To gain an understanding of what age typically developing infants begin to gain an understanding of phonotactics involving fricative and vowel sounds, statistical analyses were conducted for both the fricative and vowel data separately. First, 2 (frequency: common vs. uncommon) x2 (fricative type: /ʃ/ vs. /s/) within subjects ANOVAs were run in order to examine the effects of common and uncommon fricative sound pairs, as well as fricative type (/ʃ/ sounds vs /s/ sounds), on looking time. This was done separately for the full term groups at 7, 9, and 11 months. Second, paired-samples *t*-tests were run to compare looking times for common and uncommon vowel sounds. This was also done separately at 7, 9, and 11 months. These analyses were run so that the full term group could act as a comparison when examining the preterm infant group's ability to discriminate common from uncommon speech sounds.

A significant main effect was found for frequency (i.e., a significant difference between looking time for common vs. uncommon fricative sound pairs) in the 9-month full term group, $F(1, 55) = 8.166$, $p = .01$, $\eta_p^2 = .129$, see Figure 3. However, no main effect of frequency was found for either the 7-month full term group, $F(1, 46) = 0.009$, $p = .93$, $\eta_p^2 = .00$, or the 11-month full term group, $F(1, 66) = 0.002$, $p = .96$, $\eta_p^2 = .00$.

No significant main effects of frequency (i.e., significant preference for common vowel placement sounds) were found in the 7, 9, or 11-month full term vowel groups. Due to these null results in all three age groups, I was not able to use the full term vowel group as a baseline for comparison to the preterm infant group. Therefore, full term and preterm infant's discrimination of common versus uncommon vowel sound pairings was not explored further.

Maturation Versus Experience

In order to examine whether maturation was inhibiting infants using their extra experience when gaining an understanding of sound pairings involving fricatives, preference for common versus uncommon fricative sounds was first examined in the 7-month infants using a 2 (gestation: preterm/full term) x2 (frequency: common/uncommon) x2 (fricative type; /ʃ/ vs. /s/) ANOVA. The same was done with the 9 and 11-month infants.

Within the preterm/full term 7, 9, and 11-month age groups, there were no significant interaction effects between term status (preterm vs. full term) and frequency (looking time for common vs. uncommon fricative sound pairings) in any of the age groups (7, 9, or 11-months). Also, fricative type (/ʃ/ vs. /s/) had no effect on looking times for any of the preterm or full term age groups. Regarding looking times between the 7-month preterm and full term age group, $F(1, 53) = 1.396$, $p = .24$, $\eta_p^2 = .026$, while for the 9-month preterm and full term age groups $F(1, 80) = 0.382$, $p = .54$, $\eta_p^2 = .005$. Finally, for the looking times between 11-month preterm and full term age groups, $F(1, 90) = 0.061$, $p = .81$, $\eta_p^2 = .001$. A significant main effect of frequency remained for the 9-month group when infants were compared as one group and not by term status (F(1,

80) = 5.144, p = .03, η_p^2 = .060). Therefore, preterm infants were also analyzed independently for frequency effects.

Analyses were run with only the preterm infant groups at 7, 9, and 11 months using 2 (frequency: common/uncommon) x2 (fricative type: /ʃ/ vs. /s/) within subjects ANOVAs on looking times for each age group. Again, no significant findings were found for the 7 (F(1, 7) = 0.718, p = .43, η_p^2 = .093), 9 (F(1, 25) = 0.697, p = ..41, η_p^2 = .027), or 11-month (F(1, 24) = 0.105, p = .75, η_p^2 = .004) age groups for frequency (i.e., looking times for common versus uncommon sounds). It is important to note that, although not significant, inspection of the mean differences between listening time for common versus uncommon sounds indicates that 9-month preterm infants spent more time listening to common compared to uncommon sounds. Specifically, mean listening times (measured in milliseconds) were higher for common sound pairs than uncommon sound pairs. This indicates that 9-month preterm infants may be discriminating common versus uncommon fricative sound pairings at a similar rate to their full term peers. Further, as reported above, a small to medium effect size was also calculated for the 9-month preterm group (η_p^2 = .027; see Figure 4 for an illustration of common vs. uncommon sound discrimination).

Health and Twin Status as a Confound

To determine whether health was a confounding variable in preterm infants' discrimination of common versus uncommon fricative sounds, all infants deemed unhealthy at time of birth were removed and a 2 (frequency: common/uncommon) x2 (fricative type: /ʃ/ vs. /s/) ANOVA was again run with the 9-month preterm infant group. In order to determine whether an infant was healthy or unhealthy at birth, the parent questionnaires were examined for each infant. In total, 12 infants were excluded. Anything that indicated a risk of brain or hearing damage (hence, possibly affecting the way in which an individual learns language) was considered unhealthy. For example, any infants needing oxygen after birth were deemed unhealthy, due to lack of oxygen at birth possibly affecting brain development. No significant differences were found between the original 9-month preterm analysis on looking times for common versus uncommon fricative sound pairs and the analysis with the unhealthy infants removed ($F(1,13) = 0.068$, $p = .80$, $\eta_p^2 = .005$).

To determine whether multiple births were a confounding variable in the above ANOVA, all infants who were multiple births (eight in total) were removed and the ANOVA for 9-month preterm infants was run again. Results did not change significantly from the original 9-month preterm analysis on looking times for common versus uncommon fricative sound pairs when multiple-birth infants were removed from the analysis ($F(1, 17) = 0.676$, $p = .42$, $\eta_p^2 = .038$).

MCDI Performance in Relation to Fricative Sound Discrimination

To examine whether achievement on the 18-month MCDI was related to achievement on fricative common versus uncommon sound discrimination, infants who completed the 9-month headturn preference fricative sound discrimination task as well as the 18-month MCDI follow up were examined. A median split was implemented with the 9-month preterm and full term infants. The high scoring MCDI group was compared to the lower scoring group in terms of their ability to discriminate common versus uncommon fricative sounds.

A 2 (MCDI achievement; high/low) x2 (fricative type; /ʃ/ vs. /s/) x2(frequency;

common/uncommon) ANOVA was run on looking times with full term infants. This ANOVA could not be run with the preterm infant group as the sample size was too low ($N = 10$). No significant interaction effect was found between frequency and MCDI achievement, $F(1, 22) = 0.118$, $p>.05$, $\eta_p^2 = .005$.

Discussion

Findings

Tests of group similarities. Comparing preterm and full term infants on MCDI and BSID scores suggests that both groups were for the most part similar in terms of their cognitive, motor, and 18-month speech production abilities. This implies that these variables (i.e., overall language development and cognitive and motor abilities) did not confound my results. However, it is important to address that the motor measure within the 18-month BSID was significantly different between preterm and full term infants. Because all other variables analyzed were similar between groups, this significant result was not examined further as it was not assumed to signify any large differences between the preterm and full term groups. Sex of the infant was relatively equal both within and between full term and preterm groups, meaning that gender is also not likely to have confounded any results. SES in both groups was high, as was our White ethnicity sample in both groups.

Developmental trajectory of phonotactics. Full term infants did not appear to significantly prefer listening to common from uncommon vowel placement sounds at 7, 9, or 11-months, so this was unable to be explored further. However, the 9-month full term fricative sound pairings group significantly appeared to prefer common from uncommon fricative sounds. This result is consistent with findings from previous studies that have outlined that typically developing infants will begin to gain an understanding for the phonotactics in their environment by roughly nine-months of age (e.g., Friederici & Wessels, 1993; Jusczyk, Luce, & Charles-Luce, 1994). No significant results were found at 7-months or 11-months. The fact that no significant results were found at 11-months may be indicative of infants no longer needing to pay attention to this discrimination skill. This significant finding provided me with a baseline of when typically developing full term infants are discriminating these fricative sound pairings, which I was able to then compare preterm infant groups to.

Maturation and experience. The hypothesis that the extra experience with fricative sound pairs would be able to be utilized by the preterm group when developing an understanding for these specific phonotactic sounds (therefore, causing preterm infants to outperform full term infants on this fricative sound discrimination task) was not supported. This was made evident by examining the significant main effect of frequency in the 9-month infants. There was a main effect of frequency, but not a significant difference in how full term and preterm groups were performing on this fricative sound discrimination task, meaning the preterm infants were not outperforming the full term infants on this task. More specifically, preterm and full term infants of the same maturational age did not differ significantly in their discrimination of common versus uncommon fricative speech sound combinations, as measured by looking time. Although the preterm infants did not show a significant preference for common sound patterns when analyzed on their own, a small to medium effect size was still found. Also, the observed power within this group was .13. Therefore, this null finding may be due to a lack of power.

Health and twin status as a confound. It was found that health status did not affect the results obtained on preference for common sound patterns within the 9-month preterm group. This is most likely due to the fact that there were not many “unhealthy” infants in our sample. Further, no changes in significance were seen when the twin population was removed from the sample, which could also be due to the fact that our twin sample was small.

MCDI achievement in relation to fricative sound discrimination. The hypothesis that there would be a relationship between performance on the MCDI at 18 months and achievement on discriminating common from uncommon fricative sound pairings at 9-months was not supported. That is, infants who scored higher on the MCDI were not significantly more likely to spend more time listening to common fricative sound pairs (therefore successfully discriminating between common and uncommon sound pairs). This indicates that 9-month infants seemed to be gaining an understanding of the phonotactic properties of sounds involving fricatives in their language regardless of language abilities later on.

Limitations

Many of the preterm infants involved were “late preterm” births, characterized by preterm infants who are born between 34-<37 weeks gestation (Committee on Obstetric Practice, 2008; see Table 7 for a listing of all uncorrected ages for both preterm and full term age groups). This is a potential issue due to the fact that late preterm infants are not differing in experience to full term infants as much as preterm infants who are born much earlier. If a larger gap was obtained in experience between preterm and full term samples that were matched for maturation, we may have been able to better to measure the effects that experience has on fricative sound discrimination. For example, Gonzalez-Gomez and Nazzi (2012) used preterm participants who were born earlier compared to our sample of preterm infants, and found that these infants were outperforming their gestationally matched full term peers in discriminating sounds unable to be heard in utero.

A second limitation is that our sample was from a higher SES bracket, as measured by yearly household income. Many of the caregivers who bring their children to participate in the Baby Language Lab's studies are former university students who have obtained university degrees, allowing them to hold higher paying jobs. Infants who are raised in higher SES households sometimes experience different language environments compared to lower SES infants (Fernald, Marchman, & Weisleder, 2013). Having a broader range of SES infants could help to insure that our sample was representative of different types of language environments, not only those of higher SES. Futher, a lack of preregistration of this study paired with the small sample sizes of the preterm groups indicates that this study's findings should be considered exploratory in nature. Therefore, replication is also suggested.

Future Research

This study serves as a building block for studying how infants learn to perceive phonotactic properties of their language that are unable to be heard in utero. Further, this study examined sounds that are attenuated in utero, as did Gonzalez-Gomez and Nazzi (2012). Conflicting results between studies examining phonetic properties of the English language unable to be heard in utero suggest that researchers need to expand on this further. This can be accomplished by examining other types of phonetic properties that are also unable to be heard in utero. Future research should also focus on preterm infants who are born at a younger gestational age (e.g., 30 weeks gestation as opposed to 36 weeks gestation) in order to obtain a better picture of the effect experience has on developing an understanding of sound combinations that are unable to be heard in utero. Future research should also focus on a more diverse population in terms of SES, as these variables could have an impact on how children learn language.

Conclusion

Overall, the current study did not find support for an experiential account of infant speech perception involving common and uncommon fricative sounds, which are not heard in utero. This was evident by preterm infants performing similarly to full term infants when both groups were matched for maturational age, thus having the same amount of maturational growth but more experience compared to their full term peers. This suggests that maturation may be inhibiting preterm infants from taking advantage of their extra exposure to fricative sound pairings when being compared to their gestationally matched full term peers. This also indicates that factors other than maturation and experience need to be examined to gain a better understanding of how infants are gaining an understanding of these phonotactic properties of their language. If experience was driving this ability, I would have expected preterm infants to outperform their full term peers, who had less exposure (i.e., experience) to fricatives compared to their preterm peers.

These findings conflict with previous research that has found experiential effects when examining how infants gain knowledge about phonotactic properties in their language that are not heard in utero (i.e., Gonzalez-Gomez & Nazzi, 2012). These conflicting results suggest that experience impacts learning about different types of phonological constraints differently. Therefore, it cannot be assumed that all phonetic properties of language unable to be heard in utero should be treated similarly when examining how infants gain knowledge of the phonotactics in their language.

Results from this study also found that MCDI achievement at 18-months of age was not significantly related to infants' ability to discriminate common from uncommon fricative sound pairs at 9-months of age. More broadly, this result outlines that when infants begin to gain an understanding of phonotactic properties in their language is not always indicative of their achievement of language development later on in life. Therefore, gaining an understanding of phonetic properties of ones language and the actual understanding and production of words cannot be viewed as being indicators of one another.

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Table 1

Fricative Sound Pairings

Frequency	Common	Uncommon
/ʃ/	/ʃra/	/ʃla/
	/ʃrej/	/ʃlej/
	/ʃri/	/ʃli/
	/ʃruw/	/ʃluw/
/s/	/sla/	/sra/
	/slej/	/srej/
	/sli/	/sri/
	/sluw/	/sruw/

Table 2

Vowel Sound Placements

Frequency	Common (tense)	Uncommon (lax)
	/bej/	/bɛ/
	/tej/	/tɛ/
	/kow/	/kʊ/
	/mow/	/pʊ/
	/nuw/	/mɒ/
	/gij/	/nʊ/
	/kuw/	/gɪ/
	/bej/	/kɪ/

Table 3

Participant Data with Gestationally Corrected Ages

Age	*N* Full Term		*N* Preterm		Mean Age (Days)		Age Range (Days)	
	Fricative	Vowel	Fricative	Vowel	FT	PT	FT	PT
7-months	47	49	8	9	219	220	200-245	198-237
9-months	56	57	26	27	276	273	251-316	231-289
11-months	67	68	25	24	334	332	305--359	299-356

Note. FT = full term, PT = preterm. Due to experimenter error a small number of babies were run slightly outside of their age ranges.

Table 4

BSID Results Cognitive

Age	Term						95% CI for Mean Difference		
	Full term			Preterm					
	M	*SD*	*N*	*M*	*SD*	*N*		*t*	*df*
5-7	56.84	21.52	92	54.62	20.19	26	-7.11, 11.54	.47	116
11-14	50.20	24.36	79	53.28	28.25	25	-14.61, 8.45	.53	102
18	60.08	20.53	40	54.20	27.68	15	-7.88, 19.62	.86	53

Note: Age is measured in months, *M*= mean percentile, *SD*= standard deviation, *N*= sample size.

Table 5

BSID Results Motor

Age	Term						95% CI for Mean Difference		
	Full term			Preterm					
	M	*SD*	*N*	*M*	*SD*	*N*		*t*	*df*
5-7	48.99	25.31	92	57.58	21.61	24	-19.78, 2.58	1.52	114
11-14	48.73	28.85	79	40.41	27.07	24	-4.84, 21.47	1.25	101
18	65.00	18.48	39	55.13	26.21	15	-2.84, 22.57	1.56*	52

Note. Age is measured in months, *M* = mean, *SD* = standard deviation, *N* = sample size, *$p<.05$.

Table 6

18-month MCDI Results

Term						95% CI for Mean Difference		
Full term			Preterm					
M	*SD*	*N*	*M*	*SD*	*N*		*t*	*df*
34.30	26.78	43	36.00	33.42	13	-19.74, 16.32	.189	54

Note: M= mean percentile, *SD*= standard deviation, *N*= group size.

Table 7

Uncorrected Preterm and Full Term Ages

Age	Mean Age (Days)		Age Range (Days)	
	FT	PT	FT	PT
7-months	219	255	197-239	250-277
9-months	277	313	261-303	291-383
11-months	335	365	301-355	332-417

Note. FT = full term, PT = preterm. Due to experimenter error a small number of babies were run slightly outside of their age ranges.

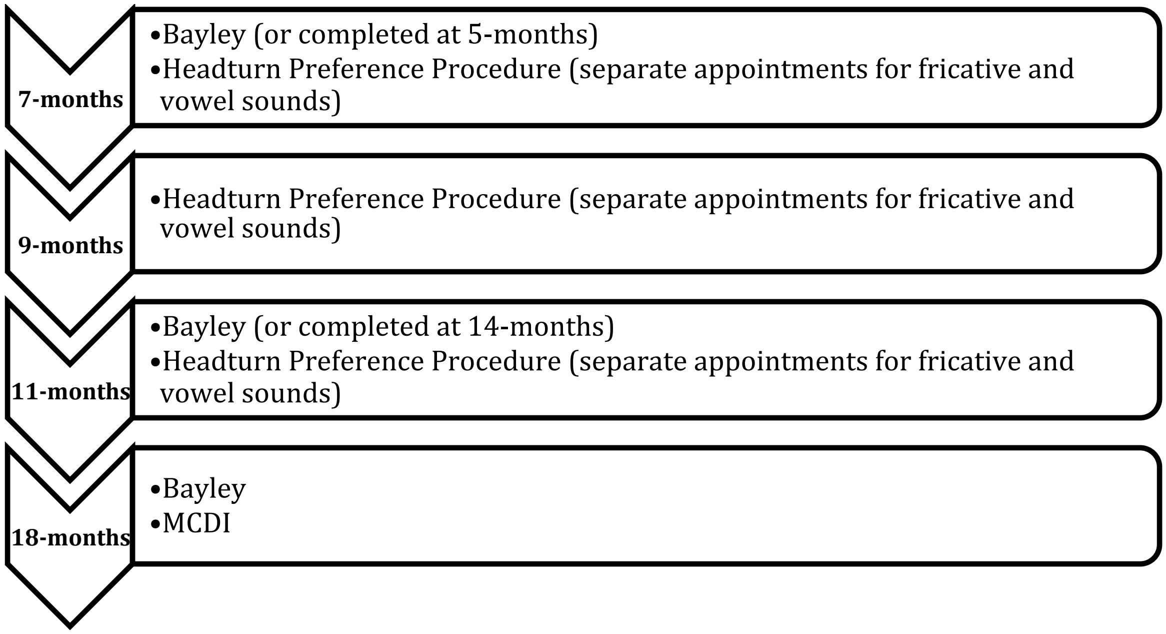

Figure 1. Study timeline.

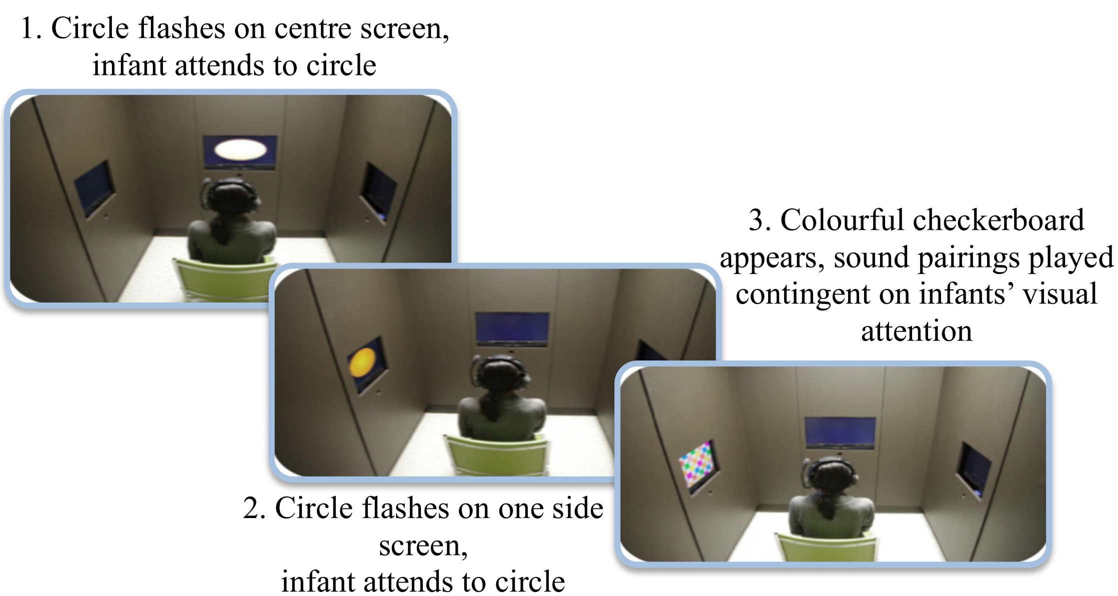

Figure 2. Visual representation of the headturn preference procedure.

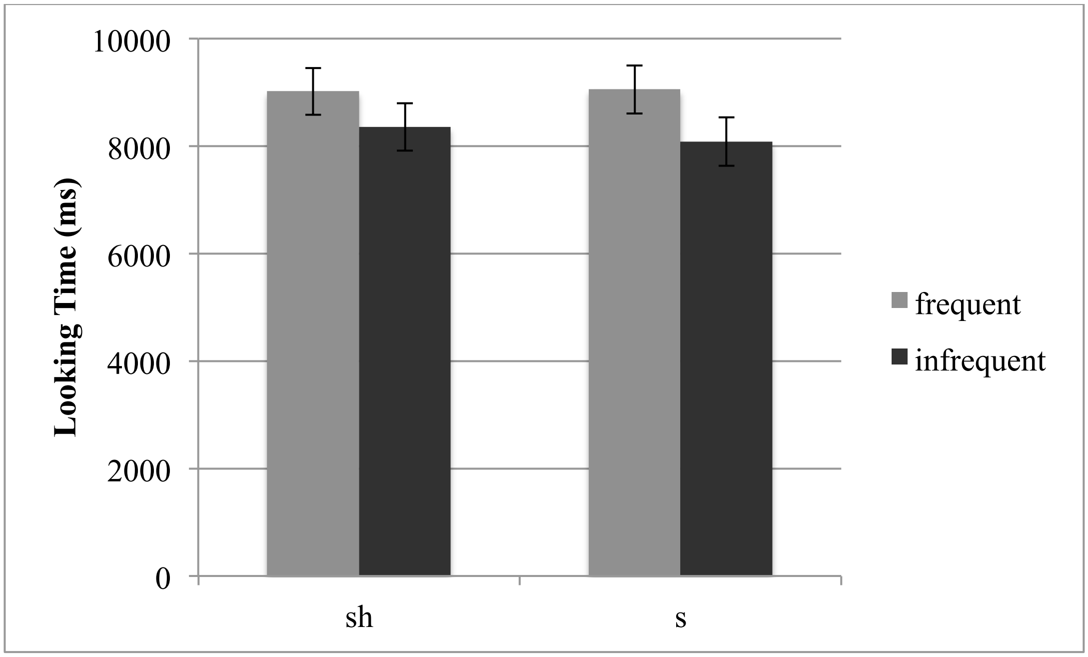

Figure 3. 9-month full term listening time for common versus uncommon fricative sound combinations. Main effect: frequency ($F(1, 55) = 8.116$, p = 01).

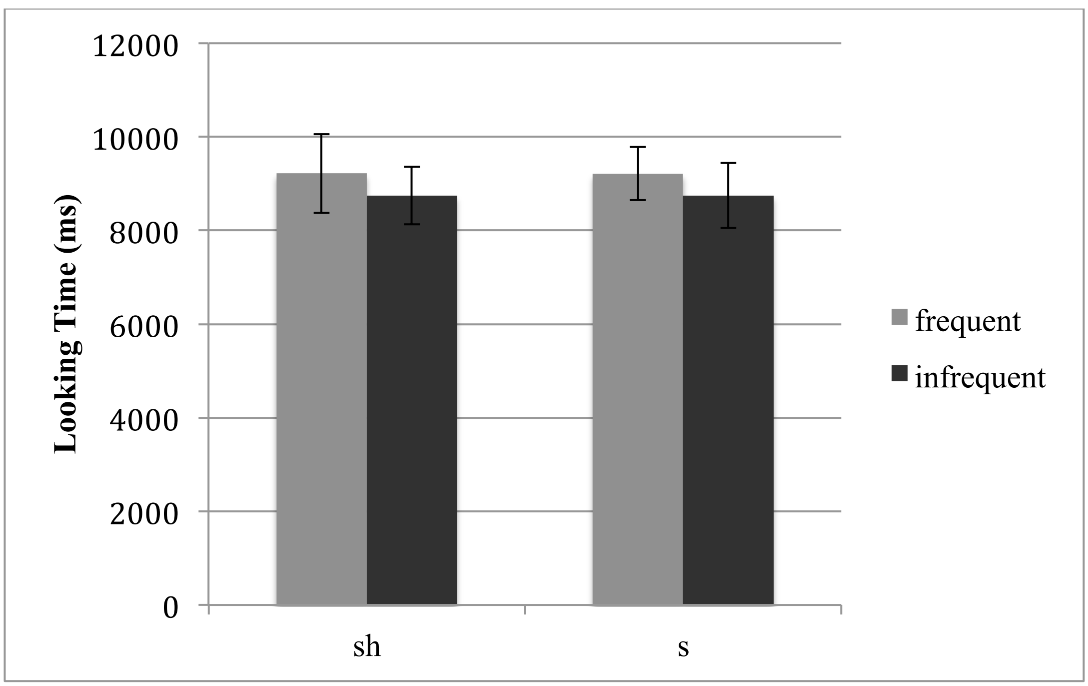

Figure 4. 9-month preterm listening time for common versus uncommon fricative sound combinations (*N.S.*).

Appendix A

UNIVERSITY OF MANITOBA

PRETERM STUDY GENERAL QUESTIONNAIRE

Please Note: Responses to these questions are entirely voluntary. The information you provide us will be very helpful in our research. Please ask if you have any questions or concerns about your responses or how they will be used or stored.

Child's data code (to be filled by experimenter): ____________________
Date:____________ Protocol (to be filled in by experimenter): ________________

Parental Information

Parent 1's:
Age: ________Ethnicity: ______________________ Gender: M/F

Parent 2's:
Age: ________Ethnicity: ______________________ Gender: M/F

1. How many years of education have you had (e.g. completed high school, 3-year degree, etc.)

Parent 1: ____________________________

Parent 2: ____________________________

2. Please circle your approximate household income (in thousands)?

<20	20-30	30-40	40-50	50-60	60-70	70-80	>90

3. How much experience have you had with children prior to becoming a parent? (please circle one)

Parent 1: None/Very Little Some experience A lot of experience

Briefly describe experience:

Parent 2: None/Very Little Some experience A lot of experience

Briefly describe experience:

4. Is there any history of language disorders, language delays, cognitive delays, or neurological impairment in the immediate family? If so, please describe.

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Child/Family Information

5. Child's Date of Birth: (Year/Month/Day) ____/___/___ Child's Gender: Male / Female

6. Was your child born early? YES / NO
   If yes, what was your child's expected due date? (Year/Month/Day) ____/___/___
   How confident are you about the due date? VERY CONFIDENT / SOMEWHAT / UNSURE

7. Was an assessment of "gestational age", sometimes called a Ballard Score, done when your baby was born? (An assessment of gestational age is based on examination of a newborn's physical and neurological characteristics.) This estimate does not necessarily match up exactly with the child's actual weeks of gestation in the womb. YES / NO / UNSURE
   If YES, what was your baby's gestational age? _____________

8. Is your child from a multiple birth? YES / NO
   If yes, fraternal or identical? FRATERNAL / IDENTICAL / UNSURE
   If yes, how many children were born? _________

9. What was your child's birth weight? __________

10. Do you recall your child's 5 minute APGAR score? If yes, please provide it here: ____________

11. Did your child experience any significant difficulties during the birth? If so, please describe:

12. Was your child considered healthy at birth? YES / NO If no, please describe:

13. Did your child spent any extra time in the hospital/NICU after the birth? YES / NO

14. How long did your child spend in the hospital after birth (if a home birth, please indicate)?

15. Did your baby need help breathing? YES / NO
    If yes, please describe the measures that were taken to help your baby breathe:

16. Does your child currently have any significant health concerns and/or neurological impairment?
    YES / NO If yes, please describe:

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17. Did your child have a newborn hearing screening? YES / NO
    If so, did they pass? YES / NO
    If they did not pass, was a secondary test performed? YES / NO
    If yes, did they pass the secondary test? YES / NO

18. Are you aware of any hearing impairments or difficulties in your child (please include cases of *otitis media* or ear infections)? YES / NO
    If yes, please describe :

19. Does your child babble (e.g., say things like [ee, ee, ee] or [ma, ma, ma]? YES/NO
    If yes, at what age did he/she begin to do this?

20. Are you aware of any language or cognitive delay in your child's development?
    YES / NO If yes, please explain:

21. Is there anything else we should know about your child? (E.g. physical impairments not described above?)

22. How many siblings or other children are there living in your home: NONE or

Date of Birth:	(Year/Month/Day) ____/___/___	Gender:	Male / Female
	(Year/Month/Day) ____/___/___		Male / Female
	(Year/Month/Day) ____/___/___		Male / Female
	(Year/Month/Day) ____/___/___		Male / Female

Child Care Arrangements (on a regular basis)

23. How often is Parent 1 the sole/primary daytime care provider?__________________________

24. How often in Parent 1 away from the child? ____

25. How often is Parent 2 the sole/primary daytime care provider? __________________________

26. How often in Parent 2 away from the child? ____

27. Are the grandparents or other family members involved in child care? If so, please describe:

28. Do you use formal childcare by a non family member on a regular basis? If so, please describe (e.g. how often, is it a babysitter, nanny, in-home daycare, child care centre?). When did your child begin using formal child care?

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29. Has the above child care situation changed significantly over your child's life? If so, please describe.

30. Has your child ever lived with someone else? If so, please describe.

Language Background

31. What percentage of the time are the following languages used in your (your child's) household?

Canadian English	0%	< 10%	10%	25%	50%	75%	90%	100%
Canadian French	0%	< 10%	10%	25%	50%	75%	90%	100%
American Sign **	0%	< 10%	10%	25%	50%	75%	90%	100%

Other languages: (please specify)

____________	< 10%	10%	25%	50%	75%	90%	100%
____________	< 10%	10%	25%	50%	75%	90%	100%
____________	< 10%	10%	25%	50%	75%	90%	100%

32. Do you use "baby sign" with your child? YES / NO

*** Please select "American Sign" only if you use sign language as a primary means of communicating with your child (e.g. if there is a deaf family member). If you use individual signs you learned from a video or a class to help you communicate with your child, please select "baby sign", even if the signs you learned are from American Sign Language.*

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