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REPORT OF INFANT VOCALIZATIONS: A CASE STUDY CONSIDERING EFFECTS OF OTITIS MEDIA WITH EFFUSION

by

Alycen Fielding

A thesis

submitted in partial fulfillment

of the requirements for the degree of

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Committee Approval

To the Graduate Faculty:

The members of the committee appointed to examine the thesis of Alycen Fielding find it satisfactory and recommend that it be accepted.

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RE: Your application dated 10/14/2014 regarding study number 4170: Report of Infant Vocalizations: A Case Study Considering Effects of Otitis Media with Effusion

Dear Ms. Fielding:

I agree that this study qualifies as exempt from review under the following guideline: 4. Analysis of existing data sets. This letter is your approval, please, keep this document in a safe place.

Notify the HSC of any adverse events. Serious, unexpected adverse events must be reported in writing within 10 business days.

You are granted permission to conduct your study effective immediately. The study is not subject to renewal.

Please note that any changes to the study as approved must be promptly reported and approved. Some changes may be approved by expedited review; others require full board review. Contact Tom Bailey (208-282-2179; fax 208-282-4723; email: humsubj@isu.edu) if you have any questions or require further information.

Sincerely,

Ralph Baergen, PhD, MPH, CIP
Human Subjects Chair

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LIST OF ABBREVIATIONS

AOM- Acute otitis media

Infant OME – Infant with otitis media with effusion

Infant THD- Infant with typical hearing development

IPA- International Phonetic Alphabet

OME – Otitis media with effusion

REPORT OF INFANT VOCALIZATIONS: A CASE STUDY CONSIDERING EFFECTS OF OTITIS MEDIA WITH EFFUSION

Thesis Abstract--Idaho State University (2015)

The purpose of this case study was to explore caregiver and naïve listener report of infant vocalizations from an infant with otitis media with effusion (OME) and a gender- and age-matched peer with no history of OME. This study was designed to determine if listeners would identify differences between the two infants' vocalizations. Research has demonstrated that naïve listener and caregiver report provide a unique perspective of vocal development when compared to traditional transcription methodologies. Using transcription, it has been shown that speech and language development can be altered or delayed in children with chronic ear infection, or what is known as otitis media with effusion. Therefore, given new methodology, it was hypothesized that caregivers and naïve listeners would report fewer phonetic features when listening to an infant with OME than to an infant with no history of OME. Potential clinical implications, study limitations, and future research will be discussed.

Chapter I: Introduction

New technologies are being developed to identify hearing loss earlier in life. Although, there has been a significant increase in the technological development for identifying children who are born deaf or hard of hearing, less has been done for those who experience otitis media and its associated hearing loss. Otitis media has been proven to cause a fluctuating hearing loss in the moderate to severe range for some children (Nathani, Oller, & Neal, 2007). Further, hearing loss at this level can be associated with speech and language delays (Nathani et al., 2007). Because of the potential for fluctuating hearing loss in this population, children who suffer from otitis media are at an increased risk of delayed speech and/or language development.

Extensive research has been conducted on the normal development of speech and language. However, much of this work has been guided by using the International Phonetic Alphabet (IPA) to document vocalizations (Ramsdell, Oller, Buder, Ethington, & Chorna, 2012). IPA, although useful for documentation of adult-like sounds, has been shown to be less functional for analyzing pre-linguistic vocal development given reliability and validity constraints (Ramsdell, Oller, & Ethington, 2007). Caregiver and naïve listener report are showing promise as a more efficient methodology for investigation of infant vocal development (Ramsdell et al., 2012). The main focus of this research will be to answer the question, "will caregiver and naïve listener report of infant vocalizations identify differences dependent upon whether or not the infant has a history of otitis media with effusion?"

While this case study only serves as a small step, through development of these new methodologies we hope to identify delays more easily and initiate treatment at

earlier ages, when the brain is most capable of change due to plasticity. It is hypothesized that caregivers and naïve listeners will report fewer phonetic features when listening to the infant with otitis media with effusion than to the infant with no history of otitis media with effusion.

Speech and Language Development

Normal speech and language development. From the earliest sound productions to first words, a series of developmental steps take place. The levels of pre-linguistic development, as outlined by Nathani, Ertmer, and Stark (2006) for infants 1 to 20 months of age, are as follows: from reflexive sounds, to control of phonation, and expansion of sounds (including vocal play with pitch and intensity), onto basic canonical syllables, and finally to advanced forms. As an infant moves through these stages he gains greater command over his ability to control sounds. Canonical babbling, which emerges between 7 to 10 months of age, is an important milestone, given that delayed onset of canonical babbling has been shown to indicate future speech sound problems (Iyer & Oller, 2011; Irwin, 1948).

Through typical speech development, the number of consonant vowel (CV) and CVC syllables increases with age, while the number of V only syllables decreases (Stoel-Gammon, 1988). Vowels are the primary sounds produced until approximately 10 months, when consonants begin outnumbering vowels (Iyer & Oller, 2011). In addition, Stoel-Gammon and Herrington (1990) created three stages of V production accuracy. Stage one consists of [i u o ɑ ʌ] and is considered early mastery. This study did not reflect complete consistency during the first stage, but with time V sounds became more reliable. The second stage consists of [æ ʊ ɔ ə]. The final stage consists of the front Vs [ɪ

e ɛ] and the rhotic Vs [ɚ ɝ], which are generally recognized as the most difficult Vs to master (Stoel-Gammon, & Herrington, 1990). According to Shriberg's classification of early, middle, and late developing phonemes, infants typically master the bilabial consonants /p b m w/ first (Paul, 2007). These sounds are all produced with a visual component (movement of the lips), and therefore are most easily reproduced by infants. Also included in the Shriberg's early eight are /j, n, d, h/. All eight of these consonants are voiced with the exception of /p/ and /h/. Despite the early development of these sounds, they are not fully mastered until age 3.

Several hypotheses have been presented to explain how children learn spoken language. One idea is that of discontinuity, where the processes of language acquisition and spoken representations are learned differently by children than by adults. At some point language knowledge switches from the child form to the adult form with no connection between the two forms. In contrast, the idea of continuity states that children innately know the adult form of language, but because of cognitive and physical limitations (e.g., immature anatomy), they are unable to produce the adult form from birth (Vihman & Croft, 2007). Vihman and Croft (2007) present a third theory in line with continuity, in which they discuss the role of what they call "radical templatic phonology." They indicate that children begin producing word *templates* for future word learning. Children demonstrate this by creating their own words that do not exactly meet the adult phonetic form (e.g., "baba" for "blanket"). In time, immature word forms eventually develop into adult-like forms, and continue to progress into fully formed words. Therefore, the first controlled sounds, or canonical syllables, are crucially

important because they are the building blocks that support future word formation (Vihman & Croft, 2007).

Canonical babbling and delayed language development. The infraphonological approach to development (Oller, 2000; Oller & Lynch, 1992; Steffens, Oller, Lynch, & Urbano, 1992) describes canonical syllables to include: a single, fully resonant nucleus (V); a clearly articulated margin (C); and a timely transition between margin and nucleus (Oller, 2000). Canonical babbling is a major stepping stone in language development, as it is the first sign that a child is using his articulators to control and manipulate speech sounds (Stoel-Gammon & Otomo, 1986). There are many indicators of normal language development, but canonical babbling is one of the earliest. In a study by Oller, Eilers, Neal, and Cobo-Lewis (1998), it was demonstrated that delayed onset of canonical babbling (beginning after the age of 10 months) is indicative of a possible speech or language delay. The research team conducted telephone surveys to the parents of 1,536 high risk infants about the state of their infants' babbling. Of those surveyed, the vast majority (93.5%) reported from open ended questions that their infants were engaging in canonical babbling. From parental report and laboratory testing, of those infants who proved to have no canonical babbling, 35% were diagnosed with developmental delays. In addition to these findings, at least three infants were diagnosed with serious medical conditions because of researcher referral, indicating a correlation between late canonical babbling onset and delays. As was demonstrated by this research, 10 months is a clear first milestone to look for in language development.

Otitis Media with Effusion

Definition of otitis media. According to Bluestone and colleagues, otitis media is defined as "an inflammation of the middle ear" (2002, p. 8). There is a distinction between acute otitis media (AOM) and otitis media with effusion (OME). AOM "is the rapid onset of signs and symptoms" whereas OME is "a chronic inflammation of the middle ear in which a collection of liquid is present in the middle ear space, but there is an absence of the signs and symptoms of acute infection" (Bluestone et al., 2002, p. 8). Based on these definitions, it has been determined that both OME and AOM may cause conductive hearing loss depending on the severity of the infection. OME is of greater concern as its effects are more prolonged and its lack of signs or symptoms cause it to be easily overlooked.

Prevalence of OME. It has been suggested that otitis media is one of the most common childhood diseases. A team of researchers gathered and analyzed data for 2,253 children from birth to 24 months of age. An estimated 91% of these children had at least one episode of AOM within the first year of life (Paradise et al., 1997). Additionally, another team of researchers found that the highest incidence of AOM occurred between 6 and 12 months of age (Teele et al., 1989). However, AOM by definition is rapid in its onset and is therefore not equal to the amount of prolonged hearing loss detected by children with OME. It has been indicated that OME rates increase after the 6^{th} month of age, and substantially increase dependent upon certain risk factors including: low socio-economic status (SES), breast feeding, and gestational age (Engel, Anteunis, Volovics, Hendriks, & Marres, 1999a; 1999b). Because of the prevalence of OME and the

increased rates during critical times in language development, OME poses a threat to speech and language development.

How Speech and Language are affected by Hearing Loss

Hearing loss is a major risk factor for delaying normal speech and language development (Iyer & Oller, 2011). When a child experiences hearing loss, he loses access to sounds that are necessary for speech and language learning. Research has been conducted across the types and severities of hearing loss and three main areas have been identified as delayed in those children with hearing loss: a reduced frequency of speech-like vocalizations at around 8 months of age, a limited inventory of syllabic structures in utterances, and a decreased phonetic repertoire (Stoel-Gammon, 1988). A study by Stoel-Gammon (1988) focused on comparing and contrasting the amount and type of consonants used by both infants who were typically developing (no hearing loss), and infants with hearing loss. The study consisted of 14 infants with hearing impairment and 11 infants with normal hearing. Those infants with hearing loss included both sensorineural and conductive hearing loss with a range from moderate to profound. Findings indicated a static or decrease in the vocal repertoires of infants with hearing loss between 4 and 18 months, but similar consonant inventories in both groups of infants (Stoel-Gammon, 1988). The conclusion was that children with hearing loss babble less as they mature than their peers with typical hearing.

In another study, Stoel-Gammon and Otomo (1986) analyzed 11 infants with typical hearing and 11 infants with hearing loss in two areas: quantity of differing consonants and frequency of multisyllabic utterances. The two groups were comparable up to 8 months of age, at which point the infants with hearing loss were shown to use

fewer consonantal types and had a smaller repertoire of multisyllabic CV utterances. These differences were noted until 18 months of infant age. The results for infants with hearing loss were very similar as a group, despite level of hearing loss (mild-moderate to profound). It was noted that the two subjects with only mild-moderate hearing loss did not have deviations as substantial as those infants with severe-profound hearing loss (Stoel-Gammon, & Otomo, 1986).

Although hearing loss originating from OME is not generally permanent or constant, these findings support the notion that children with fluctuating hearing loss need to be identified early and proper action must be taken in order to give them access to foundational speech and language input. It is possible that a child with this type of hearing loss may display a delay in canonical babbling if OME persists long enough during the critical stages of language development.

Methodological Considerations for Analyzing Pre-linguistic Vocalizations

Transcription. The International Phonetic Alphabet (IPA) is a coding system that was created to enable written documentation of human vocalizations. This writing system is unique when compared to more traditional alphabets, like the Roman alphabet, because in the IPA there is one sound for every symbol and one symbol for every sound. The IPA has been utilized as the chief methodology for documenting speech sounds in all ages. However, the IPA was developed specifically for documentation of well-formed speech sounds. Despite the immaturity of infant prelinguistic vocalizations, the IPA has been used for documentation of these utterances as well. Additionally, the IPA is often utilized to identify V sounds without utilizing V formant heights for identification, which

attributes many more V variations to the speaker than he is actually producing (Gibbon, & Ball, 2013).

As has been indicated by researchers, transcription is questionable for documentation of infant vocalizations (Ramsdell et al., 2007; 2012). This is based on several areas of weakness, including the following three. First, the IPA was designed for documentation of mature speech sounds, which infants do not produce. Second, transcription is very cumbersome and time consuming for documentation of vocalizations, and therefore not easy to translate from basic research to clinical practice. And third, because infants do not make consistent, controlled adult-like sounds, transcription can be interpreted in many different ways. Typically, transcription attributes many more sounds to infants than they have the ability to volitionally control (Ramsdell et al., 2012). If there is to be a more precise and efficient way of identifying delays early in speech and language development, namely during the prelinguistic period, new methods need to be utilized for documentation of infant vocal development.

Caregiver and naïve listener report. In recent years, a new direction for documentation of infant vocalizations has been investigated, namely, caregiver report. This approach involves asking caregivers to intuitively identify the sounds they perceive their infant to be making. According to research performed by Oller, Eilers, and Basinger (2001), onset of canonical babbling can be reliably assessed through caregiver report (Oller, et al. 2001). Parent report has been shown over several studies to be a reliable and valid means of tracking speech and language development (Feldman et al., 2005; Fenson et al., 1994; Heilmann, Weismer, Evans, & Hollar, 2005; Korkman, Jaakkola, Ahlroth, Pesonen, & Turunen, 2004; Oller, Eilers, & Bassinger, 2001; Rescorla & Alley, 2001;

Wetherby, Allen, Cleary, Kublin, & Goldstein, 2002). Additionally, Ramsdell and colleagues (2012), suggest that caregiver report may be even more accurate at identifying infant speech capabilities than the more traditional transcription laboratory measures, indicating a more efficient and appropriate way to collect infant vocalization data (Ramsdell et al., 2012).

Naïve listeners are similar to caregivers in that they are asked to identify sounds they perceive infants to be making, but they replicate this in a laboratory setting with sound recordings. In a 2012 study, Ramsdell and colleagues compared the responses of naïve listeners' on their ability to listen to infant vocalizations in a laboratory setting and report similar responses to caregivers. Sound recordings of eight infants with typical hearing development at ages 8, 10, and 12 months were presented twice to each naïve listener in a semi-random order for both an utterance and session level listening task (Ramsdell et al., 2012). The results of this study were hopeful, as they demonstrated similar findings across caregivers and naïve listeners when reporting on vocalizations from the group of infants. Specifically, the repertoires reported by caregivers and naïve listeners were more similar than the repertoires reported by caregivers and transcribers.

Caregiver and naïve listener report may be the answer to simplifying data collection and producing a more manageable amount of data when documenting infant vocal development. Additionally, these new methods may facilitate the translation from basic research to clinical practice more efficiently when working with prelinguistic infants.

Purpose

Roberts, Burchinal, Koch, Footo, and Henderson (1988) pointed out that there have been too many fallacies performed in previous studies assessing the correlation of OME and future speech delays in children. They rightly suggest that retrospective studies, where data is dependent on medical records or parent recollection of past OME episodes is flawed because it is reliant on memory recall, which can be inconsistent. They further suggest that studies conducted in a prospective manner are flawed because they are dependent on regularity of medical evaluation, which is not always attained. However, based on the proven consistency of caregiver report, future speech and language delays may be noted earlier in development. Accordingly, the present longitudinal study was conducted on the perception of caregivers and naïve listeners, rather than traditional IPA methodology, when analyzing vocalizations from both an infant with otitis media with effusion and an age- and gender-matched peer with no history of OME. Vocalizations from these infants were explored from 7- through 18-months-of-age in three age groups; early (7 to 10 months), middle (11 to 14 months), and late (15 to 18 months) age groups. Further, we compared caregiver to naïve listener report of the vocalizations.

The following question was posed: Will the phonetic makeup and quantity of vocalizations judged vary dependent upon:

- listeners (caregiver versus naïve listener);
- infants (infant with OME versus no OME); and/or
- infant age groups (early, middle, and late).

It is recognized that this case study cannot carry enough weight to apply clinically, but it has the potential to be a catalyst for further research.

It was hypothesized that naïve listeners would identify similar vocalizations to caregiver report. Similarly caregiver and naïve listener reports were hypothesized to demonstrate less phonetic variability for the infant with otitis media with effusion than to the age- and gender-matched peer with typical hearing development. It was further hypothesized that both caregiver and naïve listeners would report an increase in vocalizations with the increase in infant age groups.

Chapter II: Methodology

Participants

The participants for this case study were obtained from data collected in a previous longitudinal study by Dr. Heather Ramsdell-Hudock at East Carolina University (ECU). The cohort consisted of 16 infants and their parents. Families were followed longitudinally to gather caregiver report about infant speech and language development. From 6 to 18 months, caregiver/infant interaction was audio-video-recorded at the ECU Infant Vocal Development Laboratory monthly to obtain audio samples for transcription and naïve listener report. Full hearing evaluations were administered to each infant at 6 and 18 months of age, including Tympanometry, Distortion Product Otoacoustic Emissions, and Visual Reinforcement Audiometry. If the infant had inconclusive or atypical hearing evaluation results, or by parental request, the child was reassessed in a follow up session.

For the present case study, the selected participants were two infant/parent dyads from this cohort. The infant with otitis media with effusion was selected out of convenience because he demonstrated OME during the study. He was given a full hearing evaluation at 7 months and 8 months of age. As his assessment results were atypical (suggesting middle ear dysfunction), a report was sent to his primary care provider. Further follow up by his doctor resulted in the insertion of pressure equalization tubes at 9 months of age. This was considered to be aggressively treated as the American Academy of Pediatrics suggests documenting hearing loss for 3 months prior to more aggressive treatment ("Otitis Media with Effusion," 2004). Additional hearing evaluations were conducted at ECU on this child shortly after the pressure

equalization tubes were placed at 9 months and then again at almost 17 months. These results suggested normal hearing. The comparison infant was selected as an age- and gender-matched peer. This infant was also given full hearing evaluations at 6 and 18 months, with no demonstration of OME. The infants selected were Caucasian males with normal births and no significant medical history prior to beginning the study. Each was from an English speaking, middle socioeconomic status household, where both mother and father were present. The infants were matched on a variety of variables (e.g., age, gender, socioeconomic status, etc.) so as to increase the chance of differences in listener report resulting from hearing status alone.

Anecdotally, both infants demonstrated typical speech and language development during the recording period. Research has indicated that there is a potential for a speech or language difference in those infants who suffer from OME (Stoel-Gammon, 1988; Stoel-Gammon & Otomo, 1986; Paradise et al., 1997). As mentioned above, the purpose of this study was to determine whether or not caregivers and naïve listeners report similar findings for the infants; we considered the potential of a speech and/or language difference in the infant with otitis media with effusion.

Procedures and Materials

Laboratory setting. Infants and their caregivers came to the lab at ECU once a month for hour-long recordings. The lab was designed to simulate a natural environment, such as a nursery in a home. The lab included stuffed animals, toys, and various objects that would allow both parent and child to feel comfortable. This setting attempted to encourage natural interactions between caregivers and infants, to facilitate capture of a

representative sample of the infant's vocal abilities. The lab was equipped with both video and audio recording capabilities.

Infant utterances. Data from the recordings was prepared by trained laboratory staff, who located infant utterances based on breath group criterion (excluding both vegetative noises and utterances with substantial overlay from another noise source), and extracted the located utterances from the original recording file. These utterances were randomly selected for presentation to naïve listeners. Altogether there was one audio file for each infant at each age from 7 to 18 months of infant age, creating 12 total audio files per infant for listener judgment.

Caregiver report. The main method of collecting caregiver report was through weekly questionnaires and interviews conducted over the phone or during lab visits throughout the duration of the study. The primary question of interest for the purposes of this study was, "What sounds/words has your infant been producing since the last time we spoke?" The reported sounds or words provided by caregivers was transcribed into IPA, transferred into numerical data for analysis of reported phonetic features, and monthly data was averaged across age group (early, middle, late age) for the listeners.

Naïve listener. The laboratory recordings were obtained in the original study in order to analyze the vocalizations using laboratory methodology (e.g., phonetic transcription). Naïve listeners were females, native speakers of American English with normal hearing between the age of 18-40 years old, and with no children. Further, the two listeners were not, nor had they ever, studied in the fields of speech-language pathology, audiology, education, or music. They were selected to listen to the data

presented in the audio files detailed above. Recall that naïve listener report is being developed as a means to supplement and/or replicate caregiver report in the laboratory.

Each audio file was presented at random to two naïve listeners via website through an HTML5 and CSS (cascading style sheet) program developed by colleagues at the University of California, Merced specifically for this listening activity (see Figure 1). The naïve listeners were blinded to infant identity and infant age to prevent bias. They responded to the question "What sounds/words did the infant produce?" Following this, phonetic transcription of the reported sounds was completed by laboratory staff and transformed into numerical data. Furthermore, data from the two listeners was combined and averaged across age groups. This numerical data allowed for easy identification of the different numbers and types of sounds produced by either infant as reported by naïve listeners.

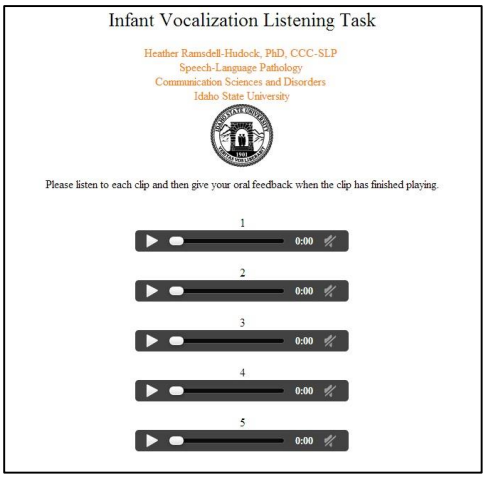

Figure 1. *A sample image of the infant vocalization listening task.*

Phonetic Features

Caregiver and naïve listener reports were transcribed separately for each infant at each age. From transcriptions, tallies were calculated for a variety of general and phonetic features reported: the total number of utterances, consonants, and vowels in

utterances; places of articulation (labial, coronal, dorsal, and laryngeal consonants), voicing (voiced and voiceless consonants), and manners of production (stop, fricative, affricate, nasal, liquid, glide, click, and trill consonants) for consonants; and tongue positions (high front, low front, central, low back, high back, rising diphthong, and rhotic diphthong vowels) for vowels.

Design

The purpose of this study was to determine if there is any quantifiable difference in the vocal development of two infants from 7 to 18 months of age as perceived by both caregiver and naïve listener report. By exploring the distinctions between caregiver and naïve listener perception of infant vocalizations, we can begin to identify the utility of these methods for determining differences in speech production between infants with dissimilar developmental patterns (e.g., one infant with otitis media with effusion, and one infant with no history of middle ear infection). To fully analyze whether or not there are quantifiable differences in reports of vocal development for these two infants, we considered: what is the effect of the listener (caregiver and naïve listener), infant (infant with otitis media with effusion and infant with typical hearing development), and infant age (early, middle, and late age group) on number of phonetic features reported.

Chapter III: Results

Features for the selected infants are displayed in table form for both caregiver and naïve listener report. The tables demonstrate general features (e.g., number of utterances reported) and specific phonetic features (e.g., place of articulation and manner of production for consonants reported).

Caregiver Report

As demonstrated in Table 1, an interesting phenomenon began to appear through the caregiver report. The infant with otitis media with effusion was reported to produce more utterances, consonant, and vowel tokens than his peer with typical hearing. This is contrary to our hypothesis as it was predicted that the infant with otitis media with effusion would produce fewer features. This phenomenon was also demonstrated across ages, including the early age group when the infant with otitis media with effusion was still demonstrating signs and symptoms of fluid in the middle ear. Despite greater quantities of general features reported by the caregiver of the infant with otitis media with effusion, each of the caregivers indicated similar increases in the overall number of sounds reported for utterances, consonants, and vowels across infant ages. For example, each caregiver noted the infants to produce 30 to 34 more utterances, 61 to 62 more consonants, and 40 to 41 more vowels in the late age group than the early age group.

Table 1. General features of caregiver report.

Infant	Infant Age (in Months)	# of Utterances	# of Consonant Tokens	# of Vowel Tokens
OME	6 – 9	30	21	29
	10 – 13	48	50	51
	14-17	60	83	70
THD	6 – 9	13	5	13
	10 – 13	35	29	35
	14-17	47	66	53

As shown in Table 2, caregivers reported a steady increase across age for both infants in labial (/m p b f v w/) and coronal (/n t d ɾ θ ð s z ʧ ʤ ʃ ʒ ɝ/) consonants, in regards to place of articulation. As anticipated, the infants did not display consistent growth for laryngeal (/h ʔ/) sounds.

Table 2. Phonetic features of caregiver report.

Infant	Infant Age (in Months)	Place of Articulation for Consonant Tokens				Voicing for Consonant Tokens	
		Labial	Coronal	Dorsal	Laryngeal	Voiced	Voiceless
OME	6 - 9	9	5	3	4	15	6
	10 - 13	18	12	14	6	34	16
	14-17	28	36	17	2	56	27
THD	6 - 9	3	1	0	1	4	1
	10 - 13	5	12	10	2	19	10
	14-17	15	37	10	4	37	29

In addition to place of articulation, Table 2 displays a steady increase of voiced and voiceless consonants with increasing age groups; there is, however, a greater increase in voiced consonants.

Overall analysis of the place of articulation indicates some interesting differences between infants. Primarily, the infant with otitis media with effusion was reported to produce more consonant tokens than the infant with typical hearing development in this category, with only a few exceptions. During the late stage the infant with otitis media with effusion was reported to produce fewer coronal, laryngeal, and voiceless consonants than his peer with typical hearing development.

Table 3 demonstrates consistency of caregiver report with early developing sounds such as stops (/p b t d k g ʔ ɾ/), fricatives (/f v θ ð s z ʃ ʒ h/), and nasals (/m n ŋ/) being reported more frequently than glides (/w j/), liquids (/r, l/), and affricates (/ʧ ʤ/), which would be anticipated based on normal phonetic development. There appears to be

some similarity between caregivers with respect to manner of production for reported consonants. Each caregiver reported more stops, followed by fricatives and nasals, then by glides, liquids, and affricates as age increased.

Table 3. Phonetic features of caregiver report.

Infant	Infant Age (in Months)	Manner of Production for Consonant Tokens					
		Stop	Fricative	Affricate	Nasal	Liquid	Glide
OME	6 - 9	12	4	0	4	0	1
	10 - 13	26	6	0	9	2	7
	14-17	42	8	4	20	6	3
THD	6 - 9	2	1	0	2	0	0
	10 - 13	15	3	1	5	2	3
	14-17	31	13	1	7	6	8

The infant with otitis media with effusion demonstrated a preference for stops through all ages. By the late stage, sounds such as fricatives (which are higher frequency sounds), and glides (which are more complicate to produce because of no exact articulatory contact and movement of the tongue during production) were more often produced by the infant with typical hearing development.

Data represented in Table 4 demonstrates that caregiver perception of vowel development is on par, and comparable across infants, with what is known about vowel development. It is interesting to note that the caregivers reported more similarities across infants for vowel tokens than for any other category analyzed. Although the infant with otitis media with effusion is still reported to produce more vowels across all ages than the infant with typical hearing development, the difference amount is much smaller.

Table 4. Phonetic features of caregiver report.

Infant	Infant Age (in Months)	Tongue Position for Vowel Tokens						
		High Front	Low Front	Central	Low Back	High Back	Rising Diphthong	Rhotic Diphthong
OME	6 - 9	3	3	8	11	1	3	0
	10 - 13	4	7	13	12	7	7	1
	14-17	13	8	13	7	10	17	2
THD	6 - 9	1	2	2	6	2	0	0
	10 - 13	2	7	8	6	3	8	1
	14-17	11	6	8	7	7	12	2

Naïve Listener Report

Similar to caregivers, it was hypothesized that naïve listeners would report an increase in infant vocalizations across infant age, and a difference in vocalizations produced between the infant with otitis media with effusion and the infant with typical hearing development. Data displayed in Table 5 demonstrates a difference in general features reported for infants between listeners. The infant with otitis media with effusion was reported to produce only a slight increase in general features between these ages. However, the infant with typical hearing development demonstrated a decrease for consonants and vowels between the early and middle age range, which is peculiar to typical development.

Table 5. General features of naïve listener report.

Infant	Infant Age (in Months)	# of Utterances	# of Consonant Tokens	# of Vowel Tokens
OME	6 – 9	15.0	9.8	15.0
	10 - 13	17.8	19.0	22.8
	14-17	21.3	19.8	23.5
THD	6 – 9	12.8	12.5	15.3
	10 - 13	13.8	9.8	12.5
	14-17	22.8	23.0	25.3

In naïve listener report for both infants, the vowels remained higher than consonants tokens across all ages. Further, listeners reported similar numbers of utterances, consonants, and vowels across infants.

Table 6 indicates that naive listeners noted a preference for labial and coronal sounds across infants. Of note, the infant with typical hearing development showed a preference for laryngeal sounds according to naïve listener report, such as /h/, in the early age range, but this was not reported for the infant with otitis media with effusion. Additionally, the infant with typical hearing development had higher quantities of voiceless consonants than the infant with otitis media with effusion across all ages. This was consistent with caregiver report.

Table 6. Phonetic features of naïve listener report.

Infant	Infant Age (in Months)	Place of Articulation for Consonant Tokens				Voicing for Consonant Tokens	
		Labial	Coronal	Dorsal	Laryngeal	Voiced	Voiceless
OME	6 – 9	3.8	3.0	1.0	2.0	7.0	2.8
	10 – 13	7.3	4.5	3.8	1.5	16.0	3.0
	14-17	6.8	7.3	2.8	3.0	13.5	6.3
THD	6 – 9	4.5	1.8	0.0	6.3	6.3	6.3
	10 – 13	2.0	5.3	0.5	2.0	5.3	4.5
	14-17	5.0	10.8	4.8	2.5	12.8	10.3

For each infant, across all ages, naïve listeners reported more stop, fricative, and nasal sounds (see Table 7). Further, according to naïve listener report, the infant with typical hearing development appears to be producing more variability in the manner of consonants produced. The infant with otitis media with effusion produced primarily stops, fricatives, and nasals, while the infant with typical hearing development produced these and some liquids, glides, and affricates by the late age group.

Table 7. Phonetic features of naïve listener report.

Infant	Infant Age (in Months)	Manner of Production for Consonant Tokens					
		Stop	Fricative	Affricate	Nasal	Liquid	Glide
OME	6 - 9	5.0	2.3	0.0	2.5	0.0	0.0
	10 - 13	14.8	0.8	0.0	1.5	2.0	0.0
	14-17	12.5	3.8	0.0	3.5	0.0	0.0
THD	6 - 9	1.5	4.8	0.0	5.8	0.0	0.5
	10 - 13	3.3	3.8	0.0	2.8	0.0	0.0
	14-17	8.8	3.8	2.8	6.0	0.3	1.5

As demonstrated in Table 8, naïve listeners reported a very high number of low back vowels for the infant with otitis media with effusion across all ages. An increase in rising diphthongs was reported for the infant with typical hearing development, which demonstrated normal progression in mastery of vowels. Again, according to naïve listener report, the infant with typical hearing development appears to be using a wider range of vowels more consistently than the infant with otitis media with effusion.

Table 8. Phonetic features of naïve listener report.

Infant	Infant Age (in Months)	Tongue Position for Vowel Tokens						
		High Front	Low Front	Central	Low Back	High Back	Rising Diphthong	Rhotic Diphthong
OME	6 - 9	2.5	2.0	2.5	6.0	1.0	1.0	0.0
	10 - 13	0.5	3.3	2.3	10.0	2.8	4.0	0.0
	14-17	4.5	2.5	1.0	11.5	1.0	3.0	0.0
THD	6 - 9	1.0	2.3	4.0	4.8	0.8	2.5	0.0
	10 - 13	0.5	4.3	0.3	3.3	2.3	2.0	0.0
	14-17	5.3	2.3	3.0	4.3	2.0	8.5	0.0

Cross Study Comparison

The approach of caregiver report is being used to create a more accurate and less cumbersome method for documenting infant vocalizations than phonetic transcription.

Naïve listeners are being used to simplify laboratory efforts by listening to infant vocalizations and reporting on sounds perceived. For these two methods of reporting, the task is the same: listen to infant vocalizations and report on the sounds or words perceived. However, the setting is very different for each method. Caregivers spend hours with the infant, interact with the infant, and have an influence on potential sound choices the infant uses. Naïve listeners are not privileged to context or interaction with the infant during listening tasks, which could potentially effect perception of vocalizations.

Additionally, the sample size of the present study is too small to be considered statistically relevant. That being said, there are differences in reports from caregivers and naïve listeners. Tables 1-4 compared to Tables 5-8 indicate that for number of utterances, consonant, and vowel tokens caregivers reported 2 to 20 times more productions of sounds as naïve listeners across ages for both infants. However, when compared as percentages of total utterances in each age group, caregiver and naïve listener report more similarities for the place of articulation (Table 2 and 6) than for manner of production (Table 3 and 7). This indicates that caregivers and naïve listeners are agreeing on the placement of articulators (e.g. labial, coronal, laryngeal, etc) during vocalization, but not how (e.g. fricative, stop, nasal, etc) they are being produced.

Further observation indicates that caregiver and naïve listener report are more similar for the infant with typical hearing development than for the infant with otitis media with effusion. Comparisons between the caregiver and naïve listeners could appear to be more similar for the infant with typical hearing development because the caregiver of that infant reported fewer overall tokens and naïve listeners generally

attributed far fewer sound to both the infants. Therefore, because the caregiver of the infant with otitis media with effusion attributes more vocalizations it may be causing the comparisons to appear to be different. A larger sample size would potentially eliminate this trend.

Chapter IV: Conclusion

The purpose of this case study was to explore caregiver and naïve listener report of infant vocalizations from an infant with otitis media with effusion and a gender- and age-matched peer with typical hearing development. Specifically, this study was designed to determine whether or not caregiver and naïve listener reports identify similar differences across infants. Research has demonstrated that caregiver report provides a unique perspective of vocal development when compared to traditional transcription methodologies. Using phonetic transcription, it has been shown that speech and language development can be altered or delayed in children with chronic ear infection, or what is known as otitis media with effusion (as a result of inconsistent auditory information). Therefore, given new methodology, it was hypothesized that caregivers and naïve listeners would report fewer phonetic features when listening to an infant with otitis media with effusion than to an infant with no history of otitis media. Potential clinical implications, study limitations, and future research will be discussed.

The new methodology used in this pilot study was able to identify minimal differences in the vocal development between the two infant participants. Reports indicated that each infants' repertoire was developing appropriately, with the infant with otitis media with effusion sometimes reported to produce more sounds than the infant with typical hearing development and vice versa.

Given the small scale of this case study, continued research in prelinguistic vocalizations using these new methodologies is warranted. Caregiver and naïve listener perspective may lead to new methods for identifying early behavioral markers for infants

at risk of future speech and language delays/disorders, which can be used in clinical practice.

Caregiver Report

Without training or copious amounts of time gathering data, caregiver report emulates the basic pattern of speech development that we would anticipate (e.g., a decrease in vowels and an increase in consonants with age, the use of more labial and coronal sounds before affricates, etc). Accordingly, we could tentatively suggest that caregivers may provide us with a more efficient means for tracking vocal development than phonetic transcription. Additional research is warranted. Despite having followed developmental trajectories, between infants, caregivers reported a higher number of utterances, consonant tokens, and vowel tokens across all ages for the infant with otitis media with effusion, with the exception of a few categories (e.g. glides, fricatives, coronal, and laryngeal consonants and voiceless consonants in the late age group). This is contrary to what was hypothesized.

Caregivers reported a steady increase across age for both infants in labial (/m p b f v w/) and coronal (/n t d ɾ θ ð s z ʧ ʤ ʃ ʒ ɝ/) consonants. Shriberg's classification of early, middle, and late developing phonemes indicates that infants typically develop mastery of the bilabial consonants first /p b m w/ (Paul, 2007). Caregiver report is consistent with these developmental norms. Also included in Shriberg's early eight are /j n d h/. Most of these sounds are represented in the steady growth of labial and coronal consonants reported by these caregivers, lending support to the claim that caregivers intuitively identify developmentally appropriate phonemes. Caregivers also reported a steady increase of voiced and voiceless consonants with increasing age groups. This too

is anticipated as Shriberg indicates that the majority of the early eight speech sounds are voiced consonants. Furthermore, caregiver perception of vowel development is on par, and comparable across infants. As an infant develops, higher and more front vowels are used more often. Vowels develop in a progression from corner vowels (/i ɑ u/), to the mid back vowel /o/, and to the central stressed vowel /ʌ/. Caregiver report was consistent with this general progression of vowels.

Still more interesting, is that despite evidence of OME, caregivers reported more phonetic features for place of articulation and manner of production for the infant with otitis media with effusion in the early age group. The infant with otitis media with effusion had inconclusive hearing results during the 7th and 8th month and pressure equalization tubes placed at 9 months; this could have precipitated a hearing loss induced speech delay.

The infant with otitis media with effusion demonstrated a preference for stops through all ages. By the late stage, sounds such as fricatives and glides were more often produced by the infant with typical hearing development. Further, the infant with otitis media with effusion was reported to produce fewer coronal, laryngeal, and voiceless consonants than his peer with typical hearing development. These categories are of particular interest because none of the sounds are produced visually and must be heard to decipher differences. Additionally, the infant with otitis media with effusion produced almost three times as many nasal sounds as the infant with typical hearing development during the late stage, but a third as many glides and half as many fricatives. As both infants came from English speaking homes these differences cannot be attributed to language learning. However, this could indicate a difference in speech development

between the infants. As previously discussed, this could potentially be indicative of the effects of a conductive hearing loss being expressed in lower quantities of fricatives, coronals, glides, and voiceless consonants.

Conversely, research conducted by Stoel-Gammon (1988) found that infants with hearing loss from moderate to profound had similar consonant inventories as their peers with typical hearing during the 4-18 month range. An additional study by Stoel-Gammon and Otomo (1986) indicated that infants with mild-moderate hearing loss did not have as substantial deviations from the norm as those infants with severe-profound hearing loss. Therefore, it could be considered that the differences between infants are still similar to what would be anticipated for vocal development between and infant with OME and a peer with typical hearing development. Despite the similarity of their consonantal inventories, only a larger sample size would be able to determine if there are, in fact, differences between infants and across listeners.

Naïve Listener Report

Naïve listeners reported differences between infants. The infant with otitis media with effusion was reported to favor more stops, labials, and low back vowels than the infant with typical hearing development, who produced a wider variety of liquids, glides, fricatives, and affricates during the late stage, and rising diphthongs through all ages. Naïve listener report demonstrated a difference in general features reported for infants between listeners. In typical development, by the late age range, a child should be utilizing sounds and potentially even words in greater number than in the middle age range. The data collected indicates a difference in typical development as the infant with typical hearing development displayed a decrease in consonant tokens between the early

and middle age groups. Additionally, the literature suggests that the percentage of vowel tokens would be making a decrease at this point and consonants increasing. However, vowel tokens remained higher than consonant tokens for both infants across all ages. Naïve listeners reported a lower quantity of features than we would have expected per age group, nevertheless, their reports were still consistent with developmental norms.

Naïve listeners reported the infants favoring Shriberg's eight early developing phonemes (e.g., / p b m w n h/), which are labials, nasals, and mostly voiced consonants. For each infant, across all ages, naïve listeners reported more stop, fricative, and nasal sounds and less affricates and liquids. This is in line with typical development as affricates and liquids are some of the last phonemes to be mastered in childhood. Of note, the infant with typical hearing development showed a preference for laryngeal sounds according to naïve listener report, such as /h/, in the early age range, which is part of Shriberg's early 8, but not consistently reported for the infant with otitis media with effusion. Interestingly, naïve listener report attributed more variability in the manner of consonants produced to the infant with typical hearing development than the infant with otitis media with effusion.

Vocalizations across Listeners and Infants

Based on the results and analysis of both listeners, it has been demonstrated that there are slight reported differences between the infants, especially in the late stage (e.g., the infant with typical hearing development was reported to produce more voiceless, coronal, fricative, and glide consonants and the infant with otitis media with effusion was reported to produce more voiced, labial, and stop consonants). The data further revealed

differences between caregiver report and naïve listener report. Both caregivers and naïve listeners reported general phonetic development similar to what would be expected (e.g., the development of labial and coronal sounds before affricates and glides). Listeners also indicated that the infants displayed a general increase in phonetic features across age. Interestingly, both caregiver and naïve listener report indicated similar place of articulation for consonants, but differed on manner of production for consonants.

Despite these differences, no delay is indicated for either infant. It is interesting, however, to note that the infant with otitis media with effusion generally produced higher, or very similar quantities, of most phonetic features according to listeners. It was hypothesized that he would produce fewer, based on his recurrent middle ear infections.

Possible Limitations

Several possible limitations have been set forth to understand better why caregiver and naïve listener reports appear to be slightly different, despite each reflecting expected developmental trends. The amount of vocalizations heard by each listener could have influenced the number of vocalizations reported. Caregivers simply have more opportunity to hear sounds produced by the infants. If naïve listeners had more opportunity to hear sounds, such as presentation of each recording twice instead of a single instance, it is anticipated that a higher number of different vocalization types would have been reported. Additionally, it is possible that the instructions to naïve listeners was not sufficient and should be looked at more closely.

It is further believed that because of closer contact with the infants, caregivers have a greater inherent understanding of the infant's repertoire. It is possible that

because there was no direct contact with the infants, no viewing of video recordings even, the naïve listeners were at a disadvantage from reporting more similar findings to caregivers.

Given the limited sample size, there were restrictions to the opportunity to observe differences between infants. The infant with otitis media with effusion was chosen because of his medical history. However, as mentioned previously, his ear infections were treated quickly and early in development by the insertion of pressure equalization tubes. The aggressive treatment could explain similar patterns of development reported between infants. Given that the infant with otitis media with effusion did not experience hearing loss for an extended period of time (no more than 3 months), it is possible that the hearing loss he did experience had little effect on his speech and language development. To further support this suggestion, follow-up speech and language testing was conducted with each child at 3 ½ years of age, and the results supported speech and language development within normal limits. This finding indicates that caregiver and naïve listener report had accurate portrayals of the infants' prelinguistic speech and language developmental trends.

Further, because this study did not explore phonetic transcription in cross examining these methodologies, this study is incomplete. In order to establish that these new methods are better suited for tracking infant vocalizations, a comparison to the gold standard (the IPA) would be required.

An additional weakness of this study is the length of time between hearing evaluations. As previously mentioned, upwards of 90% of infants within the first year of

life experience at least one episode of otitis media (Paradise et al., 1997). As the researchers only conducted a hearing evaluation for the infant with typical hearing development at 6 and 18 months, there is no way to indicate that this infant did not experience episodes of otitis media in the 12 months between those evaluations. The only anecdotal evidence supporting no history of ear infections is that caregivers did not report such episodes.

Finally, it is recognized that in order to report statistical significance, a much larger group of participants needs to be studied.

Clinical Implications

It is anticipated that through this new methodology the gap between research and clinical practice can be eliminated. For example, a clinician working with infants can easily ask caregivers (whether that be grandparents, parents, neighbors, or even daycare specialists) what sounds the infant is making. The same clinician is not likely to have time to invest in recording and phonetically transcribing the infant's vocalizations. We would anticipate caregivers to report appropriately for the infant's age. If there is a discrepancy, further testing and therapy can begin immediately, instead of waiting for a larger deficit to appear.

Naïve listeners are potentially the link between caregivers and laboratory measures, creating less need to take caregiver's limited time.

Future Directions

Based on the results and limitations of this study, it is suggested that future research be conducted on larger, more representative samples. This would increase the ability to generalize the data and broaden the scope of understanding for this

methodology. Additionally, phonetic transcription needs to be included to compare across methods and present a more solid picture of the best practice for documenting infant vocalizations.

It is further suggested that more specific training for both caregivers and naïve listeners needs to take place; perhaps utilizing a sample file to listen and compare with laboratory staff before performing the task. The naïve listeners of this study did not have children; it would be useful to determine if caregivers have greater acuity to infant vocalizations than the non-caregiver counterpart. Potentially caregivers listening to other infants would report different vocalizations than naïve listeners who do not have their own children.

As research has not indicated the efficacy of pressure equalization tube placement (Paradise, et al., 1997), and this study did not check for hearing loss with greater frequency, it would make the study more reliable to have the infants' hearing checked with greater consistency throughout the study.

Overall, the results and clinical implications of this study warrant further investigation of this topic. The potential to translate this research into accessible means for speech-language pathologist and pediatricians creates a need to continue to investigate these methodologies.

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