DEVELOPMENT OF EXPRESSIVE VOCABULARY AND GRAMMAR IN YOUNG
CHILDREN WITH REPAIRED CLEFT PALATE, CHILDREN WITH A HISTORY OF
OTITIS MEDIA, AND CHILDREN WITH TYPICAL DEVELOPMENT

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A dissertation submitted to the faculty at the University of North Carolina at Chapel
Hill in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the
Department of Allied Health Sciences in the School of Medicine.

Chapel Hill
2018

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ABSTRACT

Marziye Eshghi: Development of Expressive Vocabulary and Grammar in Young Children with Repaired Cleft Palate, Children with A History of Otitis Media, and Children with Typical Development
(Under the direction of David Zajac)

This Dissertation composes of two related studies. Study1 aimed to investigate the expressive vocabulary skill of 40 children with repaired cleft palate (CP), 29 children with histories of otitis media (OM), and 25 typically developing (TD) children at 18 and 24 months of age and compared the three groups in terms of the vocabulary growth from 18 to 24 months of age. In addition, the contribution of factors such as hearing level, tympanogram status, size of consonant inventory, maternal education level, and gender to the development of expressive vocabulary was explored. The purpose of the second study was to examine the lexical-grammatical skills of 26 children with CP with consistent velopharyngeal (VP) closure, 27 children with OM, and 20 TD children at two years of age. Further, the association between early vocabulary skills and grammatical attainment as well as the precursors of early lexical-grammatical development were explored. The MacArthur Communicative Development Inventory: Words and Sentences (CDI-WS; Fenson et al., 2007) was employed to measure the size of vocabulary as well as the grammatical ability of children in the three groups. Consistency of VP function was made objectively through nasal ram pressure (NRP) monitoring. For the second study, however, NRP data for four children with CP were missing and assessment of VP function was based on perceptual judgments. Because these studies are part of a larger

longitudinal study, sound-field audiometry screenings were performed at 12 and 24 months of age. Bilateral tympanogram data were obtained at 18 and 24 months of age.

Results of the first study showed that children with CP produced a significantly smaller number of words at 24 months of age and a significantly slower rate of vocabulary growth from 18 to 24 months of age when compared to TD children ($p< 0.05$). The observed difference remained significant when the model was adjusted for the effect of hearing level, tympanogram status, size of consonant inventory, and sociodemographic variables. However, among all variables, only the tympanogram status significantly predicted the vocabulary growth from 18 to 24 months of age across the three groups. Findings of the second study revealed significant differences among the three groups with respect to the size of vocabulary and mean number of morphemes in their three longest utterances (M3L). The difference between CP and TD groups remained statistically significant when adjusting singly for hearing level, tympanogram status, and gender. Further, significant positive associations were found between the number of words and M3L and sentence complexity in each group ($p< 0.05$). Weak performance of children with CP on measures of expressive vocabulary and grammar were accounted for by poorer hearing levels, more frequent instances of abnormal tympanogram status, as well as lower levels of maternal education. Findings highlighted the importance of comprehensive speech and language assessments to identify children with CP who need intervention services as early speech and expressive language management has the potential to considerably mitigate the effects of later language delays.

To my parents, my husband, and my mentor that had it not been for their support, my goals of excelling in education would have remained a mere dream.

ACKNOWLEDGEMENT

First, I would like to thank my parents, *Asghar* and *Esmat*, who nurtured my sense of curiosity by providing me with all sorts of educational resources that allowed me to realize my own capabilities. Having your constant love and support over the years have been the greatest gifts I could ever think of. Thank you mom for tolerating my absence during the years I have been away from you! I know at times you desired my presence but whenever we talked, you sacrificed your heart's desire behind words of encouragement and hope. Thank you dad for believing in my potential and facilitating my trip to the United States. Thanks for all of your great advice that has kept me going on my path to success. Mom and dad, thank you for loving me unconditionally without expecting anything in return. You are both role models and pillars of support!

I would also like to praise my lovely, sweet husband, *Mehdi*, for his never ending love and heartfelt support. Thank you Mehdi, for making my life journey so beautiful. Thanks for putting up with me in difficult moments where I felt overwhelmed or frustrated. Your support and patience enabled me to work more efficiently and effectively during my PhD program. You always give me the power to believe in my passion and pursue my goals with a stronger determination. You are such a wonderful and amazing partner! Thanks for your unwavering and unselfish love and support! Love you always and forever!

I would also like to extend my deepest gratitude to my esteemed mentor and dearest friend, *Dr. David Zajac*, who taught me the ABCs of research and reinforced in me the sense of

achievement and accomplishment. Thank you David for giving me the opportunity to work on your interesting project which not only expanded my research experiences but also covered my school expenses. My life could have been very stressful without the financial assurance you generously offered me during my PhD study. Thank you very much for sharing your valuable time whenever I approached you to discuss studies or any questions I had. Thanks for giving me all the freedom to conduct independent research studies and giving me insightful comments and suggestions. I shall eternally be grateful to you for your warm encouragement, and continuous support. You have been and will be my mentor and friend regardless of where my career path will take me!

I must express my very profound gratitude and best regards to *Dr. Amelia Drake, Dr. Elizabeth Crais*, *Dr. John Preisser*, *Dr. Adam Jacks*, *Dr. Katarina Haley, and Dr. Karen Erickson* for their support that was above and beyond great! You all have, in whatever manner possible, kept me going on my path to success. Thanks for your invaluable words of guidance, inspiration, and encouragement during these critical years of my life.

I have a great pleasure in acknowledging my gratitude to our research team members and my cohort of colleagues and friends at the UNC Craniofacial Center who always offered me great assistance whenever I needed their help. The completion of my research projects in general and this Dissertation in particular would not have been possible without the help of *Reuben Adatorwovor*, *Daniela Vivaldi*, *Kristen Lynch*, and *Marina Pastore Rampazzo.* Thank you all for assisting me throughout the entire course of my research projects. Your continued support and encouragement have been definitely great contributors to the completion of this work.

I should also mention the names of my most compassionate friends *Nancy Quick*, *Tyson Harmon*, and *Nicole Corbin* who made every single moment of my PhD journey a celebration of

true friendship, joy, and mutual learning. I should give my special and sincerest thanks to Nancy Quick whose kindness, passion, generosity, and favor go beyond the horizon of the universe. Thank you Nancy for connecting me with many people who all had something valuable for me to learn. Thanks for showing me different aspects of American culture and lifestyle. I will never forget the language-play entertainment time we had together after a long day of work!

Finally, I would like to thank my omnipotent creator for his grace and blessings throughout my life. My Almighty Lord, thanks for bringing all these wonderful people to my life. Thanks for giving me the strength, knowledge, talent, and opportunity to undertake these studies and for the ability to persevere and complete them satisfactorily. I could never have done this without the faith I have in you.

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CDI-WS   the MacArthur-Bates Communicative Development Inventories: Words and Sentences

CLP   Cleft Lip and Palate

CP   Cleft Palate

CPO   Cleft Palate Only

MEL   Maternal Education Level

MLU   Mean Length of Utterance

M3L   Mean Number of Morphemes in Three Longest Utterances

NRP   Nasal Ram Pressure

OM   Otitis Media

PE   Pressure Equalization

TD   Typically Developing

VP   Velopharyngeal

VPI   Velopharyngeal Inadequacy

CHAPTER 1: INTRODUCTION

Cleft palate (CP) is one of the most common birth defects with the prevalence of 1-in-500 to 1-in-750 live births. Moreover, cleft of the lip and/or palate can occur as part of a syndrome. For example, about 400 syndromes may cause cleft of the lip and/or palate along with other medical conditions. Anatomically, depending on the type and extent of the cleft, cleft may lead to muscular malformation of the lips, bone and soft tissue abnormalities of the palate, and mismorphology of the nose. These structural complexities cause a range of problems including aesthetic, feeding, otologic, and speech/language difficulties. In this Dissertation I will focus on specific aspects of language impairment in children with CP.

Prior to palatal surgery, velopharyngeal inadequacy (VPI), reduced palatal surface for lingual-palatal contact, abnormal morphology of the oral cavity, and concurrent conductive hearing loss are the main pathologic factors that affect normal development of prelinguistic vocalizations and babbling. Research has shown that VPI following the primary cleft palate surgery may still persist in up to 30% of children with CP (Inman, Thomas, Hodgkinson, & Reid, 2005; Webb, Watts, Read-Ward, Hodgkins, & Markus, 2001). Usually children with inadequate VP function show complex issues in production of high-pressure sounds (i.e., stops and fricatives) as well as speech resonance (e.g., hyper- or hyponasality). However, assuming that palatal surgery results in a structurally competent VP mechanism, nasal ram pressure (NRP) monitoring has suggested that children with repaired CP may achieve consistent VP closure by 14 months of age, approximately 3 to 4 months following palate repair (Eshghi, Vallino, Baylis, Preisser, & Zajac, 2017). Other structural factors such as postsurgical oronasal fistulae (Bureau,

Penko, & McFadden, 2001; Marino, Williams, Wharton, Paulk, Dutka-Souza, & Schulz, 2005),

maxillary arch anomalies (Eshghi & Zajac, 2014, 2017; Eshghi, Zajac, Bijankhan, & Shirazi,

2013; Okazaki, Kato, & Onizuka, 1991; Zajac, Cevidanes, Shah, & Haley, 2012), dental-occlusal

problems (Golding-Kushner, 1995), reduced tactile feedback due to postsurgical cicatrices

(Hardcastle, Morgan Barry, & Nunn, 1989), and early-established retracted tongue posture

possibly related to early feeding patterns (Hardcastle et al., 1989; Russell & Grunwell, 1993),

may restrict the ability of children with CP to produce vocalizations.

In addition, fluctuating conductive hearing loss is common in children with CP

(Paradise, Bluestone, & Felder, 1969) due to malformation of the tensor veli palatine

muscles. Conductive hearing loss distorts the auditory input needed for acoustic decoding and

aural-oral matching during speech production. Studies have shown a relationship between otitis

media and delayed phonological and expressive language skills in populations without cleft

(Donahue, 1993; Luloff, Menyuk, & Teele, 1993; Petinou, Richard, Maria, & Judith, 1999;

Rvachew, Slawinski, Williams, & Green, 1999). Jones, Chapman, and Hardin-Jones (2003) also

reported that children with a higher number of reported episodes of otitis media and failed

tympanometry at pre- or postsurgery sessions showed less progress in size of consonant

inventory after palatal repair.

Phonetic Characteristics of Speech in Children with CP

According to a general principle of phonetic development, language-specific parameters

of speech sounds are learned and fine-tuned during the babbling stage. Research has

demonstrated that later stages of phonological and language development are built upon speech

skills developed during canonical babblings (Oller, Wieman, Doyle, & Ross, 1976; Stoel-

Gammon & Cooper, 1984; Vihman, 1992). Therefore, any anatomical and/or physiological

anomaly that can disrupt the developmental course of canonical babbling may place the child at risk of phonological and language delay compared to their peers with typical development.

Research has shown that compared to typically developing (TD) children, those with CP are delayed in the onset of babbling (Chapman, Hardin-Jones, Schulte, & Halter, 2001) and frequency of babbling (Scherer, Williams, & Proctor-Williams, 2008). In addition, babbling produced by children with CP has been characterized to consist of fewer total consonants (Lohmander, Lillvik, & Friede, 2004), fewer multisyllabic productions (Chapman, 1991), and more vowel-only syllables than consonant–vowel productions (Scherer, Williams, Henley, Lambert, Lassiter, & Osborne, 2000). Chapman et al. (2001) reported that babies with unrepaired CP had smaller canonical babbling ratios than their age-matched peers, with just 57% of the babies with CP reaching the canonical babbling stage by 9 months compared to 93% of babies without CP.

Studies of babbling in children without clefts report a predominance of anterior sounds in pre-speech productions (Kent & Bauer, 1985; Roug, Landberg, & Lundberg, 1989; Smith & Oller, 1981; Stoel-Gammon, 1985). In contrast, in children with CP, glottal and labial productions were more frequent than the alveolar, palatal, and velar productions (Chapman, 1991; Chapman et al., 2001; Grunwell & Russel, 1987; Hutters, Bau, & Brøndsted, 2001; O'Gara & Logemann, 1988; Olson, 1965). Predominance of initial consonants articulated at the periphery of the oral tract (i.e., [-coronal]) rather than the center of the oral tract (i.e., [+coronal]) was reported in some studies (Estrem & Broen, 1989; O'Gara & Logemann, 1988). For example, O'Gara and Logemann (1988) reported that in the babbling of children with clefts, sounds produced in the extremes of the vocal tract (i.e., the glottal and labial place features) dominate over those produced in the central portion of the vocal tract (i.e., alveolar, palatal, or velar

sounds). Lohmander-Agerskov, Söderpalm, Friede, Persson, and Lilja (1994), however, suggested that there are correlations between cleft type and place of articulation. Sounds with anterior place of articulation occurred frequently among TD children and children with CP only. In children with cleft lip and palate (CLP), however, sounds with posterior place of articulations are more frequently produced.

Differences were also observed in the size of consonant inventory (Chapman, Hardin-Jones, & Halter, 2003; Chapman et al., 2001; Scherer, 1999). Examination of spontaneous vocalizations produced by children with CP demonstrated smaller consonant inventories consisting of low-pressure consonants such as nasals, glides, and liquids (Chapman et al., 2001; O'Gara & Logemann, 1988; Olsen, 1965; Salas-Provance, Kuehn, & Marsh, 2003). When compared to TD infants, infants with CP produced fewer oral stops, velars, and alveolars (Chapman, 1991; Chapman et al., 2001; Hutters, 2001; Lohmander et al., 2004; Lohmander, Olsson, & Flynn, 2011; O'Gara & Logemann, 1988; Willadsen & Albrechtsen, 2006), as well as more nasals and glottals (Chapman et al., 2001; Hutters et al., 2001; O'Gara & Logemann, 1988; Olsen, 1965; Willadsen & Albrechtsen, 2006).

Children with CP may also show delay in the development of specific phonetic features. For example, development of anticipatory and carry-over coarticulation appears to be more gradual and less extensive in both school-aged children and infants with CP (Eshghi, Vivaldi, Dorry, & Zajac, 2016; Fea, Eshghi, & Zajac, 2016). In a study conducted by Eshghi et al. (2016), development of carry-over nasal coarticulation in children with and without CP was studied longitudinally at 12, 14, and 18 months of age. Results indicated that in TD children, carry-over nasal coarticulation increased over time as it occurred in 19%, 66%, and 81% of vowels at 12, 14, and 18 months of age, respectively. In children with CP, however, carry-over coarticulation

occurred in 32%, 21%, and 67% of vowels at 12, 14, and 18 months of age, respectively. As suggested by the data, while carry-over coarticulation increased considerably between 12 and 14 months of age in the TD group, a similar increase occurred with approximately 2 to 4 months delay in the CP group (i.e., between 14 and 18 months of age). Overall, children with CP were found to produce less co-articulated speech compared to TD children. The authors hypothesized that reduced carry-over nasal coarticulation occurred as a strategy to circumvent hypernasal speech or as a consequence of prolonged speech segments in children with repaired CP (Eshghi, Preisser, Bijankhan, & Zajac, 2016; Forner, 1983).

Phonological Processes in Children with CP

Speech disruptions may initially occur as a consequence of the structural deviations, but over time become incorporated into the child's developing phonological system. For example, glottal stop substitution for a bilabial stop could develop in response to presurgical VPI and persist as a learned phonological rule in the phonology of a child with CP. Chapman (1993) reported that children with CP exhibited more instances of phonological processes at 3 and 4 years of age, but by 5 years of age they were similar to children without CP in phonological process usage. In another study by Chapman and Hardin (1992), two-year-old children with CP employed the same phonological processes with similar frequency as observed in the speech of their age-matched TD peers. In other words, children with CP were similar to children without CP with regard to the phonological patterns at 2 and 5 years of age, but they produced more phonological process errors at 3 and 4 years of age. The authors explained the observed phonological regression of children with CP at 3 and 4 years of age through the course of normal phonological development. They argued that the suppression of phonological processes is delayed for children with CP compared to TD children. Children without CP begin to show

substantial decreases in the number of processes at 3 and 4 years while children with CP employ phonological process for a longer period of time.

Deletion of final consonants and syllable reduction are two productive phonological processes in the speech of children with CP, whereas these two processes are commonly seen in the speech of TD children prior to 3 years of age (Stoel-Gammon & Dunn, 1985). Other common phonological processes in the speech of children with CP are: backing (using back sounds for front sounds), stopping (substitution of stops), stridency deletion, and deaffrication (substituting a fricative for an affricate) (Chapman, 1989). These processes might be employed by children with CP at 3 years of age for ease of articulation. In addition, three syllable structure processes including deletion of final consonants (Chapman, 1989), syllable reduction (Chapman, 1989), and cluster simplification (Chapman, 1989; Powers, Dunn, & Erickson, 1990) were also observed to be more frequent in the speech of the 3-year-old children with CP.

The Effect of Prelinguistic Vocalization on Vocabulary and Language Development in Children with CP

Longitudinal studies have reported a positive relationship between early vocalization and later speech and language abilities in children with CP (Chapman, 2004; Chapman et al., 2003; Scherer et al., 2000). Typically, children with larger consonant inventories and higher rates of stop consonants at the prelinguistic stage have better speech and language performance. Studies of the prelinguistic abilities of children with CP showed that they vocalize as frequently as young children without CP, but their early vocalizations are less complex and they are delayed in transitioning to word use (Scherer, Boyce, & Martin, 2013; Scherer et al., 2008). Scherer et al. (2008) reported that complexity of early vocalizations rather than frequency of vocalizations alone may account for the differences observed in early sound development of children with CP.

They documented that children with CP have a specific deficit in the complexity of early sound production that was characterized by lower mean babbling level (MBL) and reduced use of stop consonants.

Chapman at al. (2003) reported that among indices for speech development, onset and composition of canonical babbling can differentiate children with CP from TD children at prelinguistic stages. However, neither of the two variables was significantly correlated with later speech or language measures. In contrast, later phonological and language measures were significantly associated with small consonant inventories and restricted production of stop consonants. Restricted consonant inventories may lead to delayed onset of first words and poor expressive vocabulary development (Broen, Devers, Doyle, Prouty, & Moller, 1998; Chapman et al., 2003; Eshghi, Baylis, Vallino, Crais, Preisser, Vivaldi, Dorry, & Zajac, 2017; Eshghi, Dorry, Vivaldi, Crais, Vallino, Baylis, Preisser, & Zajac, 2017; Jocelyn, Penko, & Rode, 1996; Jones et al., 2003; Scherer, 1999; Scherer & D'Antonio, 1995).

In addition, the transition from the prelinguistic stage to linguistic level has been reported to take longer for children with CP. In a study conducted by Scherer et al. (2013), all 15 children with CP were still in the prelinguistic level at 17-19 months of age and half of them remained in the prelinguistic level at 23-25 months of age in comparison to TD children. Hardin-Jones & Chapman (2014) reported that while children with CP showed similar expressive vocabulary skill to that of TD children at 13 months of age, they showed significantly reduced size of their lexicon at 21 and 27 months of age. Further examination of the words produced by the children with CP revealed that restricted consonant inventory may influence early vocabulary development, as children with CP tend to attempt words beginning with sounds that are part of their phonological system and avoid words consisting of sounds outside their phonological

system. Marked lexical selectivity and avoidance have been observed by Hardin-Jones &

Chapman (2014) and Willadsen (2013) who reported that children with CP produced

significantly more words beginning with sonorants and fewer words beginning with obstruents in

their spontaneous speech samples.

In addition to expressive vocabulary skills, children with CP have exhibited poorer

grammatical performance by producing shorter mean length of utterance (MLU) (Spriestersbach

et al., 1958, Eshghi et al., 2017), and less syntactictically complex utterances (Morris, 1962;

Eshghi et al., 2017). Considering other aspects of language, young children with CP have shown

weaker scores for social communication skills (Eshghi, Vivaldi, Dorry, Crais, Vallino, Baylis,

Preisser, & Zajac, 2017) and symbolic behavior (Eshghi, Dorry, Crais, Baylis, Vallino,Vivaldi,

Preisser, & Zajac, 2017), but both domains were typically within normal limits, when compared

to TD children.

The observed early speech and language impairments in children with CP deserve closer

attention especially because a significant number of research studies have reported that young

children diagnosed with speech and language problems have literacy difficulties at school

(Felsenfeld, Broen, & McGue, 1994; Lewis, Hansen, Stein, Shriberg, Iyengar, & Taylor, 2006;

Scarborough, 1990; Sices, Taylor, Freebairn, Hansen, & Lewis, 2007). For example, using the

Standard Reading Inventory, Richman, Eliason, & Lindgren, (1988) reported that out of 172

elementary school children with CLP and CPO, approximately 52% exhibited moderate (35%) to

severe (17%) reading disability. Children with CP have a high prevalence of speech and

language disorders that can increase the likelihood of literacy disabilities. Consistent with these

findings, school under-achievement in children with CP has been observed in a number of

studies (Kommers & Sullivan; 1979; Richman, 1976, 1980). Contrary findings, however, could

be found in Collett, Leroux, & Speltz, (2010), who reported that children with clefts showed similar language skills and academic achievement compared to their TD peers. It should be noted that children with clefts in Collet et al. (2010) benefitted from frequent early speech and language interventions as well as good quality mother-child interaction. Further research is warranted to examine early language milestones in young children with CP.

Significance of the Current Studies

Literature on the association between cleft palate and speech/language development suffers from various methodological limitations. Some studies applied a cross-sectional research design by recruiting participants from a wide age span. Because of the inherent heterogeneity in the cleft palate population and the multiplicity of factors that affect early expressive language development, a cross-sectional research design especially with a small sample size would fail to represent a true picture of language abilities in a larger population. Although attempts have been made to investigate language patterns of children with CP from a longitudinal perspective, in some studies, discrete intervals between two consecutive sessions of speech/language evaluation were not frequent enough to trace different trajectories of language development. In addition, insufficient information about the hearing status of children with CP is another limitation of some previous studies. Given that hearing status can affect the course of speech and language development, it is not known to what extent auditory deprivation impacts the observed delay in speech and vocabulary performance of children with CP. Most importantly, because objective assessment of VP function through imaging and pressure-flow techniques requires high level of cooperation from the participants, in previous studies, any assumption with regard to the status of the VP mechanism of children with CP was made indirectly from perceptual evaluation of speech and articulation. VP status is an important variable in interpreting the data related to

children with CP and lack of information about it could jeopardize the subject-matching criteria. Furthermore, research on language and communication skills of children with CP has focused almost exclusively on speech and early expressive language. Little research, however, has been conducted on the grammatical ability of these children. Research has documented a strong association between size of the lexicon and measures of grammatical skills such as MLU and sentence complexity (e.g., Bleses, Vach, Slott, Wehberg, Thomsen, Madsen, & Basbøll, 2008; Marjanovič-Umek, Fekonja-Peklaj, & Podlesek, 2013; Stolt, Haataja, Lapinleimu, & Lehtonen, 2009). If children with CP have delayed and deficient phonological and expressive language, they are more likely to have difficulties in other domains of language such as grammar as well. Finally, language development is a multifactorial process. This means that multiple physiological, environmental, and sociodemographic factors can influence normal development of language profiles singly or in combination. Therefore, the contribution of factors such as maternal education level, gender, and cleft type should be taken into account in investigations of language development in children with CP.

In an attempt to address limitations in the literature, two studies were conducted to improve our understanding about early expressive language development and grammatical skills of young children with CP. These studies were part of a larger longitudinal study that sought to investigate the development of stop consonants in children with repaired CP (PI: Dr. David Zajac). The first study explored the development of expressive vocabulary in young children with repaired CP, children with OM, and TD children at 18 and 24 months of age and compared the three groups in terms of the vocabulary growth from 18 to 24 months of age. The second study, explored the grammatical skills of children with CP, children with OM, and TD children at 24 months of age and examined the association between the size of vocabulary and

grammatical skills measured through the MacArthur-Bates Communicative Development

Inventories: Words and Sentences (CDI WS; Fenson et al., 2007). The contribution of factors

such as VP status, hearing level, tympanogram status, maternal education level, and gender to the

development of expressive vocabulary and grammar was further examined. NRP monitoring was

used innovatively to obtain objective estimation of VP status during production of stop

consonants. Findings of these studies could highlight the importance of early speech and

language assessment to identify children with CP who are in need of appropriate

speech/language management.

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CHAPTER 2: VOCABULARY GROWTH FROM 18 TO 24 MONTHS OF AGE IN CHILDREN WITH AND WITHOUT REPAIRED CLEFT PALATE

Introduction

Early expressive vocabulary development has been characterized by two idiosyncratic features. First, there is a high individual variability in the onset, size, and rate of vocabulary development (Bates, Bretherton, & Snyder, 1988; Bleses, Vach, Slott, Wehberg, Thomsen, Madsen, & Basbøll, 2008; Devescovi, Caselli, Marchione, Pasqualetti, Reilly & Bates, 2005; Fenson, Marchman, Thal, Dale, Reznick & Bates, 2007; Ganger & Brent, 2004; Marjanovič-Umek, Fekonja-Peklaj & Podlesek, 2013; Marjanovič-Umek, Fekonja-Peklaj & Sočan, 2017; Rowe, Raudenbush & Goldin-Meadow, 2012). Second, regardless of the ambient language the child is exposed to, the transition from prelinguistic vocalizations to canonical babbling and subsequent production of first words is gradual with no discrete landmarks (e.g., Ganger & Brent, 2004; Vihman, Macken, Miller, Simmons, & Miller, 1985).

Although identifying a robust profile of expressive vocabulary development is challenging due to the large individual variability, several longitudinal and cross-sectional studies have provided estimations of vocabulary size along the continuum of children's language development. Children with typical development (TD) may babble around 6 months of age and their first words typically appear around 12 months. It has been reported that a TD child usually has a productive vocabulary of about 50 words by 18 months of age (e.g., Anglin, 1989; Bates et al., 1988; Rescorla, 1980) and about 300 words by 24 months of age (Anglin, 1989). Fenson, Dale, Reznick, Hartung, & Burgess (1990), however, reported a higher average of about 110

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words at 18 months and 312 words at 24 months in normal toddlers. In addition, using the MacArthur Communicative Development Inventories (CDI) in a cross-sectional study on 1,803 middle-class children, Fenson, Dale, Reznick, Bates, Thal & Pethick (1994) reported that TD children at the median produced fewer than 10 words, about 40 words, and 573 different words at 12-, 16-, and 30-month of age, respectively.

The rate of early vocabulary development has been described as slow in the first few months after the emergence of first words followed by a period of accelerated growth (e.g., Fenson et al., 1994; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991). This transition has often been referred to as the "vocabulary spurt" or "vocabulary burst", which usually occurs between 18 to 24 months of age (Bates & Goodman, 2001; Fenson et al., 1994; Fernald, Pinto, Swingley, Weinberg & McRoberts, 1988; Goldfield & Reznick, 1990; Kauschke & Hofmeister, 2002). This exponential increase in the size of vocabulary has been explained in light of the emergence of two-word combinations between 18 to 24 months of age (Bzoch & League, 1971; Frankenburg & Dodds, 1967; Nelson, 1973; Stoel-Gammon, 1998), which requires the child to link more sound sequences with concepts and make combinatorial speech in his or her attempts to communicate with others. Therefore, there is a bidirectional bootstrapping between lexical and syntactic knowledge during early stage of language acquisition. On the one hand, the child's lexicon needs to reach the critical mass threshold necessary to trigger grammatical development (Bates & Goodman, 1997; Bates & Goodman, 2001; Marchman & Bates, 1994) and on the other hand, word combinations and syntactic relationships between words trigger lexical development as children become more cognizant about concepts and the demand for conveying concepts with greater specificity (Anisfeld, Rosenberg, Hoberman, & Gasparini, 1998).

In spite of the abundance of research on the developmental course of expressive vocabulary, our understanding of the patterns of vocabulary growth is not yet complete. Investigations of lexical development have identified a number of cognitive, physiological, and sociodemographic factors that singly and in combination influence the onset and rate of the vocabulary growth in toddlers. For example, normal development of various cognitive skills including lexical memory (Woodward, Markman & Fitzsimmons, 1994), categorization and naming (Gopnik & Meltzoff, 1987, 1992), and the ability to associate objects with words (Woodward & Hoyne, 1999) have been identified as essential cognitive precursors of lexical development. In addition, physiological factors such as competent anatomical structure and normal hearing are essential for making articulatory movement and oral-aural adjustments to produce sounds that comprise words. Research has shown that children with cognitive disabilities, abnormal anatomical structure, or disrupted hearing are at risk of developing poor vocabulary skills (Bates, Thal, Trauner, Fenson, Aram, Eisele, & Nass, 1997; Estrem and Broen, 1989; McGregor, Berns, Owen, Michels, Duff, Bahnsen, & Lloyd, 2012; Rvachew, Slawinski, Williams, & Green, 1999; Scherer and D'Antonio, 1995; Singer Harris, Bellugi, Bates, Jones, & Rossen, 1997). Because there is a continuity from prespeech vocalizations to speech sounds and consequently to first word productions (Locke, 1989; Stoel-Gammon, 1989; Vihman & McCune, 1994), any pathological condition that disrupts normal development of pre-speech vocalizations and canonical babble is likely to jeopardize the development of other aspects of language in general and expressive vocabulary in particular.

Furthermore, the effect of sociodemographic factors in the development of expressive language in populations without cleft has been well documented. Various studies have reported evidence for a significant association between family socioeconomic status (SES) and both onset

and rate of vocabulary growth (Arriaga, Fenson, Cronan, & Pethick, 1998; Hoff, 2003; Pan, Rowe, Singer, & Snow, 2005). These studies suggest that children from families lower in SES were exposed to significantly fewer words compared to children from families higher in SES and subsequently experienced slower rates of vocabulary growth. Strong association has been also reported between maternal educational levels (MEL) and early language skills such as expressive vocabulary, comprehension, and grammatical skills (Dollaghan, Campbell, Paradise, Feldman, Janosky, Pitcairn, & Kurs-Lasky, 1999; Magnuson, Sexton, Davis-Kean, & Huston 2009; Marjanovič-Umek, Fekonja, Kranjc, & Bajc, 2008; Marjanovič-Umek, Bozin, Cermak, Stiglic, Bajc, & Fekonja-Peklaj, 2016).

Gender has been also shown to be an influential factor in early expressive language development. Research has established that, compared to boys, girls tend to have a progressively more rapid vocabulary growth (Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991; Bauer, Goldfield & Reznick, 2002; Bornstein, Hahn & Haynes; 2004; Hadley, Rispoli, Fitzgerald, & Bahnsen, 2011), and a larger vocabulary size (Eriksson, Marschik, Tulviste, Almgren, Pérez Pereira, Wehberg, Marjanovič-Umek, Gayraud, Kovacevic, & Gallego, 2012; Marjanovič-Umek et al. 2008; Marjanovič-Umek, Fekonja-Peklaj, & Podlesek, 2012). Contrary to these findings, Marjanovič-Umek et al. (2016) did not find significant differences between boys' and girls' vocabulary size at different ages, but they reported differences between the two genders in terms of the type of vocabulary (i.e., masculine-type words vs. feminine-type words). In addition, they reported that although toddlers' gender and parental education did not have a significant effect on toddlers' vocabulary size at different ages, toddlers' gender had a significant effect on the shape of the vocabulary growth curve, with the average curve being slightly more close to linear for girls than boys.

Speech and language characteristics of children with repaired cleft palate (CP) have been the focus of substantial research as children with CP are born with palatal cleft, which may prevent normal tongue-palate contact to make prelinguistic vocalizations. After palatal surgery (which typically occurs by 12 months of age), adequate velopharyngeal (VP) function is not surgically restored in up to 30% of children (Inman, Thomas, Hodgkinson, & Reid, 2005; Webb, Watts, Read-Ward, Hodgkins, & Markus, 2001). The VP mechanism plays an important role in early speech development by assigning appropriate resonance feature to speech sounds and setting up the aerodynamic condition for the production of high pressure sounds (i.e., stops, fricatives, and affricates). Using nasal ram pressure (NRP) technique, Eshghi, Vallino, Baylis, Preisser, & Zajac (2017) reported that while TD children exhibited consistent VP closure at 12 months of age, some children (33% of participants) with CP achieved consistent VP closure approximately 3 to 4 months following palate repair around 14 months of age. Delayed achievement of consistent VP closure in children with CP may negatively impact early development of speech sounds. After palatal surgery, complications such as collapsed maxilla, postsurgical scarred palate, and in some cases oronasal fistulae may restrict tongue maneuverability and normal tongue-palate contact.

In addition, children with CP are usually prone to degrees of conductive hearing loss. Occurrence of otitis media (OM) in babies with cleft palate is common due to malformation of tensor veli palatini muscle which is responsible for opening and closing of the eustachian tube. Conductive hearing loss distorts the auditory signal that children with CP may use for acoustic-articulatory adjustments. Studies have shown a relationship between OM and delayed phonological and expressive language skills in children without cleft (Donahue, 1993; Luloff, Menyuk, & Teele, 1993; Petinou, Richard, Maria, & Judith, 1999; Rvachew et al., 1999). Jones,

Chapman, and Hardin-Jones (2003) also reported that children with CP who had a higher number of reported episodes of OM and failed tympanometry at the pre- or postsurgery sessions showed less progress in size of consonant inventory after palatal repair. All these physiological factors put a child with CP at risk for developing poor expressive language skills.

Differences in prespeech babbling between children with CP and TD children have been observed as early as 6 months of age (Scherer, Williams, & Proctor- Williams, 2008). Numerous studies have documented delayed onset of babbling in children with CP (Chapman, Hardin-Jones, Schulte, & Halter, 2001), less frequent (Scherer et al., 2008), and less complex prespeech vocalizations (Scherer et al., 2008, Scherer, Boyce, & Martin, 2013; Park, & Ha, 2016), and restricted consonant inventory (Chapman, Hardin-Jones, & Halter, 2003; Park, & Ha, 2016). The composition of babbling produced by children with CP consists of fewer total consonants (Chapman et al., 2001; Lohmander, Lillvik, & Friede, 2004; Lohmander, Olsson, & Flynn, 2011), fewer multisyllabic productions (Chapman, 1991), and more vowel-only syllables than consonant–vowel productions (Scherer, Williams, Henley, Lambert, Lassiter, & Osborne, 2000). In addition, the transition from the prelinguistic stage to linguistic level takes longer for children with CP. In a study conducted by Scherer et al. (2013), all 15 children with CP were still in the prelinguistic level at 17-19 months of age and half of them remained in the prelinguistic level at 23-25 months of age. In addition, Hardin-Jones and Chapman (2014) reported that while children with CP showed similar expressive vocabulary skills to that of TD children at 13 months of age, they showed significantly reduced size of their lexicons at 21 and 27 months of age.

Early expressive vocabulary skills in children with CP has been characterized as smaller in size (Eshghi, Dorry, Vivaldi, Crais, Vallino, Baylis, Preisser, & Zajac, 2017; Estrem & Broen, 1989; Park & Ha, 2016; Willadsen, 2013) and delayed (Chapman et al., 2003; Scherer &

D'Antonio, 1995; Scherer et al., 2008). In a longitudinal study conducted by Broen, Devers, Doyle, Prouty, and Moller (1998), toddlers with CP exhibited a slower rate of vocabulary acquisition as they were behind their age matched peers without CP for approximately 3 months. Because of the documented strong correlation between early phonological development and later vocabulary skills (Ferguson & Farwell, 1975; Stoel- Gammon, 1989; Storkel, 2001; Storkel & Morrisette, 2002; Vihman, 1992), delayed onset of first words, and poor expressive vocabulary skills in children with CP have been largely attributed to restrictions in size and diversity of consonants (especially stop consonants), at earlier stages of language acquisition (Scherer & D'Antonio, 1995; Chapman et al., 2003; Jones et al., 2003, Broen et al. 1998; Jocelyn et al., 1996; Scherer, 1999). In support of this speculation, several studies reported that children with CP may have tacit knowledge of their phonology as they "select" or "avoid" words based on the level of difficulty. Children with CP have been observed to produce significantly more words beginning with sonorants (i.e., nasals, liquids, glides) and fewer words beginning with obstruents (i.e., stops and fricatives) in their spontaneous speech samples (e.g., Hardin-Jones & Chapman, 2014; Willadsen, 2013; Park & Ha, 2016). Of particular interest, Willadsen (2013) noted that as it has been described for English-speaking toddlers with and without cleft palate, Danish toddlers with CP displayed marked lexical selectivity at 18 months by using words with initial sounds with high distribution at 11 months of age. The term lexical selection was first used by Ferguson & Farwell, (1975) who observed that TD children choose words that are consistent with their developing phonological system and avoid words with characteristics that are outside their phonological system. This pattern was further observed by Leonard, Schwartz, Morris and Chapman (1981), Schwartz and Leonard (1982), Vihman (1981), and Stoel-Gammon and Cooper (1984).

One source of complexity in the study of expressive language skills in children with CP, however, pertains to the multiplicity of factors that can influence the trajectories of language growth in general and expressive vocabulary in particular. For example, Scherer et al. (2000) provided evidence for the effect of cleft type on the development of the expressive language skills, as they observed that children with isolated CP performed poorer than the group with cleft lip and palate (CLP) on measures of expressive language and vocabulary.

The purpose of the present study was to further investigate the development of expressive vocabulary in children with repaired CP, children with OM, and TD children at 18 and 24 months of age. In addition, the effect of variables such as hearing level (at 12 months of age), tympanogram status (at 18 months of age), size of consonant inventory (at 18 months of age), MEL, and gender on the vocabulary growth from 18 to 24 months of age was examined. The following research questions were asked: (1) What is the developmental course of expressive vocabulary in young children with CP compared to children with OM and TD children at 18 and 24 months of age? (2) To what extent do variables such as, hearing level, tympanogram status, size of consonant inventory, MEL, and gender influence the vocabulary growth from 18 to 24 months of age? In a secondary data analysis, I was further interested in comparing the vocabulary growth of subgroups of children with CP based on the cleft type and VP status in reference to the performance of children with OM and TD children. I hypothesized that: a) children with CP would be behind the OM and TD groups with regard to the vocabulary growth, and children with OM would fall in between; b) factors such as hearing status, size of consonant inventory, MEL, and gender may be predictors for the hypothesized differences among the three groups. Further, cleft type and VP status may be important factors in the development of expressive vocabulary skills.

This study has both theoretical and clinical significance. Findings of this study will provide additional information about the pattern of vocabulary growth in children with CP while their VP function is objectively assessed through the nasal ram pressure (NRP) monitoring. This is promising as literature on the development of expressive vocabulary skills in children with CP lacks a solid understanding of the effect of VP status on the observed differences. In all studies conducted so far, assumptions about the VP function were based on articulatory or perceptual evidence only. In addition, in this study, the effects of hearing status on the development of expressive vocabulary were isolated by incorporating children with a history of OM. This methodological design has not been implemented in previous studies. In addition, this study can further support the clinical application of the CDI assessment tool to identify the subgroup of children with CP who need early speech and language interventions. Given that impaired expressive language has been shown to negatively impact higher level language and literacy attainment in later childhood (Felsenfeld, Broen, & McGue, 1994; Lewis, Hansen, Stein, Shriberg, Iyengar, & Taylor, 2006; Scarborough, 1990; Sices, Taylor, Freebairn, Hansen, & Lewis, 2007), early assessment of expressive language with subsequent management could prevent persistent language delay and later literacy underachievement.

Methods

Participants

A total of 94 children participated in this study: 40 children with repaired CP (19 males, 21 females), 29 children with OM (20 males, 9 females), and 25 TD children (13 males, 12 females). These children were a subset of participants recruited for an ongoing multi-site longitudinal study who had expressive vocabulary data at 18 and 24 months of age at the time of this study.

Information about birth and family history, demographics, medical history, surgical history as well as cleft classification were obtained from the primary care giver of the child at the screening visit when the child was initially enrolled in the study. Cleft type and date of palate surgery were verified from medical records. Of 40 children with repaired CP, 37 children were non-Hispanic/Latino and 3 children were Hispanic/Latino. In addition, 31 children with CP were Caucasian, 2 were African-American, and 7 belonged to more than one race. None of the children with CP were born prematurely (i.e., gestation less than 36 weeks) or diagnosed with any known syndromes including Pierre Robin syndrome. Of the 40 children with repaired CP, 15 had cleft of the lip and palate (CLP) (13 male, 2 female) and 25 had cleft of the hard and/or soft palate only (CPO) (6 male, 19 female). All children with CP had undergone a single surgery to repair the palate by at least 11 months of age (mean = 10.43 months, SD= 1.39). Oral examination was performed at both 18 and 24 months to rule out the presence of oronasal fistulae. All children in the CP group underwent myringotomy with insertion of pressure-equalization (PE) tubes at the time of their palate surgery.

All children in the OM group had experienced multiple episodes of otitis media with effusion during their first year of life and also underwent myringotomy with insertion of PE tubes prior to the enrollment in the project (12 months of age). None of these children had any type of clefts. Twenty-eight children with OM were non-Hispanic/Latino and only one child in this group was Hispanic/Latino. In addition, 27 children with OM were Caucasian, one was African-American, and one belonged to more than one race.

Finally, none of the children in the TD group had any type of cleft nor PE tubes. All TD children showed normal language development at 12 months of age determined by the Communication and Symbolic Behavior Scales Developmental Profile (CSBS DP; Wetherby &

Prizant, 2002) assessment tool. In addition, none received any early speech/language or developmental intervention services. Twenty-three TD children were non-Hispanic/Latino and 2 TD children were Hispanic/Latino. In addition, 20 TD children were Caucasian, 2 were African-American, and 3 belonged to more than one race.

All participants (CP, OM, and TD) were from monolingual American English–speaking families and they showed normal development of social and symbolic skills of language as determined by the CSBS DP. Further, all children who participated in the study were in good general health and had no documented sensorineural haring loss or global developmental delays. As described below, all participants underwent tympanometry at 18 and 24 months of age to evaluate middle-ear function and/or confirm the presence of PE tubes (for the CP and OM groups). In addition, audiometric assessments were performed at 12 and 24 months of age as described below. This study was approved by the intuitional review board (IRB) of the University of North Carolina at Chapel Hill.

As described below, expressive vocabulary skills of each child were measured at two time points: 18 and 24 months of age. Children with CP ranged in age from 17 to 19 months (mean= 17.82 months, SD = 0.55) at the first time point and ranged in age from 23 to 26 months (mean= 23.80 months, SD = 0.65) at the second time point. Children with OM ranged in age from 17 to 19 months (mean= 17.79 months, SD = 0.45) at the first time point and ranged in age from 23 to 24 months (mean= 23.55 months, SD = 0.51) at the second time point. Finally, TD children ranged in age from 17 to 19 months (mean= 17.72 months, SD = 0.54) at the first time point and ranged in age from 23 to 25 months (mean= 23.68 months, SD = 0.56) at the second time point. Twenty seven of the children (12 CP, 6 OM, and 9 TD) were examined at the Craniofacial Center, University of North Carolina at Chapel Hill; 36 children (11 CP, 15 OM,

and 10 TD) were examined at A. I. duPont Hospital for Children, Wilmington, DE; and 31

children (17 CP, 8 OM, and 6 TD) were examined at Nationwide Children's Hospital, Columbus,

OH.

Assessment of Expressive Vocabulary

The MacArthur-Bates Communicative Development Inventories: Words and Sentences

(CDI WS; Fenson et al., 2007) was used to measure the expressive vocabulary skills of children

in the three groups. The fidelity of the CDI-WS form has been verified by various studies (e.g.,

Dale, Bates, Reznick & Morisset, 1989; Fenson, et al., 1994; Heilmann, Weismer, Evans, &

Hollar, 2005) and it also has been shown to be a valid assessment tool to measure expressive

language development in children with CP when compared to comprehensive speech and

language evaluations (Scherer and D'Antonio, 1995). The CDI WS questionnaire was either

mailed or handed to the primary caregiver at the end of the child's previous study visit and the

primary caregiver was asked to complete the checklist at home. Parents completed the CDI-WS

checklist at home around the time when their child was 18 months of age (mean= 17.79 months,

ranged from 17 to 19 months, SD = 0.53) and 24 months of age (mean= 23.69 months, ranged

from 23 to 26 months, SD = 0.59). Parents were given instructions to complete the CDI-WS and

they were asked to mark words only if they had heard the child produce them spontaneously and

not as a result of prompting the child to say a word. The primary caregivers who completed the

CDI-WS checklist were primarily mothers (i.e., 97% for 18 months and 94% for 24 months).

Parents returned the completed CDI-WS checklists when they were scheduled for the 18- and 24-

month study visits as part of the larger study. Parents were provided a monetary compensation

for the time they spent completing the form after the CDI was returned to the study personnel.

The CDI WS consists of two parts. The first part is a vocabulary checklist of 680 words and the second part samples sentences and grammar. For the present study, the first part of the CDI-WS inventory was used to measure the lexical (i.e., expressive vocabulary) development of the participants. The number of words was derived from a checklist of 680 commonly used vocabulary items in 22 categories: 12 words for onomatopoeic words (i.e., sound effects and animal sounds), 43 words for animals, 14 words for vehicles, 18 words for toys, 68 words for food and drink, 28 words for clothing, 27 words for body parts, 50 words for small household items, 33 words for furniture and rooms, 31 words for outside things, 22 words for places, 29 words for people, 25 words for games and routines, 103 action words, 63 descriptive words, 12 time expressions, 25 pronouns, 7 question words, 26 prepositions and locations, 17 quantifiers and articles, 21 helping verbs, and 6 conjunctions.

Estimation of the Size of Consonant Inventory

The size of consonant inventories of the children was estimated by direct observation through the administration of the Communication and Symbolic Behavior Scales Developmental Profile (CSBS DP; Wetherby & Prizant, 2002) at 18 months of age. The CSBS DP consists of six semi-structured communication and play opportunities to sample various speech and language skills. All personnel (speech-language pathologists, SLPs, at UNC-CH and NWC, and a social worker at AID) were trained in administration of the CSBS DP and met interrater agreement at the 85% level or higher with the trainer. The participant, caregiver, and tester were video-recorded during the administration of the CSBS DP using a camera (SONY, HDR CX380) with 8.9 megapixels resolution and a built-in zoom microphone. The camera was mounted on a tripod and positioned in front of the participant. The CSBS DP videos were watched and spontaneous speech sounds including stops (/p, b/, /t, d/, /k, g/), fricatives (/s/, /sh/), nasals (/m/,

/n/), glides (/w/, /y/), and the liquid sound /l/ were identified per instructions in the CSBS DP scoring manual by well-trained SLPs with known reliability at UNC-CH. It should be noted that the CSBS DP does not distinguish between voiced/voiceless stop cognates. This may be due to the fact that the voice onset time (VOT) dichotomy of short timing lag for voiced stops and long timing lag for voiceless stops develops between two-years of age and adulthood (Zlatin & Koenigsknecht, 1976). The sound weighted raw score was calculated and used as an estimation of the size of consonant inventory.

Evaluation of Middle Ear Function

Bilateral tympanogram data at 18 months of age was used to assess the status of the middle ear and to check the functionality of the myringotomy tubes. Tympanograms were obtained by either SLPs and/or certified audiologists at each of the sites. Tympanogram status for each ear was defined by two levels of normal (type A and type B as an indication of large volume in the presence of tube) and three levels of abnormal (type A_s, type B as an indication of small volume, and type C for compliance with pressure less than -250 daPa). Finally, normal tympanogram status was defined as normal tympanogram readings of both ears and abnormal tympanogram status was defined as an abnormal reading for at least one ear.

Evaluation of Hearing

Because this study was part of a larger longitudinal study, audiometry tests were obtained annually when the child was 12 and 24 months of age. However, air-conduction hearing levels at 12 months of age for frequencies of 500, 1000, 2000, and 4000 Hz were used in this study. Sound field audiometry assessments were obtained in sound-attenuated booths by licensed audiologists according to pediatric assessment protocols. Hearing levels at four frequencies were

averaged and three categories of hearing were defined: 1) normal hearing (between 15 to 20 dB), 2) slight hearing loss (between 20 to 25 dB), and 3) at least mild hearing loss (greater than 25 dB).

Evaluation of VP Status

The status of VP closure in children with CP was objectively determined through nasal ram pressure (NRP) monitoring at 18 months of age. This aerodynamic technique detects localized nasal air velocity sensed at the anterior nares during speech production (Bunton & Hoit, 2018; Thom, Hoit, Hixon, and Smith, 2006; Eshghi et al., 2017). During NRP monitoring, a two-pronged, nasal cannula (AirLife, infant or pediatric size) was inserted into the nares and looped around the ears of the child. The end of the cannula was connected to a bidirectional, differential pressure transducer (Setra, model 239, range ± 1 inch WC) referenced to atmosphere. This transducer was part of the PERCI-SARS system (Version 3.2, Microtronics, Inc., Chapel Hill, NC) and provides both filtered (80 Hz low pass) and unfiltered outputs. Audio signals were obtained using an omnidirectional condenser microphone (Shure, model MX150) attached to the clothing of the infant under the chin. The low-pass filtered NRP signal, the unfiltered NRP signal, and the audio signal were digitized by an A/D converter (Data Translation, model 9804) to a computer. The NRP and audio signals were digitized at 2 kHz and 20 kHz, respectively, using TF32 Lab Automation software (Milenkovic, 2001). During the 15-minute NRP monitoring, a standardized set of toys/pictures was used to elicit spontaneous production of oral stop consonants /p b t d k g/ in the initial and final word positions while the participant was video recorded for the entire session. All targeted words are listed in Appendix A. Only stop consonants in prevocalic positions were analyzed to avoid any misinterpretation of the VP status due to the offset effect of the NRP signal at the end of the breath group. NRP technique provides

a binary determination of the status of the VP port as being either open or closed (Thom et al., 2006). See Eshghi et al. (2017) for details regarding the NRP analysis procedures. Of 40 children with CP, 16 children exhibited consistent VP closure at 18 months of age as defined as closure during production of at least 85% of stop consonants (Eshghi et al., 2017). Eight children with CP, however, did not achieve consistent VP closure on stop consonants by 18 months of age. Six children with CP did not produce any stops during the NRP monitoring and the NRP recording of one child was not scored because he produced stops in postvocalic rather than prevocalic positions. NRP data were not obtained for 9 children due to the child's unwillingness to cooperate for the procedure.

Reliability of the Measurements

Inter- and intra-rater reliabilities were assessed by randomly selecting 20% of participants and repeating the scoring for the CSBS DP assessment tool and NRP recordings. Reliability for the NRP data was assessed by calculating exact agreements between raters. Inter- and intra-rater reliability was greater than 85% for both CSBS DP and NRP scorings.

Statistical Analysis

Descriptive analyses were performed on each variable to obtain mean estimates and their corresponding standard deviations for the number of words across the three groups. The absolute change in the number of words produced by children from 18 to 24 months of age was calculated to answer the research questions. One child with CP was observed to produce fewer words at 24 months than 18 months of age. In this case, the negative change in the number of words within the six-month period was set to zero. Multiple linear regression analysis was used to model the change in the number of words produced by children from 18 to 24 months of age within and across the groups. The predicted trajectory of vocabulary development from 18 to 24 months of

age was graphed for visual representation of group performance over the six-month period. Next, covariates of hearing levels (15 to 20 dB, 20 to 25 dB, and greater than 25 dB), tympanogram status (normal and abnormal), sound weighted raw score, MEL (holding education below Bachelor's degree vs. Bachelor's degree and above), and gender (male vs. female) were added to the statistical model. All statistical analyses were run in SAS version 9.4 (TS1M1, SAS institute, Cary, NC) and p-values were compared against the 0.05 significance level a priori.

Results

Descriptive statistics including mean estimates for the number of words at 18 and 24 months of age, mean estimates of vocabulary growth from 18 to 24 months of age, and their corresponding standard deviations are presented in Table 2.1. On average, children with CP produced 22 words less than TD children at 18 months of age. However, they lagged behind TD children by about 133 words at 24 months of age. Examination of the data revealed that all children with CP produced less than 425 words at 24 months of age except for one child who was reported to produce 653 words at that age. The mean absolute changes from 18 to 24 months of age was 158 and 267 words in children with CP and TD children, respectively. Compared to TD children, children with OM were observed to produce a similar number of words at 18 months of age, but, on average, 63 fewer words at 24 months of age.

Table 2.1: Mean and standard deviation for the number of words produced by each group at 18 and 24 months of age as well as the six-month's vocabulary growth from 18 to 24 months of age

Group	N	18 months	24 months	Vocabulary growth from 18 to 24 months of age
		Mean (Std)	*Mean (Std)*	*Mean (Std)*
CP	40	38.40 (35.22)	195.05 (145.49)	157.45 (129.10)
OM	29	57.41 (42.30)	261.59 (149.26)	204.17 (116.54)
TD	25	60.80 (48.73)	327.60 (165.86)	266.80 (145.14)

The model-predicted trajectory of vocabulary growth in each group over the six months' period is shown in Figure 2.1. As suggested by the model, children with CP were behind children with OM and TD children over the course of the development and continued to diverge as they got closer to 24 months of age. Although children with OM and TD children clustered at the starting point, they diverged at later months.

Figure 2.1: The trajectory model of vocabulary growth in CP, OM, and TD groups from 18 to 24 months of age

Table 2.2 presents descriptive statistics for the number of words produced by children in CP, OM, and TD groups at 18 and 24 months of age as well as the change in the number of words from 18 to 24 months of age while taking the covariates of hearing level, tympanogram status, MEL, and gender into account.

Table 2.2: Descriptive statistics for number of words produced by children in CP, OM, and TD groups categorizing children based on hearing level, tympanogram status, MEL, and gender.

Variable	Group	Categories	N	Number of words at 18 months		Number of words at 24 months		Change in the number of words	
				Mean	Std	Mean	Std	Mean	Std
Hearing Level	CP	(15-20]dB	27	39.33	34.11	187.33	126.03	149.19	109.97
		(20-25]dB	11	40.91	40.64	240.18	185.25	199.27	168.46
		>25dB	2	12.00	11.31	51.00	62.23	39.00	50.91
	OM	(15-20]dB	21	57.76	46.09	272.90	164.71	215.14	126.01
		(20-25]dB	5	56.20	21.12	246.60	81.82	190.40	88.86
		>25dB	3	57.00	53.93	207.33	144.55	150.33	97.33
	TD	(15-20]dB	20	58.50	49.73	331.95	162.95	273.45	139.75
		(20-25]dB	2	78.50	48.79	475.00	164.05	396.50	115.26
		>25dB	3	64.33	58.52	200.33	134.84	136.00	132.89
Tymp	CP	Missing	1	39.00	.	359.00	.	320.00	.
		Normal	28	37.07	34.77	195.21	151.69	159.29	138.73
		Abnormal	11	41.73	39.45	179.73	132.22	138.00	99.84
	OM	Missing	3	51.33	58.71	163.00	165.43	111.67	106.98
		Normal	22	62.32	43.39	286.95	146.23	224.64	112.10
		Abnormal	4	35.00	18.49	196.00	140.78	161.00	130.59
	TD	Missing	5	40.80	23.21	368.40	201.79	327.60	195.40
		Normal	13	53.85	35.47	346.77	131.44	292.92	107.38
		Abnormal	7	88.00	72.95	262.86	203.13	174.86	146.02
Gender	CP	Male	19	32.11	31.63	174.37	162.70	142.26	149.29
		Female	21	44.10	38.03	213.76	129.15	171.19	109.65
	OM	Male	20	55.05	45.27	260.45	160.61	205.40	123.88
		Female	9	62.67	36.75	264.11	129.21	201.44	105.25
	TD	Male	13	67.15	57.97	343.46	180.31	276.31	154.88
		Female	12	53.92	37.63	310.42	154.70	256.50	139.89
MEL	CP	Low	21	32.29	34.63	174.67	164.07	143.90	149.87
		High	19	45.16	35.54	217.58	122.20	172.42	103.46
	OM	Low	6	76.33	58.15	278.33	221.52	202.00	169.84
		High	23	52.48	37.23	257.22	130.78	204.74	103.58
	TD	Low	2	77.00	63.64	390.00	332.34	313.00	395.98
		High	23	59.39	48.79	322.17	156.86	262.78	125.06

Mean values for sound weighted raw score at 18 months of age were 11.77 (std= 6.01),

14.41 (std= 6.19), and 15.64 (std= 5.99) in CP, OM, and TD groups, respectively. The mean

sound weighted raw score in children with CP was significantly lower than children with typical

development (p< 0.05).

Unadjusted and adjusted model estimates for the absolute change in the number of words

observed from 18 months of age to 24 months of age are presented in Table 2.3. The intercept

estimates the change in the mean number of words observed in a female TD child with a normal

hearing level (between 15 to 20 dB) and normal tympanogram results whose mother had at least

a bachelors' degree. Negative estimates indicate a decrease in the effect.

Table 2.3: Unadjusted and adjusted model estimates for change in the mean number of words across the three groups.

	Parameter	Estimate	P-value	95% CI
Unadjusted Model	*Intercept (TD is the reference)*	266.80	-	(215.20, 318.41)
	CP	-109.35	0.001	(-175.14, -43.56)
	OM	-62.63	0.081	(-133.05, 7.80)
Adjusted Model	*Intercept (TD is the reference)*	269.68	-	(175.63, 363.74)
	CP	-101.88	0.009	(-177.40, -26.36)
	OM	-57.12	0.140	(-133.32, 19.08)
	Audiogram threshold (20-25)dB	51.05	0.130	(-15.37, 117.47)
	Audiogram threshold (>25dB)	-102.76	0.063	(-211.13, 5.60)
	Abnormal tympanogram	-72.78	0.023	(-135.08, -10.47)
	Sound Weighted Raw Score	1.61	0.474	(-2.84, 6.06)
	Lower maternal education	-30.87	0.326	(-93.01, 31.27)
	Male	-12.06	0.669	(-67.94, 43.83)

In table 2.3 the adjusted intercept represents the model estimated increase in the number of words from 18 to 24 months for a typically developing female child with a hearing level between (15-20) dB, normal tympanogram whose mother hold at least a bachelor's degree.

The unadjusted multiple linear regression analysis suggested that children with CP showed significantly slower rate of vocabulary growth from 18 to 24 months of age in comparison with children in the TD group ($p= 0.001$). The observed difference between children with CP and TD children remained significant when the model was adjusted for the effect of covariates (i.e., hearing levels, tympanogram status, sound weighted raw score, MEL, and gender) on vocabulary growth ($p= 0.009$). No significant difference was observed between the OM and TD groups in both unadjusted and adjusted models ($p>0.05$). Although all variables of interest affected the vocabulary growth to different extents, only hearing level and tympanogram status were observed to significantly predict the vocabulary growth from 18 to 24 months of age ($p<0.05$).

Secondary Data Analysis

In separate statistical analyses, the vocabulary growth of children was further compared based on the cleft type and VP status. Mean number of words (standard deviations in parentheses) produced by children with CP categorized based on the cleft type and the status of VP closure at 18 and 24 months of age as well the vocabulary growth from 18 to 24 months of age are shown in Table 2.4. The corresponding values for children with OM and TD children are presented in Table 1 and hence are not displayed in Table 2.4 to avoid redundancy. One-way analysis of variance (ANOVA) revealed no significant differences among children with cleft lip and palate (CLP), cleft palate only (CPO), OM children, and TD children with regard to the number of words produced at 18 months ($p>0.05$). However, significant group differences were

observed among groups for the number of words produced at 24 months of age (p= 0.002), as well as the vocabulary growth from 18 to 24 months of age (p= 0.002). Post hoc Tukey tests revealed significant group differences between CLP and TD groups only with regard to the number of words produced at 24 months age (p= 0.001) and the vocabulary growth from 18 to 24 months of age (p= 0.001). The difference between children with CLP and OM groups approached but did not quite reach the statistical level of significance for the number of words produced at 24 months of age (p= 0.058) and the vocabulary growth from 18 to 24 months of age (p= 0.069).

In addition, ANOVA test and post hoc pairwise comparisons did not show any difference among groups for the effect of the VP status on the number of words produced at 18 and 24 months of age, nor for vocabulary growth from 18 to 24 months (p>0.05).

Table 2.4: Mean (standard deviations in parentheses) for the number of words produced at 18 and 24 months of age as well the vocabulary growth from 18 to 24 months after splitting the CP group based on the type of the cleft and VP status.

	Group	N	18 months Mean (Std)	24 months Mean (Std)	Vocabulary growth from 18 to 24 months of age Mean (Std)
Cleft Type	*CLP*	15	36 (42.06)	139.4 (113.67)	103.4 (87.69)
	CPO	25	39.84 (31.27)	228.44 (154.15)	189.88 (140.27)
VP Status	*CP with consistent VP closure*	16	37.87 (32.28)	199.75 (167.9)	161.87 (155.18)
	CP with inconsistent VP closure	8	61.50 (43.15)	252.62 (110.84)	195.12 (86.61)

Discussion

The first aim of this study was to investigate expressive vocabulary skills of children with CP, children with OM, and TD children at 18 and 24 months of age and to compare the vocabulary growth from 18 to 24 months of age across the three groups. Looking at the size of vocabulary from a developmental perspective, TD children were observed to produce on average about 61 and 328 words at 18 and 24 months of age, respectively. These numbers are similar to what has been suggested before by various studies. For example, Bates et al. (1988), Rescorla (1980), and Anglin (1989) reported a productive vocabulary of approximately 50 words by 18 months and 300 words by 24 months for children with typical development. In the current study, children with OM were observed to be in close proximity to TD children in terms of the number of words produced at 18 months, but they diverged from the TD children at 24 months of age although the difference was not statistically significant.

Although children with CP displayed a slightly smaller number of words at 18 months of age compared to TD children, differences between the two groups emerged afterwards so that the difference between the two groups became statistically significant at 24 months of age. These findings are similar to those of others that reported delayed onset of first words and poor expressive vocabulary development in children with CP compared to their age matched peers without CP (Broen et al., 1998; Chapman et al., 2003; Eshghi et al., 2017; Jocelyn et al., 1996; Jones et al., 2003; Scherer, 1999; Scherer & D'Antonio, 1995). In addition, findings of this study characterized the vocabulary growth of children with CP as occurring at a slower rate (smaller slope) compared to TD children. Results of this study are in agreement with a study conducted by Scherer et al. (2013). Those investigators reported that half of their participants with CP were still in the prelinguistic level at 23-25 months of age rather than producing single words or two-

word combinations. In this study, the mean percent change values for the increase in the number of words from 18 to 24 months of age were 529%, 440%, and 717% in CP, OM, and TD groups, respectively. Therefore, on average, while TD children showed about a sevenfold increase in productive vocabulary over the six-month period (i.e., from 18-24 months), this growth rate dropped to 5 and 4 times in children with CP and children with OM, respectively.

Numerous explanations have been proposed as to why expressive language development appears to be particularly susceptible to disturbance among children with CP. The widely accepted inference is that delayed or deficient sound development in children with CP is the main etiology for poor vocabulary skills in children with CP. It has been well documented in the literature that children with CP lagged behind their age matched normal peers in the onset of babbling (Chapman et al., 2001), the frequency of babbling (Scherer et al., 2008), and the composition of babbling (Lohmander et al., 2004). In addition, Eshghi et al. (2017) reported that children with CP with adequate VP function exhibited a significantly reduced composite speech standard score (rate of sounds and word acquisition) on the CSBS DP assessment tool compared to TD children at both 18 and 24 months of age, although scores fell within normal limits. In this study, children with CP exhibited significantly lower sound weighted raw scores compared to TD children at 18 months of age. However, findings of this study revealed that among all variables, only tympanogram status (middle ear function) at 18 months of age significantly predicts the vocabulary growth from 18 to 24 months of age.

Children with CP may have different auditory experiences due to concurrent episodes of OM, especially during the first year of life, which may put them at risk of speech and language difficulties. Although some studies have yielded null findings about the pathologic sequelae of early conductive hearing loss on expressive language development (e.g., Black, Gerson,

Freeland, Nair, Rubin, & Hutcheson, 1988; Silva, Kirkland, Simpson, Stewart, & Williams, 1982; Pearce, Saunders, Creighton, & Sauve, 1988; Brookhouser & Goldgar, 1987; Fischler, Todd, & Feldman, 1985; Friel-Patti & Finitzo, 1990; Lous, Fiellau-Nikolajsen, & Jeppesen, 1988; Wright, Sell, McConnell, Sitton, Thompson, Vaughn, & Bess, 1988), numerous studies have documented a relationship between OM and delayed phonological and expressive language skills in populations without cleft (Donahue, 1993; Luloff et al., 1993; Petinou et al., 1999; Rvachew et al., 1999). Children with an early history of OM have been observed to have lower expressive language scores (Friel-Patti, Finitzo-Hieber, Conti, & Brown, 1982; Wallace, Gravel, McCarton, & Ruben, 1988) and a smaller size of vocabulary (e.g., Holm & Kunze, 1969; Teele, Klein, & Rosner, 1984) compared to those without a history of OM. In this study, although children with OM tended to show a smaller size of vocabulary compared to TD children at 24 months of age, the difference between the two groups was not statistically significant. However, tympanogram status was found to play an important role in the development of vocabulary skills as the general trend observed in this study suggested that children with normal tympanograms produced a greater number of words and showed better vocabulary growth from 18 to 24 months of age. Consistent with these studies, Jones et al (2003) reported that children with CP who exhibited a higher number of episodes of OM and failed tympanometry at the pre- or post-surgery sessions showed less progress in size of consonant inventory after palatal repair.

One possible explanation for the negative effect of conductive hearing loss on early speech and vocabulary development is that the auditory distortion associated with fluctuating conductive hearing loss prevents the child from making a link between acoustic-perceptual characteristics of sounds and the corresponding kinesthetic/proprioceptive feedback during speech production. Therefore, inconsistent auditory input may negatively affect

the child's ability to capture small acoustic differences of speech sounds. On that note, children with otitis media with effusion (OME) perform poorly on auditory processing tasks such as identification tasks (Sandeep & Jayaram, 2008) as well as discrimination tasks (Welsh, Welsh, & Healy, 1983; Clarkson, Eimas, & Marean, 1989; Gravel & Wallace, 1992; Haapala, Niemitalo-Haapola, Raappana, Kujala, Suominen, Kujala, & Jansson-Verkasalo, 2014). To give a more specific example, children with OME have shown difficulty with the discrimination of fricatives (Petinou, Schwartz, Gravel, & Raphael, 2001) and subsequently were observed to produce restricted number of fricatives in their consonant repertoire (Haapala, Niemitalo-Haapola, Raappana, Kujala, Kujala, & Jansson-Verkasalo, 2015).

Although only tympanogram status was found to significantly contribute to the vocabulary growth, findings of this study suggest that two sociodemographic factors (i.e., gender and MEL) may influence development of expressive vocabulary skills, as girls who had mothers with higher education level (i.e., Bachelor's degree and above) tended to have stronger expressive vocabulary skills compared to boys whose mothers had lower education level (i.e., below Bachelor's degree). These findings are similar to previous studies in which girls were reported to outperform boys by producing a larger size of vocabulary (e.g., Eriksson et al., 2012; Marjanovič-Umek et al., 2008; Marjanovič-Umek et al., 2012) and showing more rapid vocabulary growth (Bauer, Goldfield & Reznick, 2002; Bornstein, Hahn & Haynes; 2004; Hadley et al., 2011; Huttenlocher et al., 1991). Findings also support the positive association reported in the literature between maternal educational levels (MEL) and early expressive vocabulary and language skills (e.g., Dollaghan et al., 1999; Magnuson, et al. 2009; Marjanovič-Umek et al., 2008; Marjanovič-Umek et al., 2016).

In our secondary data analysis, children with CLP were observed to have significantly slower vocabulary growth compared to TD children. The observed trend is consistent with Collett, Leroux, and Speltz (2010) who reported slightly poorer performance of older children with CLP on language and reading scales compared to children with CPO. These findings are in contrary to the broadly accepted argument that children with CPO are more vulnerable to develop poorer language and cognitive skills than children with CLP (Richman, 1980; Eliason & Richman, 1990; Scherer & D'Antonio, 1997) due to underlying brain structure differences formed during embryonic development (Nopoulos, Berg, Canady, Richman, Van Demark, & Andreasen, 2002). For example, Scherer et al. (2000) reported poorer expressive language and vocabulary skills in children with isolated CP compared to the CLP group. The observed discrepancies may be related to differences in the severity of the cleft and/or other physiological/environmental factors. For example, while about 87% of children with CLP were boys, children with CPO were predominantly girls and only 24% of them were boys. Therefore, it seems plausible to say that the expected unbalanced gender distribution between the CLP and CPO groups might have partially caused the observed differences between the two groups in terms of the vocabulary skills.

In addition, although we initially hypothesized that delayed onset of achieving consistent VP closure in children with CP may be a contributing factor to the poor development of expressive language skills, results of this study revealed no significant difference between the vocabulary growth of children with CP without consistent VP closure compared to children with CP with consistent VP closure, TD children, and children with OM. Surprisingly, children with inconsistent VP closure showed trends to produce a greater number of words compared to children with CP who have consistent VP closure. Although it is difficult to explain this pattern,

it should be noted that the sample size for children with CP with and without consistent VP closure was too small to substantiate any statement about the effect of VP status on the development of vocabulary skills.

Finally, some other confounding factors can affect speech and expressive vocabulary skills that need to be controlled in future studies. Studies have shown that the development of expressive language skills may also be a function of other variables such as age at the time of primary palatal surgery (Chapman, Hardin-Jones, Goldstein, Halter, Havlik, & Schulte, 2008; O'Gara & Logemann, 1988), mother-child dyad (Wasserman, Allen, & Linares, 1988; Wasserman & Allen, 1985; Field & Vega-Lahr, 1984), and early speech interventions (Scherer & Brothers, 2002). In addition, presurgical procedures such as palatal obturators may facilitate the lingual-palatal contact during production of alveolar stops and subsequently enhance expressive language development. However, further empirical evidence is needed to substantiate this conceptually convincing argument as some researches have questioned whether appliance usage makes an appreciable difference in consonant development (Hardin-Jones, Chapman, Wright, Halter, Schulte, Dean, Havlik, & Goldstein, 2002; Dorf, Reisberg, & Gold, 1985; Konst, Weersinkbraks, Rietveld, & Peters, 1999). Although, these factors do not pertain to the focus of the current study, further research is warranted to examine the developmental course of speech and language in children with CP while taking the above mentioned factors into account.

Clinical Implications

Although early identification of true expressive vocabulary delay is challenging due to high variability among young children in the emergence of first words (Bates et al. 1995), findings of this study along with other studies (e.g., Bzoch & League, 1971; Capute et al., 1986; Coplan, Gleason, Ryan, Burke, & Williams, 1982; Rescorla, 1989; Resnick, Allen, & Rapin,

1984) have shown that reliable indicators of expressive language delay can be detected by 2 years of age if appropriate standardized tests are used. This research supports the applicability of the CDI-WS form as an efficient assessment tool to identify young children who are at risk of vocabulary and language impairment. Despite the fact that some children with delayed onset of expressive vocabulary have been observed to catch up at later ages, research has demonstrated that some children with delayed onset of expressive language by 24 months of age are at considerable risk for continuing language problems (e.g., Bates et al., 1995; Fernald & Marchman, 2012; Rescorla & Schwartz, 1990). Reduced size of vocabulary at 24 months of age may lead to delayed transition to two-word utterances and subsequently impact normal development of syntactic skills and higher-level linguistic abilities. Evidence for poor grammatical skills in children with CP could be found in some studies (e.g., Eshghi, Baylis, Vallino, Crais, Preisser, Vivaldi, Dorry, & Zajac, 2017; Morris, 1962). In addition, persisting speech and expressive language deficits have been reported to account for later reading and academic difficulties in children without CP (Felsenfeld, Broen, & McGue, 1994; Lewis et al., 2006; Lewis, Freebairn, & Taylor, 2000, 2002; Nathan, Stackhouse, Goulandris, & Snowling, 2004; Sices, Taylor, Freebairn, Hanson, & Lewis, 2007). Similarly, poor reading skills in children with CP were also reported by a number of other studies (Broder et al., 1998; Chapman, 2011; Richman, 1980; Richman, Eliason, & Lindgren, 1988). More specifically, lower reading scores have been documented in children with CLP who exhibited the most severe speech problems (Chapman, 2011).

Therefore, identifying subgroups of children at risk for expressive language delay and applying appropriate speech intervention are of paramount importance. To this end, different techniques such as parent-implemented interventions (Scherer, 2003; Scherer & Brothers, 2002;

Scherer & McGahey, 2004), reading-aloud to children (Duursma, Augustyn, & Zuckerman, 2008), and mother-child interactive shared reading (Westerlund & Lagerberg, 2008) have been suggested by speech-language pathologists to improve and facilitate child's expressive language abilities. The parent-implemented interventions, for example, can be used for children with CP as early as 18 months of age. In this technique, mothers are encouraged to use and reinforce words consisting of stop consonants in their communication with their child which in turn would yield the enhancement of the size of the consonant inventory and subsequently vocabulary skills (Scherer & Brothers, 2002). It should be noted, however, that the physiological and sociodemographic status of each child should be evaluated thoroughly by clinicians prior to making any diagnostic decision or initiating a language management. For example, as the literature suggests and findings of this study confirmed, the association between auditory deprivation and poorer speech and expressive language outcome has important implications for the way hearing needs of children with CP should be addressed.

Limitations of the Study

Several methodological limitations must be acknowledged. First, because data used in this study were a subset of data collected for a larger project, audiogram data at 12 months of age rather than 18 months of age were used to examine the effect of hearing level on the vocabulary growth. In addition, although the bilateral tympanometry was obtained at 18 months of age, precise information about the duration and/or magnitude of hearing deprivation as a result of fluctuating conductive hearing loss was not available. Consequently, the effect of hearing status and middle ear function on expressive vocabulary development should be interpreted with caution. Second, missing NRP data reduced the sample size when children with CP were categorized to two subgroups of children with consistent VP closure and those without consistent

VP closure at 18 months of age. Missing NRP data occurred because some children did not tolerate the cannula or they tolerated the cannula but did not produce stops. Finally, it should be noted that the MEL variable was skewed toward higher levels of education as mothers of most children participating in this study held a high education level, particularly mothers of TD children, which may have dissipated some of the differences among groups.

Conclusion

The current study suggests that children with CP have a significantly smaller number of words at 24 months of age and slower rate of vocabulary growth from 18 to 24 months of age compared to TD children. Among various physiological and sociodemographic variables, tympanogram status was found to significantly influence the development of expressive vocabulary skills. Findings of this study provide further support for the validity of the CDI-WS questionnaire as a cost effective assessment tool. Clinicians should perform early assessment of speech and vocabulary development to identify subgroups of children who are vulnerable to persistent expressive language delay. Early speech and vocabulary interventions are necessary to prevent long-term language impairments.

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**CHAPTER 3: ASSOCIATION BETWEEN LEXICAL AND GRAMMATICAL SKILLS
IN 2-YEAR-OLD CHILDREN WITH REPAIRED CLEFT PALATE, CHILDREN WITH
OTITIS MEDIA, AND TYPICALLY DEVELOPING CHILDREN**

Introduction

Children with cleft palate (CP) have a range of speech and language difficulties, which develop at early stages of language acquisition. Research has documented restricted consonant inventories, delayed onset of first words, and poor expressive vocabulary development in young children with CP (Broen, Devers, Doyle, Prouty, & Moller, 1998; Chapman, Hardin-Jones, & Halter, 2003; Eshghi, Dorry, Vivaldi, Crais, Vallino, Baylis, Preisser, & Zajac, 2017; Jocelyn, Penko, & Rode, 1996; Jones, Chapman, & Hardin-Jones, 2003; Scherer, 1999; Scherer & D'Antonio, 1995). Numerous explanations have been proposed as to why expressive language development appears to be particularly susceptible to disturbance among children with CP. For example, consistent velopharyngeal (VP) closure during production of stop consonants has been observed to develop with at least a two-month delay in children with CP (Eshghi, Vallino, Baylis, Preisser, & Zajac, 2017). Using nasal ram pressure (NRP) monitoring, Eshghi, et al. (2017) reported that while TD children exhibited consistent VP closure for stop consonants and vowels at 12 months of age, some children with repaired CP (33%) did not achieve consistent closure until 14 months of age, approximately 3 to 4 months following palate repair. Given that the VP mechanism plays an important role in speech production by facilitating the pressure buildup for most oral consonants and signaling oral-nasal phonetic contrasts, observed delay in the development of consistent VP closure may explain part of the differences reported between

children with CP and their non-cleft peers with respect to the onset of babbling, size of consonant inventories, and later vocabulary size.

In addition, children with CP usually experience varying degrees of conductive hearing loss due to the otitis media (OM), which occurs during the first few months of life and will persist most probably throughout infancy or later (Paradise, Bluestone, & Felder, 1969). Conductive hearing loss distorts the auditory signal that children with CP may use for auditory-oral matching. Studies have shown a relationship between OM and delayed phonological and expressive language skills in populations without cleft (Donahue, 1993; Luloff, Menyuk, Teele, 1993; Petinou, Richard, Maria, & Judith, 1999; Rvachew, Slawinski, Williams, & Green, 1999). Children with an early history of OM have been observed to have lower expressive language scores (Friel-Patti, Finitzo-Hieber, Conti, & Brown, 1982; Wallace, Gravel, McCarton, & Ruben, 1988), smaller size of vocabulary (e.g., Holm & Kunze, 1969; Teele, Klein, & Rosner, 1984), and slower rate of word combinations or less complex syntax (e.g., Holm & Kunze, 1969; Schlieper, Kisilevsky, Mattingly, & Yorke, 1985; Zinkus & Gottlieb, 1980). Consistent with these studies, Jones et al. (2003) reported that children with CP who exhibited a higher number of episodes of OM and failed tympanometry at the pre- or post-surgery sessions showed less progress in size of consonant inventory after palatal repair.

However, despite the abundance of information on phonological and language sequelae of early onset OM, the association between a history of early OME and later speech and language outcomes remains inconclusive. Numerous studies provide evidence against the hypothesized link between early OME and later phonological and expressive language. For example, similar expressive language (Black, Gerson, Freeland, Nair, Rubin, & Hutcheson, 1988; Silva, Kirkland, Simpson, Stewart, & Williams, 1982; Pearce, Saunders, Creighton, &

Sauve, 1988; Wright, Sell, McConnell, Sitton, Thompson, Vaughn, & Bess, 1988) and vocabulary skills (e.g., Brookhouser & Goldgar, 1987; Fischler, Todd, & Feldman, 1985; Friel-Patti & Finitzo, 1990; Lous, Fiellau-Nikolajsen, & Jeppesen, 1988; Wright et al., 1988) were reported in children with OM compared to children without a history of OM.

Cleft type may also play a role in the development of expressive language. Although, Hardin-Jones, Chapman, and Schulte (2003) did not find any significant association between cleft type and early consonant development in infants with CP, Scherer, Williams, Henley, Lambert, Lassiter, and Osborne (2000) reported that children with isolated CP performed poorer than the CLP group on expressive language and vocabulary development. Finally, other factors such as age at the time of primary palatal surgery and presurgical procedures might also impact the development of expressive language. However, these factors are not germane to the current study's focus.

Although the literature on the early speech and phonological characteristics of children with CP is relatively rich, little attention has been directed toward the lexical diversity and grammatical complexity of this subgroup of children. In a cross-sectional study conducted by Spriestersbach, Darley, and Morris (1958), 3;6 to 8;5 year old children with CP revealed smaller vocabulary size and shorter MLU compared to normative data obtained from Templin (1957). Syntactic complexity was also reported to be less advanced in children with CP (Morris, 1962), although Spriestersbach et al. (1958) did not note any significant differences between the syntactic skills of children with and without CP. Given that the foundation for acquiring syntax is established around the age of two, it is of considerable heuristic value to determine whether children with repaired CP follow similar developmental trajectories compared to children with OM and TD children during the course of language acquisition.

The Relationship between Lexicon and Grammar

Despite the extensive individual variations in the rate of vocabulary growth, studies have determined that first words usually emerge between 12 and 20 months of age (e.g., Fernald, Pinto, Swingley, Weinbergy, & McRoberts, 1998; Tomasello & Bates, 2001). Children acquiring American-English have a vocabulary size of approximately 300 words by age two (Fenson, Bates, Dale, Marchman, Reznick, & Thal, 2007). First words are characterized as spontaneous productions of phonetically adult-like forms that a child utters in reference to certain entities or objects within similar contexts (Ingram, 1974; Vihman, Macken, Miller, Simmons, & Miller, 1985). The beginning of syntactic development typically occurs between 18 to 24 months with the appearance of two-word combinations in the speech of the child (e.g., Bzoch & League, 1971; Nelson, 1973). Marchman and Bates (1994) reported that two-word utterances emerged once toddlers' lexicon included 50–100 words. In addition, Marjanovič-Umek, Fekonja-Peklaj, and Podlesek (2013) reported that with every increase of one word in vocabulary of Slovenian toddlers, aged from 1;4 (year; month) to 2;6, the probability that a toddler combines words to make sentences increased by 1.4%.

Literature on the development of lexical and grammar domains of language shows two major competing views: the dual-mechanism account vs. the single-mechanism account. The dual-mechanism account of language development postulates that the lexicon and grammar are two distinct language subsystems developed autonomously in different cognitive and neural modules. Advocates of the dual-mechanism theory emphasize the separateness and independence of lexicon and grammar (Pinker, 1991, Pinker & Ullman, 2002; Ullman, 2001; Ullman, Izvorski, Love, Yee, Swinney, & Hickok, 2005). In contrast, the single-mechanism account of lexical and grammatical development assumes that in the course of language acquisition, lexical and

grammatical skills develop interdependently within the same language mechanism (Bates, Bretherton, & Snyder, 1988; Bates & Goodman, 1997; Marchman & Bates, 1994; Marchman, Martínez-Sussman, & Dale, 2004; Marchman & Thal, 2005; McGregor, Sheng, & Smith, 2005). Proponents of this view emphasize the inseparability and interconnection between the lexicon and the grammar.

Despite the equivocality in the literature with regard to the lexical–grammatical association, a substantial number of studies support the single-mechanism view. Various studies have reported that vocabulary development is a strong predictor of later morphological and syntactic achievements (e.g., Bates et al., 1988; Bates & Goodman, 2001; Fenson, Dale, Reznick, Bates, Thal, & Pethick, 1994; Marchman & Bates, 1994). For example, vocabulary size has been shown to be a significant predictor of the development of grammar (Devescovi, Caselli, Marchione, Pasqualetti, Reilly, & Bates, 2005; McGregor et al., 2005), grammatical complexity (Mariscal & Gallego, 2012), and mean length of utterances (MLU) (Bates et al., 1988). Mariscal and Gallego (2012) also reported that the variance in grammatical complexity was better explained by the size of vocabulary (84.4% of variance) rather than age (58% of variance). In addition, a growing body of research has provided evidence for the continuity between vocabulary and grammar as two key and yet linked linguistic milestones (Bates et al., 1988; Hadley, McKenna, & Rispoli, 2018). Lexical development has been observed in young children to precede the onset of combinatorial speech and has been assumed to be a prerequisite for the emergence of morphosyntactic and syntactic constitutions (Bartsch, 2006; Bates et al., 1988; Bates & Goodman, 1997; Marchman & Bates, 1994; Marchman & Thal, 2005). In other words, the transition from single-word production to combinatorial speech requires prior maturation of lexical knowledge. Continuity between lexical and grammatical development has been well

explained by the critical mass hypothesis. According to this theory abstraction of morphosyntactic patterns cannot occur unless the child's lexicon reaches the critical mass threshold necessary to trigger grammatical development (Marchman & Bates, 1994; Bates & Goodman, 1997; Bates & Goodman, 2001). For example, Marchman and Bates (1994) studied the relationship between the number of verbs in the vocabulary and the use of past-tense verbs in more than 1,130 English-speaking children between 1;4 (year; month) and 2;6. They discovered that children progress through a developmental sequence in the use of regular and irregular past-tense verbs. During this developmental course, children started with correct use of both regular and irregular past tense and then they overused the past tense marker (-ed) to irregular forms that were previously produced correctly. In the last phase, both irregular and regular past-tense verbs were produced correctly. Marchman and Bates (1994) explained the observed past-tense development in light of the continuity of lexical and morphosyntactic development. They hypothesized that overgeneralization errors would occur during the time when children are enhancing the size of their vocabulary. Children will continue an overgeneralization process until they acquire critical mass of verb vocabulary. In addition, Marchman and Bates (1994) argued that transition from single-word utterances to two-word utterances occurs when the vocabulary inventory exceeds from 50 to 100 words, suggesting the existence of a relationship between lexical and grammar acquisition.

In addition to English (e.g., Fenson et al., 1994; Marchman & Bates, 1994), various cross-linguistic studies demonstrated tightly linked relationships between lexical acquisition and subsequent grammatical development. For example, early lexical-grammatical association were reported in speakers of languages such as Spanish (Conboy & Thal, 2006; Jackson-Maldonado, Thal, Marchman, Bates, & Gutierrez-Clellen, 1993; Marchman et al. 2004), Danish (Bleses,

Vach, Slott, Wehberg, Thomsen, Madsen, & Basbøll, 2008), Italian (Caselli, Bates, Casadio, Fenson, Fenson, Sanderl, 1995; Caselli, Casadio, Bates, 1999; Devescovi et al., 2005), Slovenian (Marjanovič-Umek et al., 2013), Icelandic (Thordardottir, Weismer, & Evans, 2002), Hebrew (Maital, Dromi, Sagi, & Bornstein, 2000), Finnish (Stolt, Haataja, Lapinleimu, & Lehtonen, 2009), and Japanese (Ogura, Yamashita, Murase, & Dale, 1993). Findings of studies on Romance languages such as Spanish and Italian better illuminate the high interdependence between these two domains of language due to the morphological richness of these languages compared to poorly inflected languages such as English. Another important source of data within the study of the lexical-grammatical relationship arises from previous studies on young children with various language impairments including children with autism spectrum disorder (McGregor, Berns, Owen, Michels, Duff, Bahnsen, & Lloyd, 2012), Down and Williams syndromes (Singer Harris, Bellugi, Bates, Jones, & Rossen, 1997), focal brain lesions (Bates, Thal, Trauner, Fenson, Aram, Eisele, & Nass, 1997), lexically precocious talkers (McGregor et al., 2005), and late-talkers (Moyle, Weismer, Evans, & Lindstrom, 2007).

Early development of vocabulary, however, is known to be influenced by a number of factors. For example, early prelinguistic vocalization and canonical babbling have been shown to significantly influence subsequent lexical acquisition. Research has demonstrated positive associations between consonant inventories that occur frequently during canonical babbling and those that typically appear in early word productions of young children (Oller, Wieman, Doyle, & Ross, 1976; Stoel-Gammon, 1985; Stoel-Gammon & Cooper, 1984; Vihman, et al., 1985). Furthermore, maternal education and socioeconomic status (SES) are known to be important sociodemographic predictors of early language development. For example, a strong association has been reported between maternal educational levels (MEL) and early language skills such as

expressive vocabulary, comprehension, and grammatical skills (Dollaghan, Campbell, Paradise, Feldman, Janosky, Pitcairn, & Kurs-Lasky, 1999; Magnuson, Sexton, Davis-Kean, Huston, 2009; Marjanovic-Umek, Bozin, Cermak, Stiglic, Bajc, & Fekonja-Peklaj, 2016; Marjanovič-Umek, Fekonja, Kranjc, & Bajc, 2008). In addition, various studies suggested that compared to children from families with higher SES, children from lower SES families have smaller vocabulary size (Arriaga, Fenson, Cronan, & Pethick, 1998; Hoff, 2003; Malin, Karberg, Cabrera, Rowe, Cristaforo & Tamis-LeMonda, 2012; Mol & Neuman, 2014), less complex utterances (Arriaga et al., 1998), and delayed onset of word combinations (Arriaga et al., 1998).

Gender also has been shown to be an influential factor in early expressive language development. Research has established that, compared to boys, girls tend to have progressively more rapid vocabulary growth (Bauer, Goldfield & Reznick, 2002; Bornstein, Hahn & Haynes; 2004; Hadley, Rispoli, Fitzgerald, & Bahnsen, 2011; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991) and a larger vocabulary size (Eriksson, Marschik, Tulviste, Almgren, Pérez Pereira, Wehberg, Marjanovič-Umek, Gayraud, Kovacevic, & Gallego, 2012; Marjanovič-Umek et al. 2008; Marjanovič-Umek, Fekonja-Peklaj, & Podlesek, 2012). In addition, girls were observed to outperform boys by producing longer and more grammatically complex utterances (e.g., Bornstein & Haynes, 1998; Eriksson et al., 2012; Fenson et al., 1994; Simonsen, Kristoffersen, Bleses, Wehberg, & Jørgensen, 2014). Contrary to these findings, Marjanovič-Umek et al. (2016) did not find significant differences between boys' and girls' vocabulary size at different ages. They reported, however, that while boys' vocabulary consisted of more masculine-type words, girls tended to use more feminine-type words.

Missions of the Present Study

The current study focuses on the lexical-grammatical skills of two-year old children with cleft palate (CP), children with otitis media (OM), and typically developing (TD) children. The purpose of the present study was to further elucidate the relationship between early lexical and grammatical skills in two-year old children with repaired CP and consistent VP closure, children with OM, and TD children. In addition, the effect of variables such as hearing level, tympanogram status, MEL, and gender on vocabulary and grammar was examined. The study questions were: 1) Do two-year old children with CP show the same or different lexical and grammatical development compared to children with OM and TD children? 2) Is there any association between lexical and grammatical development at this early stage of language acquisition in children with CP, children with OM, and TD children; and, whether the size of vocabulary predicts the performance of children on grammatical scales? and 3) To what extent do variables such as hearing level, tympanogram status, MEL, and gender impact early lexical-grammatical development? It was hypothesized that: a) children with repaired CP would fall behind the other two groups with regard to the size of vocabulary inventory as well as grammatical attainments; b) there is a strong association between vocabulary and grammatical skills at two-years of age and the number of words produced predicts the performance of children on grammatical scales; and c) variables such as hearing level, tympanogram status, MEL, and gender may influence early development of lexical and grammatical skills.

This study has both theoretical and clinical significance. Findings of this study may provide additional evidence for early interactions between lexical and grammatical domains of language. Further, in the available clinical literature on children with CP, developmental milestones for the transition from single word productions to sentences are not well understood.

Given that impaired expressive language has been shown to negatively impact higher level language and literacy attainment in later childhood (Felsenfeld Broen, & McGue, 1994; Lewis, Freebairn, Hansen, Stein, Shriberg, Iyengar, & Taylor, 2006; Scarborough, 1990; Sices, Taylor, Freebairn, Hansen, & Lewis, 2007), if differences are found in the current study, early language intervention could have an impact on persistent language delay and later literacy underachievement.

Methods

Participants

The participants of this study consisted of 26 children with repaired CP (15 males, 11 females), 27 children with OM (19 males, 8 females), and 20 TD children (11 males, 9 females). Sixty-eight (about 93%) of children (25 children with CP, 26 children with OM, and 17 TD children) were the same children who participated in the first study of this Dissertation. Twenty-two of the children (7 CP, 7 OM, and 8 TD) were examined at the Craniofacial Center, University of North Carolina at Chapel Hill; 25 (6 CP, 12 OM, and 7 TD) were examined at A. I. duPont Hospital for Children, Wilmington, DE; and 26 (13 CP, 8 OM, and 5 TD) were examined at Nationwide Children's Hospital, Columbus, OH. These children were a subset of participants recruited for an ongoing multi-site longitudinal study who had data on the number of words and grammatical skills at 24 months of age at the time of this study.

Children with CP ranged in age from 23.42 to 26.88 months (mean= 24.32 months, SD = 0.72). Information about birth and family history, demographics, medical history, surgical history as well as cleft classification were obtained from the primary care giver of the child at the screening visit when the child was initially enrolled in the study. Cleft type and date of palate surgery were verified from medical records. Of 26 children with repaired CP, 25 children were

non-Hispanic/Latino and one was Hispanic/Latino. In addition, 23 children with CP were Caucasian, one was African-American, and two belonged to more than one race. None of the children with CP were born prematurely (i.e., gestation less than 36 weeks) or diagnosed with any known syndromes including Pierre Robin syndrome. With regard to the type of the cleft, 10 children had clefts of the lip and palate (CLP) and 16 had clefts of the hard and/or soft palate only. All children with CP had undergone a single surgery to repair the palate. Seventeen children had their palatal surgery by 11 months of age (mean = 9.51 months, range = 7.2 to 10.8 months) while 9 children had their palatal surgery after 11 months of age (mean = 11.83 months, range = 11.2 to 13.2 months). Oral examination was performed at the study visit to rule out the presence of oronasal fistulae. All children in the CP group underwent myringotomy with insertion of pressure-equalization (PE) tubes at the time of their palate surgery.

Children with OM ranged in age from 23.30 to 25.63 months (mean= 23.98 months, SD = 0.47). All children in the OM group had experienced multiple episodes of otitis media with effusion during their first year of life and also underwent myringotomy with insertion of PE tubes prior to the enrollment in the project (12 months of age). None of these children had any type of clefts. Twenty-six children with OM were non-Hispanic/Latino and only one child in this group was Hispanic/Latino. In addition, 25 children with OM were Caucasian, one was African-American, and one belonged to more than one race.

Finally, TD children ranged in age from 23.49 to 24.70 months (mean= 23.89 months, SD = 0.31). None of the children in the TD group had any type of cleft nor PE tubes. All TD children showed normal language development at 12 months of age determined by the Communication and Symbolic Behavior Scales Developmental Profile (CSBS DP; Wetherby & Prizant, 2002) assessment tool. In addition, none received any early speech/language or

developmental intervention services. All TD children were non-Hispanic/Latino. In addition, 15 TD children were Caucasian, 2 were African-American, and 3 belonged to more than one race.

All children participated in this study were from monolingual American English–speaking families and they showed normal development of social and symbolic skills of language as determined by the CSBS DP. Further, all children in CP, OM, and TD groups were in good general health and had no documented sensorineural haring loss or global developmental delays. All participants underwent bilateral tympanometry at 24 months of age to evaluate middle-ear function and/or confirm the presence of PE tubes. Tympanograms were obtained by either SLPs and/or certified audiologists at each of the sites. In addition, air-conduction hearing levels at 24 months of age for frequencies of 500, 1000, 2000, and 4000 Hz were used in this study. Sound field audiometry assessments were obtained in sound-attenuated booths by licensed audiologists according to pediatric assessment protocols. This study was approved by the intuitional review board (IRB) of the University of North Carolina at Chapel Hill.

Evaluation of VP Status

VP status was objectively assessed by NRP monitoring during spontaneous production of stop consonants for 22 children. See Eshghi et al. (2017) for details regarding the NRP analysis procedures. All 22 children exhibited consistent VP closure defined as closure during production of at least 85% of prevocalic stop consonants (Eshghi et al., 2017). NRP data, however, were not obtained for 4 children due to either the child's unwillingness to cooperate for the procedure (3 participants) or poor NRP recording as a result of a runny nose (one participant).

For the four participants with missing NRP data, the status of the VP mechanism was determined perceptually. Perceptual judgments of speech were made during a 20-minute recording of standardized speech samples. During these recordings, spontaneous speech samples

were elicited by presenting pictures of common toys and animals that targeted the six stop consonants (/p b t d k g/) in both initial and final word positions. All targeted words are listed in appendix A. Two speech-language pathologists independently listened to the speech samples and perceptually judged the adequacy of the VP mechanism based on the quality of stop consonants, resonance on voiced segments, and absence of nasal emission, or compensatory misarticulation. All four participants were judged by both listeners to have an adequate VP mechanism.

Assessment of Vocabulary and Grammatical Skills

The MacArthur–Bates Communicative Development Inventory: Word and sentences (CDI-WS) form is a standardized test to measure the development of the expressive language and grammar in toddlers. This parent report tool has been widely used for both clinical and research purposes in TD children as well as children with disorders (Fenson et al., 1994; Jackson-Maldonado et al., 1993; Miller, Sedey, & Miolo, 1995; Scherer & D'Antonio, 1995; Thal, Marchman, Stiles, Aram, Trauner, Nass, & Bates, 1991). Parents completed the CDI-WS at home around their child's second birthday (mean= 24.08 months, ranged from 23.30 to 26.88 months, SD = 0.56). For most of the participants (i.e., 93%), the primary caregiver who completed the CDI-WS checklist was the mother. For the present study, the first part of the CDI-WS was used to measure the participant's lexical (i.e., expressive vocabulary) development. This part includes the number of words produced by the child and how the child used the words. The number of words was derived from a checklist of 680 commonly used vocabulary items. The primary caregivers were asked to indicate the words that the child produced spontaneously (maximum score 680). In addition, parents were asked to identify whether their child used words to talk about past events or people, future events, absent objects (production), or absent owner. Grammatical development was measured from the second part of the CDI-WS. Different

inflectional paradigms including plural (-s), possessive (-'s), progressive (-ing), and past tense marker (-ed), as well as different word forms such as regular/irregular past tense verbs and regular/irregular plural nouns were targeted as an index of morphosyntactic development.

Syntactic knowledge of the participants and sentence complexity was measured through mean number of morphemes used in three longest utterances (M3L). To obtain information about M3L, parents were first asked whether their child already produced word combinations. If so, they were further asked to write down the three longest utterances they heard their child say. The M3L scale was then calculated by counting the number of morphemes used in each sentence and taking the mean. The investigators followed the guidelines stated in the CDI-WS manual to identify morphemes. For Sentence Complexity, CDI-WS has a list of 37 sentence pairs with the second sentence being grammatically more complex than the other sentence with regard to the use of morphosyntactic markers, auxiliary verbs, using prepositions, or embedded clauses serve to increase sentence length and complexity. From the list of 37 sentence pairs, parents were asked to identify whether they heard the child using the syntactically simpler sentence or the syntactically more complex one.

Statistical Analyses

For unadjusted comparisons of the three groups (CP, OM, TD), one-way analysis of variance was used for the continuous variables (i.e., the number of words, number of irregular plural nouns and irregular past tense verbs, overuse of (-s) and (-ed) markers, M3L, and sentence complexity). In addition, Fisher's exact tests were used for categorical variables (i.e., how words were used, inflectional word endings, and if the child was observed to combine words). Two-way analysis of variance was used for comparing continuous outcomes across the groups adjusting for a single categorical variable. Exact conditional logistic regression was used to

compare the groups with respect to binary outcomes while adjusting for another categorical variable in the model. Analyses involving multiple comparisons were adjusted using the Bonferroni correction. P-values were compared against the 0.05 significance level a priori. SAS version 9.4 (TS1M1, SAS institute, Cary, NC) was used in all analyses.

Hypothesis 1: Children with repaired CP will fall behind the other two groups with regard to the size of vocabulary inventory as well as grammatical skills.

To test this hypothesis, One-way Analyses of Variance were used to compare the three groups with respect to the number of words produced (CDI-WS list of 680 words), word forms (CDI-WS list of 25 irregular plural nouns and irregular past tense verbs), overuse of (-s) and (-ed) markers (CDI-WS list of 45 nouns and verbs), M3L, and sentence complexity (CDI-WS list of 37 utterances). Fisher's exact tests were used to compare the use of words to talk about past and future events, absent object (production), and absent owner, the use of inflectional paradigms (i.e., word endings) including plural (-s), possessive (-'s), progressive (-ing), past tense (-ed), word combinations, and finally, the combined effects of lexical and grammatical variables across the three cohort groups.

Hypothesis 2: Syntactic scales of M3L and sentence complexity will be correlated with the number of words produced. Furthermore, the size of vocabulary will predict the performance of children on the grammatical measures.

To test this hypothesis, Pearson correlation analysis was used to examine the correlation between the lexical and grammatical development in two-year old children. Correlational analyses were conducted to determine the association between syntactic scales (M3L and sentence complexity) and the number of words produced. In addition, regression analysis was

used to test the hypothesis that vocabulary size predicts grammatical scales of M3L and sentence complexity.

Hypothesis 3: Overall variables such as hearing level, tympanogram status, MEL, and gender may influence early development of lexical and grammatical skills.

Two-way Analysis of Variance (for continuous outcomes) and exact conditional logistic regression (for dichotomous outcomes) were used to test this hypothesis while singly adjusting for each variable. Hearing levels of participants at 500, 1000, 2000, and 4000 Hz were averaged and hearing levels between 15 to 20 dB indicated normal hearing sensitivity, hearing levels between 20 to 25 dB indicated slight hearing loss, and hearing levels greater than 25 dB indicated at least mild hearing loss. Tympanogram status, MEL, and gender were dichotomous variables. Tympanogram status was defined by two levels: normal and abnormal. Normal tympanograms were indicated by type A or type B (as an indication of large volume in the presence of tube). Abnormal tympanograms were indicated by type A_s, type B (as an indication of small volume), and type C. MEL was categorized in two levels of holding education below Bachelor's degree vs. Bachelor's degree and above. The variable gender had two levels: male vs. female.

Results

Lexical and Grammatical Skills

As seen in table 3.1, TD children were observed to significantly outperform both children with OM and children with CP with respect to lexical and grammatical skills by producing, on average, a greater number of words (p=0.012) and longer sentences (ML3, p = 0.041). Although not statistically significant, TD children tended to produce more grammatically complex utterances compared to the other two groups. Descriptively, the performance of children with

OM on vocabulary and grammatical scales fell somewhere between that of TD children and

children with CP. Post hoc pairwise comparisons revealed that while there was a significant

difference between children with CP and TD children relevant to the number of words (p=

0.003), the difference between children with OM and TD children approached but did not quite

reach statistical significance (p= 0.0627). Similarly, the post hoc pairwise comparisons for the

syntactic scale of M3L revealed that children with CP produced significantly shorter sentences

(smaller M3L) compared to TD children (p= 0.0121). However, no other significant pairwise

group differences were observed for this scale (p> 0.05). Due to high inter subject variability in

the use of irregular forms of words (i.e., irregular plural nouns and irregular past tense verbs), as

well as sentence complexity, the observed mean differences among the three groups were not

statistically significant (p> 0.05). Children in the three groups showed relatively similar

performance with regard to the overuse of plural (-s) and (-ed) markers.

Table 3.1: Mean (standard deviation) estimates of lexical and grammatical development for children with CP, children with OM, and TD children

Lexical & Grammatical Scales	Mean (SD)			
	CP Group	OM Group	TD Group	p-value*
Number of words	193.69 (155.52)	246.59 (131.38)	329.25 (159.29)	0.012
Word forms (irregular plural nouns, irregular past tense verbs)	2.73(4.29)	3.38(2.70)	4.85(4.36)	0.175
Overuse of (-s) and (-ed) markers	1.00(2.79)	1.65(2.46)	1.25(2.00)	0.632
M3L	3.03(1.65)	3.48(1.24)	4.26(1.97)	0.041
Sentence complexity	5.65(6.44)	5.30(5.75)	9.35(10.11)	0.142

The overall F-test from the one-way Analysis of Variance test

The proportions of children who used words to talk about past and future events, absent

object (production), and absent owner are presented in Table 3.2. In addition, Table 3.2 presents

the proportion of children in each group who were observed to combine words. Overall, a

significantly higher proportion of TD children used words to talk about past events (future events

neared significance), absent objects (production), and absent owners followed by children with

OM and then children with CP. Children in all three groups showed the same performance for

absent objects (comprehension), and hence this index was not shown in Table 3.2. Although

significant group differences were observed for the proportion of children who used words to

refer to events that occurred in the past, absent objects (production), and absent owners (p<

0.05), the combined effect of how words were used approached but did not quite reach statistical

significance level (p-value= 0.054). No significant difference was observed across groups for the

ability to combine words (p> 0.05), however descriptively, children with CP exhibited poorer

performance compared to the other two groups, and OM and TD children showed very similar

performances.

Table 3.2: Proportion of children in CP, OM, and TD groups who used words to refer to past events, future events, absent objects (production), and absent owners as well as children who were reported to be able to combine words.

How words were used	Proportion of yes (%)			
	CP	OM	TD	p-value*
Using words to talk about past events	61.54	88.89	90	0.027
Using words to talk about future events	53.85	70.37	85	0.081
Using words to talk about absent objects (production)	84.62	100	100	0.011
Using words to talk about absent owners	88.46	100	100	0.011
The combined effect of how words were used	46.15	62.96	80	0.054
The ability to combine words	80.77	96.30	95	0.128

* Fisher's exact test with mid p-value adjustment.

Table 3.3 presents the proportion of children who used inflectional word endings. Visual

inspection of the proportions, however, suggested that children with CP fell behind the other two

groups with regard to the use of inflectional paradigms including possessive (-'s), progressive (-ing), and past tense (-ed). While children with OM and TD children clustered together in the use of plural (-s) and possessive (-'s), children with OM lagged behind the TD children in producing the inflectional word endings of progressive (-ing) and past tense (-ed). Despite the observed trends, Fisher's exact tests failed to show any significant differences across the three groups in individual scales of inflectional word endings as well as the combined effect of them ($p > 0.05$).

Table 3.3: Proportion of children in CP, OM, and TD groups who produced inflectional word endings.

Inflectional word endings	Proportion of yes (%)			
	CP	OM	TD	p-value*
Plural (-s)	76.92	80.77	80	0.937
Possessive (-'s)	57.69	76.92	80	0.203
Progressive (-ing)	34.62	46.15	60	0.208
Past tense (-ed)	15.38	26.92	40	0.171
The combined effect of inflectional word endings	15.38	23.08	30	0.742

* Fisher's exact test with mid p-value adjustment.

Association between Lexical and Grammatical Development

Pearson correlation analyses revealed statistically significant positive associations between the number of words and syntactic scales of M3L and sentence complexity in each group ($p < 0.05$). The observed correlation between the number of words and the M3L scale were 0.4541, 0.5958, and 0.5677 for CP, OM, and TD groups, respectively. The correlation between the number of words and the scale of sentence complexity were 0.5394, 0.5228, and 0.6738 for children with CP, children with OM, and TD children, respectively. Overall, the lowest correlations tended to be among children with CP while the highest correlations were among the

TD children. In addition, results of regression analyses revealed that both scales of M3L and sentence complexity were significantly predicted by the number of words in each of the three groups ($p < 0.05$).

Predictors of Lexical-grammatical Development

Because the interactions of group with each controlling variable were not statistically significant ($p > 0.05$), several tests based on main effects of two-way ANOVAs were used to assess the effect of predictor variables on lexical and grammatical development while the model was adjusted separately for hearing level, tympanogram status, MEL, and gender. Based on the main effects of two-way ANOVAs, the three groups were significantly different with respect to the mean number of words ($p < 0.05$), and approached but did not reach statistical significance when adjusting for MEL ($p = 0.063$).

Further, the non-significance of group differences with respect to use of irregular plural nouns and irregular past tense verbs (i.e., word forms) as reported in Table 3.1 is in agreement with the non-significance following adjustment for tympanogram, MEL, and gender. However, the groups differed significantly ($p = 0.016$) adjusting for normal hearing level. With respect to the association of group with inflectional word endings and sentence complexity, all adjusted tests were non-significant, as were their corresponding unadjusted tests in Table 3.1. Relevant to the association of groups with the M3L scale, tests adjusting for tympanogram and gender were significant ($p < 0.05$) and approached significance for hearing level ($p = 0.053$), but the group differences were not significant adjusting for MEL.

The three groups were further compared with respect to how children used words adjusting for hearing level, tympanogram status, MEL, and gender. Results indicated that the unadjusted significant difference between groups with respect to use of words to refer to past

events from Table 3.2 remained statistically significant after adjusting for gender (p<0.05), while the test adjusting for tympanogram approached significance (p= 0.053). Next, the non-significant unadjusted test for use of words to refer to future events from Table 3.2 remained non-significant after adjusting for any single variable. Also, the unadjusted significant difference between groups with respect to use of words to talk about absent objects (production) and absent owners from Table 3.2 remained statistically significant after adjusting for tympanogram (p=0.041), but became non-significant upon adjustment for any of the other variables. In addition, the non-significant unadjusted test for the ability of children to combine words from Table 3.2 became statistically significant after adjusting for hearing level (p<0.028), but remained non-significant after adjusting for tympanogram status, MEL, and gender.

Finally, singly adjusting for hearing level, tympanogram status, MEL, and gender, the cohort groups did not show significant differences in their uses of inflectional word endings (i.e., plural (-s), possessive (-'s), progressive (-ing), and past tense (-ed) suffixes) for any of the groups.

The Effect of Hearing Level on Lexical and Grammatical Skills

Hearing level significantly predicted the number of words, word forms (i.e., irregular plural nouns and irregular past tense verbs), and if the child was able to combine words. In general, children with normal/better hearing level (15 to 20 dB) produced a greater number of words, showed better performance for the use of irregular plural nouns and past tense verbs, and showed better ability to combine words. Table 3.4 demonstrates the adjusted means for number of words and word forms in children with CP, children with OM, and TD children after controlling for the effect of hearing level based on main effects of two-way ANOVA.

Table 3.4: The adjusted means for the number of words and word forms after controlling for different hearing levels from the two-way ANOVA without interaction model.

Variable	Categories	Groups	Adjusted means for number of words	Adjusted means for word forms
Hearing Level	15-20 dB	CP	191.56	2.30
		OM	238.24	2.69
		TD	359.97	5.14
	20-25 dB	CP	191.05	3.42
		OM	237.73	3.81
		TD	359.46	6.26
	Above 25 dB	CP	72.15	0.29
		OM	118.83	0.68
		TD	240.56	3.13

As suggested by Table 3.4, regardless of the cohort groups, hearing levels that ranged from 15 dB to 25 dB yielded similar results on vocabulary skills. However, for hearing level greater than 25 dB, the number of words was significantly different between the CP and TD groups (p= 0.0001) as well as between OM and TD groups (p= 0.0041). In general, the number of words produced by children with hearing level greater than 25 dB reduced by about 120 words compared to children with hearing levels below 25 dB.

Similarly, for children with hearing level greater than 25 dB, significant group differences were observed between the CP and TD groups (p = 0.0074) as well as between OM and TD groups (p= 0.0208) with regard to the use of word forms (irregular plural nouns and past tense verbs). In addition, children with CP whose hearing level was greater than 25 dB used past tense marker (-ed) less frequently compared to TD children with the same hearing level (p< 0.05).

Further analyses revealed that compared to children with elevated hearing levels, children with hearing level between 15 dB to 20 dB demonstrated significantly better skills in combined effect of how they used words (p= 0.0059). Further post hoc analyses also showed significantly better performance of TD children in the M3L scale compared to CP children (p= 0.0167), adjusting for hearing level. For example, the mean values for the M3L scale of children who had hearing level above 25 dB were 4.21, 3.34, and 2.86 in TD, OM, and CP groups, respectively.

The Effect of Tympanogram Status on Lexical and Grammatical Skills

Tympanogram status significantly predicted the number of words produced and the M3L scale. Table 3.5 demonstrates the adjusted means for the number of words and the M3L scale, in children with CP, children with OM, and TD children after controlling for the effect of tympanogram status based on main effects of two-way ANOVA. Children with normal tympanograms tended to produce a greater number of words and utterances with a greater number of morphemes (larger M3L) in all three groups (p<0.05).

Table 3.5: The adjusted means for the number of words produced and the M3L scale after controlling for tympanogram status from the two-way ANOVA without interaction model**.**

Variable	Categories	Group	Adjusted mean number of words	Adjusted means for the M3L
Tympanogram status	Normal	CP	206.31	3.1
		OM	234.31	3.45
		TD	348.83	4.42
	Abnormal	CP	182.35	2.91
		OM	210.35	3.26
		TD	324.87	4.23

Adjusting for tympanograms, significant group differences were found between CP and TD groups (p=0.0030) as well as between OM and TD groups (p= 0.0167) in terms of the number of words produced. Furthermore, Children with CP also produced smaller M3L compared to TD children, irrespective of tympanogram status (p=0.0146).

The Effect of MEL on Lexical and Grammatical Skills

Table 3.6 reports the adjusted means for the number of words produced by children with

CP, children with OM, and TD children after controlling for the effect of MEL based on main

effects of two-way ANOVA.

Table 3.6: The adjusted means for the number of words produced and the M3L scale after
controlling for the MEL from the two-way ANOVA without interaction model.

Variable	Categories	Groups	Adjusted mean number of words
MEL	Low MEL	CP	171.79
		OM	202.49
		TD	282.65
	High MEL	CP	223.57
		OM	254.27
		TD	334.43

Overall, children whose mothers had below a bachelor's degree education produced

about 52 fewer words compared to children whose mothers had at least a bachelors' degree,

however, the difference was not statistically significant (p>0.05). Adjusting for maternal

education, children with CP produced significantly fewer words compared to TD children (p=

0.0255).

The Effect of Gender on Lexical and Grammatical Skills

The variable gender was observed to significantly predict the number of words and the

M3L scale (p<0.05). Table 3.7 demonstrates the adjusted means for the number of words and the

M3L in children with CP, children with OM, and TD children after controlling for the effect of

gender based on main effects of two-way ANOVA. Adjusting for gender, in each group, girls

outperformed boys by producing significantly a greater number of words and greater M3L (p<0.05).

Table 3.7: The adjusted means for the number of words produced and the M3L scale after controlling for gender from the two-way ANOVA without interaction model.

Variable	Categories	Groups	Adjusted mean number of words	Adjusted means for the M3L
Gender	Male	CP	171.64	2.61
		OM	231.15	3.18
		TD	305.79	3.82
	Female	CP	223.77	3.58
		OM	283.28	4.17
		TD	357.92	4.79

Girls and boys in the TD group produced significantly longer utterances (greater M3L) compared to girls and boys in the CP group (p<0.05). In addition, the effect of gender on the combined effect of how words were used was significant within (controlling for) the cohort groups (p= 0.0047). However, no significant differences were observed for the effect of gender on the scale of sentence complexity among boys or girls within cohort groups.

Discussion

This study investigated the early development of lexical and grammatical skills in two-year old children with repaired CP who exhibited adequate VP function compared to children with OM and TD children. Children with CP demonstrated less mature lexical and grammatical development compared to TD children. Specifically, children with CP were observed to produce fewer words and shorter utterances (lower M3L scale) compared to the TD children. In addition, a smaller proportion of children with CP used words to refer to past and future events, absent objects (production) and absent owners. These findings are in agreement with previous studies that reported delayed onset of first words, poor expressive vocabulary skills (Broen et al. 1998;

Chapman et al., 2003; Jocelyn et al., 1996; Jones et al., 2003; Scherer and D'Antonio, 1995; Scherer et al., 1999), shorter MLU (Spriestersbach et al., 1958), and less syntactically complex utterances (Morris, 1962) in children with CP compared to non-cleft healthy controls.

The observed pattern can be described through the continuity view of language development. According to this view, there is a continuity from early prelinguistic vocalizations to canonical babbling, to single word production and ultimately to combinatorial speech and the construction of more complex syntactic structures (e.g., Bates & Goodman, 2001; Marchman & Bates, 1994; Marchman & Thal, 2005; Oller, Eilers, Neal, & Cobo-Lewis, 1998; Stoel-Gammon & Cooper, 1984; Vihman et al., 1985). Consistently, a significant correlation was observed between canonical babbling frequency and later vocabulary size of children with CP as measured on the CDI-WS (Chapman et al. 2003; Scherer, Williams, & Proctor-Williams, 2008). Therefore, the observed reduced size of vocabulary and poor grammatical skills in children with CP can be linked to early vocalizations and speech difficulties documented in the literature for children with CP. For example, restricted consonant inventories, smaller canonical babbling ratios, delayed onset of babbling, and less frequent and complex babbling have been reported by a number of studies (Chapman et al., 2003; Chapman, Hardin-Jones, Schulte, & Halter, 2001; Jones et al., 2003; Scherer, 1999; Scherer, Boyce, & Martin, 2013; Scherer et al., 2008). Most recently, Eshghi et al. (2017) reported that children with CP with adequate VP function exhibited a significantly reduced composite speech standard score (rate of sounds and word acquisition) on the CSBS DP assessment tool compared to TD children at both 18 and 24 months of age although scores fell within normal limits.

According to the single mechanism view of lexical and grammatical development, vocabulary weaknesses may lead to a less mature grammar due to mutual reliance between the

two language subsystems. Therefore, restricted size of vocabulary and lack of lexical diversity may set the basis for poor development of grammatical skills. Findings of this study could be explained in light of the single-mechanism account of lexical and grammatical development. Children with CP exhibited reduced size of vocabulary and subsequently lower scores of the M3L index compared to TD children. Although not statistically significant, they also showed the trend to produce fewer inflectional word endings and sentences with less complex syntactic structure. As suggested by the findings of the second research question, the number of words produced by children in each group was positively associated with scales of grammatical development including the M3L and sentence complexity. These findings are consistent with previous studies in which vocabulary development was associated with MLU and sentence complexity (e.g., Bleses et al. 2008; Marjanovič-Umek et al. 2013; Stolt et al. 2009). Therefore, vocabulary size is a significant predictor of grammatical development. Most notably, the larger the vocabulary inventory, the stronger the correlation. In this study, TD children with a larger vocabulary size produced longer utterances (higher M3L scores) and were more likely to combine words into grammatically more complex utterances compared to children with CP. These results also supported the continuity view of language development (e.g., Bates et al., 1988; Marchman & Bates, 1994) in that grammar appears to emerge from the lexicon.

Although children with OM showed stronger vocabulary and grammatical skills compared to the CP group, they lagged behind the TD group with regard to these scales. The observed trends were consistent with previous studies in which children with an early history of OM exhibited lower expressive language scores (Wallace, et al., 1988; Friel-Patti et al., 1982), smaller vocabulary size (e.g., Holm & Kunze, 1969; Teele et al., 1984) and a slower rate of word

combination or less complex syntax (e.g., Holm & Kunze, 1969; Schlieper et al., 1985; Zinkus & Gottlieb, 1980).

Fluctuating conductive hearing loss due to OM is common in children with CP. Therefore, these children may not receive integrated auditory input to make aural-oral adjustments for competent speech production and perception. As a result, the number of words and subsequent higher-level language skills (e.g., syntax) will be reduced considerably because of the combined effect of structural and auditory deficits. Although not statistically significant, children with OM along with children with CP showed trends for poorer performance on inflectional word endings. It should be noted that stridency deletion of fricatives has been commonly reported in the speech of children with OM (e.g., Churchill, Hodson, Jones, & Novak, 1988; Dyson, Holmes, & Duffitt, 1987; Haapala, Niemitalo-Haapola, Raappana, Kujala, Kujala, & Jansson-Verkasalo, 2015). Moreover, nasals are deviated and less frequently produced by children with OM (e.g., Dyson et al., 1987; Shriberg & Smith, 1983). Therefore, early OM may be considered as a pathological condition for the acquisition and development of prosodically unstressed inflectional suffixes such as plural (-s), possessive (-'s), progressive marker (-ing), and past tense (-ed) as well as derivational suffixes such as (-en), (-ment), (-ize). However, deficits in these skills may not be detectable before the age of 4 as Hoff (2009), page 3, pointed out "the development of complex (i.e., multi-clause) sentences usually begins some time before the child's second birthday and is largely complete by age 4".

Demographic and physiological variables can influence early lexical and subsequent grammatical development. In the present study, we examined the contributions of variables such as hearing level, tympanogram status, MEL, and gender to the development of lexical and grammatical skills. Hearing level was confirmed to be a strong predictor for the development of

vocabulary and grammar. After adjusting for hearing level, the difference between the OM and the TD groups relevant to the number of words and word forms became significant. In addition, children with CP showed significant differences to TD children with regard to the number of words, word forms and the M3L scale. Adjusting for hearing level, the number of words produced by children with CP, children with OM, and TD children decreased by 63%, 52%, and 27%, respectively.

Findings of the study also revealed that tympanogram status was also a factor in the development of lexical and grammatical skills. Adjusting for Tympanogram status, mean number of words produced by children in CP, OM, and TD groups with abnormal tympanograms reduced by 6%, 15%, and 13%, respectively. In addition, both children with CP and children with OM with abnormal tympanograms showed a significantly smaller number of words compared to TD children. These findings could be linked to a study conducted by Jones et al. (2003) who reported a reduced size of consonant inventory in young children with CP with higher number of episodes of OME and failed tympanometry at pre- or postsurgery sessions. In addition, children with CP with abnormal tympanograms produced significantly shorter utterances (lower M3L scores) compared to the TD children. Therefore, children with higher susceptibility to elevated hearing level and abnormal tympanograms produced fewer words and performed poorer in combining morphemes to make longer utterances.

MEL was also shown to contribute to the size of the lexicon. The number of words produced by children with CP, children with OM, and TD children who had mothers with an education below bachelor's degree decreased by 11%, 18%, and 14%, respectively. The effect of MEL to the development of language skills in general and expressive language in particular has been well documented by various studies. For example, Dollaghan et al. (1999) also reported

statistically significant linear associations across MEL and indices of mean length of utterance in morphemes (MLUm), number of different words (NDW), total number of words (TNW), and the Peabody Picture Vocabulary Test–Revised (PPVT–R).

Finally, gender was found to predict the development of lexical and grammatical skills. While the adjusted mean number of words increased by 16%, 15%, and 9% for girls in CP, OM, and TD groups, respectively, they decreased by 11%, 6%, and 7% for boys in the same groups. These findings are consistent with previous studies that reported a larger size of vocabulary (Eriksson et al., 2012; Marjanovič-Umek et al. 2008; Marjanovič-Umek et al., 2012) and stronger grammatical skills for girls rather than boys (e.g., Bornstein & Haynes 1998; Eriksson et al., 2012; Fenson et al. 1994; Simonsen et al. 2014).

Although the effect of cleft type on lexical and grammatical skills of children with repaired CP was not the focus of the current study, we decided to further compare more discrete cleft type subgroups as a post hoc analysis. Results indicated that children with cleft palate only (CPO) achieved better vocabulary and grammatical scores compared to children with cleft lip and palate (CLP). Significant group differences between the two subgroups were observed for sentence complexity ($p< 0.05$). Similarly, in a study conducted by Collett, Leroux, & Speltz, (2010), older children with CPO performed slightly better (although not significantly) than children with CLP on language and reading scales at 5 and 7 years of age. These findings are contrary to Scherer et al. (2000) who reported poorer performance for children with isolated CP compared to children with CLP on expressive language and vocabulary scales. The observed discrepancies may be related to differences in the severity of the cleft and/or other physiological factors. Further research is warranted to examine the developmental milestones of speech and language in children with different cleft type.

Clinical Implications

The premise that grammatical development depends upon lexical maturity highlights the importance of comprehensive assessment of early vocabulary development and grammar. Findings of this research can be translated into clinical practice by emphasizing the use of criterion-referenced approaches to target language growth in general and trajectories of expressive language and grammatical skills in particular. This study supports the applicability of the CDI-WS as an assessment tool that targets both vocabulary and grammar skills in children as young as two-years of age. It has been reported in the literature that while some children with delayed onset of expressive vocabulary ultimately show progress in vocabulary skills at a later stage of language acquisition, others may continue to show poor higher-level linguistic abilities (Bates, Dale, & Thal, 1995; Fernald & Marchman, 2012). Various studies have emphasized the correlation between delayed onset of expressive language and later language and academic difficulties (Felsenfeld Broen, & McGue, 1994; Lewis et al., 2006; Scarborough, 1990; Sices et al., 2007). Young children observed with slower trajectories of language growth may fail to achieve literacy and higher-level linguistic milestones at later ages. Given that early speech and language interventions can improve children's expressive language (Blakeley & Brockman, 1995; Scherer & Brothers, 2002), identifying subgroups of children at risk for expressive language delay and applying a target-based speech intervention are of paramount importance. This study highlights the importance of language management as early as 24 months of age when it has been documented that vocabulary proficiency lays the basis for syntactic skills.

Limitations of the Study

Several limitations of the study should be acknowledged. Potentially, because of the small sample size some observed differences among groups approached but failed to achieve

statistical significance (e.g., the difference between children with OM and TD with regard to the number of words, or difference among groups for sentence complexity). It also should be noted that the present study investigated lexical and grammatical skills at 24 months of age when the grammatical skills of children are still at an early stage of development. Future research is required to study the morphosyntactic skills of children with CP at later stages of language development when significant group differences may emerge at various aspects of morphology and syntax.

Another shortcoming of the study pertains to the limited scope of the CDI-WS instrument to capture a true picture of the child's syntactic ability. True syntactic competence is reflected not only through making simple and complex sentences but also through making new combinations of words to generate novel sentences. Although, the CDI-WS captures, to some extent, the ability of a child to make longer or syntactically more complex sentences, it fails to reflect mastery of expressive syntax. Another limitation of the study is related to the skewness of maternal education level toward higher levels. Most of children participating in the study had mothers with a high level of education which may have dissipated some of the differences among groups.

Conclusion

The current study suggests that two-year-old children with repaired CP who exhibited consistent VP closure are behind their age-matched TD peers in lexical and grammatical skills. Significant group differences were observed between CP and TD groups in the number of words produced and M3L. Although not statistically significant, children with OM also demonstrated a trend for poorer vocabulary and grammatical skills compared to the TD children. In addition, all groups showed a significant positive correlation between their lexical and grammatical skills,

although this correlation was the strongest in the TD group compared to the other two groups. The findings were explained in light of the effect of hearing status as a significant predictor of early vocabulary attainment and syntactic development. Demographic variables such as MEL and gender were also found to impact the early development of lexical and grammatical abilities. These findings emphasize the importance of early assessment and potential intervention that targets specific lexical and grammatical skills.

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CHAPTER 4: CONCLUSION AND FUTURE DIRECTIONS

Findings of the first study revealed that the vocabulary growth from 18 to 24 months of age is slower in children with CP compared to TD children. While children in both CP and TD groups performed similarly with regard to the number of words produced at 18 months of age, differences between the two groups emerged at later months so that a significant difference between the two groups was observed at 24 months of age. In the second study, significant differences were found between children with CP and TD groups in the size of vocabulary and measures of grammatical skills such as MLU at 24 months of age. In addition, a significant association was observed between lexical and grammatical development.

Having both studies integrated, findings support the continuity view of language acquisition and the connectivity and interdependency between different domains of language. This means that prelinguistic vocalizations lay the foundations for the emergence of speech sounds and formation of the phonological system. Similarly, the formed phonology is a prerequisite for the lexical development. As lexical diversity increases, the child is able to make two-word or multi-word combinations. Emergence of two word combinations can be marked as the onset of grammatical development that occurs sometimes between 18 to 24 months of age and expected to be established by 24 months of age. It has been well documented in the literature that any pathological condition that disrupts normal development of former stages of language domains can negatively impact the development of latter ones. In children with repaired CP, restricted prelinguistic vocalizations and smaller size of consonant inventory acts as prohibitory factors in making attempts to produce new words. In other words, children with CP have smaller

repertoire of sounds to combine and make words. In addition, words are more likely be attempted if the words begin with sounds that are already part of the child's established sound system. Restricted size of consonant inventory might have led to reduced size of vocabulary (particularly at 24 months of age) and slower rate of vocabulary growth from 18 to 24 months of age. Because, the transition from single-word production to combinatorial speech requires prior maturation of lexical knowledge, poor grammatical skills at 24 months of age occurred secondary to less diverse vocabulary and delayed onset of word combinations.

Although studies showed that delays in the onset of expressive vocabulary development are short-lived and some children with slower rate of vocabulary growth will proceed on a normal trajectory at later ages, adopting a wait and see approach without considering possible underlying etiological factors may place the child at risk of developing long-term language and literacy difficulties. Findings of both studies highlighted the importance of normal auditory conditions (i.e., hearing level between 15 dB to 20 dB and normal tympanogram) as important precursors of lexical and grammatical development. Among various physiological and sociodemographic factors, hearing level and tympanogram status were the strongest predictors of vocabulary growth and grammatical development. The effect of early hearing status on later expressive language development was observed to be far stronger than the size of consonant inventory.

In addition to the palatal cleft, children with CP are born with conductive hearing loss that would put these children at greater risk for developing poor language skills. Normal auditory information is required for acoustic decoding of speech sounds and adjusting the sensorimotor system to translate the auditory input to speech motor output. This auditory–articulatory loop provides motor rehearsal for early production of sounds and words. Further supports for the

pathologic consequence of disrupted auditory input could be found in data obtained from children with OM who also demonstrated the trend for poorer vocabulary and grammatical skills compared to the TD children although the differences were not statistically significant. These findings highlight the importance of monitoring the hearing needs of children with CP during initial steps of speech and language assessment.

In addition to hearing status, sociodemographic variables such as MEL and gender were also observed to impact the early development of lexical and grammatical skills. However, further research is needed to further examine the effect of MEL on lexical and grammatical skills of children with CP as in this study most of the children in all three groups had mothers with high level of education. In addition, literature on the role of factors such as mother-child dyad and mother-child communication style in early speech and language development is scarce and any study that aims to focus on this gap in the literature is appreciated. Finally, findings of these two studies highlight the importance of comprehensive assessment of expressive language and grammatical skills of children with CP as young as 24 months of age to prevent or at least alleviate long-term language impairments.

Words containing oral stops in initial and final positions elicited during the NRP monitoring and

standardized speech sample test.

prevocalic	postvocalic
pupp**y**	po**p**
pop	u**p**
ba**b**y	bi**b**
tub	tu**b**
tummy	goa**t**
duck	ca**t**
Dora	be**d**
dog	hea**d**
car	duc**k**
cow	boo**k**
goat	do**g**
go	pi**g**