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DEPARTMENT OF PSYCHOLOGY

DEFINITE ARTICLE ACQUISITION AND MORPHOSYNTACTIC DEVELOPMENT IN CYPRIOT-GREEK COCHLEAR IMPLANTED CHILDREN COMPARED TO TYPICALLY HEARING PEERS

DOCTOR OF PHILOSOPHY DISSERTATION

ELENA YIANGOU

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ABSTRACT

Ο πρωταρχικός στόχος αυτής της έρευνας ήταν να εξετάσει αν κωφά Ελληνοκύπρια παιδιά με κοχλιακά εμφυτεύματα, ακολοθούν την ίδια αναπτυξιακή πορεία όσο αφορά την χρήση του οριστικού άρθρου της Ελληνικής γλώσσας και κατ'επέκταση της Κυπριακή διαλέκτου σε όλες τις πτώσεις, σε όλους τους αριθμούς και σε όλα τα γένη καθώς επίσης και τη μορφοσυντακτική τους ανάπτυξη, σε σύγκριση με αυτήν τυπικά αναπτυσσόμενων παιδιών της ίδιας ηλικίας. Η έρευνα διεξάχθηκε σε νηπιαγωγεία στην Κύπρο. Οι συμμετέχοντες σχημάτισαν δύο ομάδες: 1) Ελληνοκύπρια κωφά παιδιά με κοχλιακά εμφυτεύματα, δύο χρόνων, και 2) Ελληνοκύπρια τυπικά αναπτυσσόμενα ακούοντα παιδιά επίσης δύο χρονών. Διεξάχθηκαν συγκρίσεις μεταξύ των δύο ομάδων ως προς την επίδραση της ηλικίας και της ακουστικής τους κατάσταση, στην αναπτυξιακή πορεία και ρυθμό ανάπτυξης στη χρήση του οριστικού άρθρου και μορφοσυνατκτικών δείκτων, όπως το Mean Length of Utterance (MLU). To Test of Early Receptive and Expressive Language (TEREL) αναπτύχθηκε για τους σκοπούς αυτής της έρευνας για να μπορούν να γίνουν έγκυρες στατιστικές συγκρίσεις μεταξύ των δύο ομάδων. Δεν φαίνεται να υπάρχει σημαντική επίδραση της κατάστασης ακοής των παιδιών στη χρήση του οριστικού άρθρου και την ανάπτυξη των μορφοσυντακτικών δείκτων. Η ηλικία έχει σημαντική επίδραση στην ανάπτυξη όλων των συμμετεχόντων. Ανιχνεύτηκαν ατομικές διαφορές μοναδικές σε κάθε συμμετέχοντα και συντείναν στις διαφορές στην γενική ανάπτυξη και χρήση του οριστικού άρθρου και την ανάπτυξη μορφοσυνατκτικών δείκτων. Δεν υπήρχε σημαντική διαφορά στις ανεπέξεργαστες βαθμολογίες των δύο ομάδων με την ομάδα νόρμας (231 παιδιά).

ABSTRACT

The primary purpose of this research project was to determine whether deaf Greek-Cypriot children with cochlear implants (CIs) follow the same developmental path as to their morphosyntactic development, and acquire the definite article in all genders, cases, and numbers in the same order and stage of development as their typically hearing and developing peers. The study was conducted across kindergartens in Cyprus. Two groups of children were recruited; a) Two-year-old Greek-Cypriot prelingually deaf children with CIs, and b) Two-year-old typically hearing children with no developmental delays. Comparisons were made between the two groups to examine if their increasing age and hearing status explained a proportion of the variability in the outcome. Mixed Linear Models were used to detect random effects. The Test of Early Receptive and Expressive Language (TEREL) was developed within the scope of this study to enable comparison of language levels using a standardized language tool. Age had a significant linear effect on definite article acquisition for both groups. Hearing status (CI vs TH) did not significantly affect any of the outcome measures. Inherent differences in children, i.e. random effects, explained about 33% to 50% of the variability in definite article acquisition. Alignment of both groups' TEREL raw scores support lack of significant effect of hearing status on definite article acquisition. Both groups achieved comparable scores to the normative sample of 231 children. Even though the participant sample was small, results indicate that children with CIs acquire the definite article in the same order and at the same age as their typically hearing and developing peers.

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

1.1. Hearing and Language

Acquiring language is a natural process that happens effortlessly for all children who have typical unremarkable development. For children who are born with a disability or developmental delay, language acquisition may be one of the hardest goals to achieve; worse yet, language may be something they never fully acquire.

Language is a complex system essential in everyday life if needs and wants are to be met. Children do not have the necessary linguistic skills to express themselves verbally for the entirety of the first year of life. During that first year, children's expressive language is characterized by a set of non-verbal prelinguistic skills necessary for spoken language to become the main mode of communication (Watt, 2006). These skills include but are not limited to eye-contact, joint attention, gestures, and facial expressions. Prelinguistic skills, like joint attention, are a prerequisite to acquiring language because a child needs to attend to stimuli, objects, and people in the environment to learn about them (Beuker, 2013). Eye-contact is important because a child needs to focus on the mother's face while she is talking, to understand that the mother is moving her lips to say something and that what she says has meaning. Prerequisite to the acquisition of these prelinguistic skills and ultimately the foundation to language learning, is hearing (Shojaei, Jafari, & Gholami, 2016). A sound will draw a hearing child's attention to a learning opportunity in the environment. Children who are born deaf will not have the proper foundation to develop the full set of prelinguistic skills such as using audition to turn to sound and thus seize a potential learning opportunity. This in turn affects the development of spoken language when defined as the output signal of speech perception and speech production (Blamey & Sarant, 2003). Based on the aforementioned definition, deaf children will have great difficulty in developing spoken language in its full form (Deal, 1996).

Hearing is achieved through one of the smallest organs in the body. The ear. Despite its small size it has a specialized function and is essential to language learning. A basic but important function of the ear is capturing sound. Once sound is captured, it is passed through the ear canal, to the middle ear, to the cochlea and then to the brain to be decoded and understood. The ear is the means to audition. Without hearing, localization and detection of sound are impossible; sounds in the environment and spoken language do not make sense (Plack, 2018).

Language is a broad term used to singify a system, a mode of communication. A language can have a phonological base as does spoken language, or an iconic base as does sign language. Both linguistic systems are comprised of a set of syntactical, grammatical, semantic and pragmatic rules. The stark constrast between spoken language and sign language is phonology. Spoken language needs to have a phonological foundation for it to develop normally and fully(Fowler, 1992). Sign language does not have a phonological system based on acquisition and blending of sounds, but rather a system based on the acquisition of gestures that acts as a replacement to the sound oriented phonological system of the spoken language (Perfetti & Sandak, 2000; Stokoe, 2005). Ergo, hearing is imperative in developing a phonological language as is spoken language, since it depends on the acquisition of sounds.

Hearing is required for sound recognition, a prerequisite for phonological development. Phonological development is necessary for word formation which is essential for semantic development in a phonologically based language, as is spoken language. Semantic development operates as the basis for syntactical and grammatical development. The glue that combines and ensures these language aspects work together to form a complete communication system, is pragmatics (Oller, 2005). Pragmatic development enables the child to make sense of the world and its interactions with peers and caregivers. Comprehending someone’s intention in communication and “reading” the non-verbal cues given during a conversation is what consititutes pragmatic development (Longobardi, Lonigro, Laghi, & O'Neill, 2017). A child needs all of these language aspects for it to acquire a phonological language, as is spoken language in its entirety and have it be an efficient and effective mode of communication.

Audibility has been associated with stronger language skills (Tomblin et al., 2015) and better speech perception McCreery et al. (2015). Constant exposure to auditory stimuli has been shown to aid in speech recognition (Pisoni & Geers, 2000) proper development of executive funtions such as auditory processing, sustained attention in adverse conditions (McCreery, Walker, Spratford, Lewis, & Brennan, 2019), and the development of pragmatics (Goberis et al., 2012; Shojaei et al., 2016). A hearing person can attend to the main speaker while being in a noisy environment. This skill cannot develop if hearing is absent.

1.2. Cochlear Implantation

As outlined previously, hearing is the foundation to language learning. Therefore, congenitally deaf children do not have the opportunity to acquire spoken language naturally. Consequently, sign language is the only mode of communication they can develop unless their hearing is restored.

Luckily, deafness is no longer untreatable. Parents of deaf children have the option of gaining access to sound through cochlear implantation. The two key functions of a normal-functioning cochlea are sound amplification and frequency resolution. Profoundly deaf children cannot discriminate any speech sounds. In other words, frequency resolution carried out by the cochlea is not taking place. Currently, new technology advancements can improve or restore hearing in two ways: hearing aids and cochlear implantation. Hearing aids amplify the sound but do not restore lost frequency resolution (Stelmachowicz, Pittman, Hoover, Lewis, & Moeller, 2004). They are appropriate for remediating mild to severe degrees of hearing loss. On the contrary, cochlear implants increase and partially restore the frequency resolution of the cochlea. This is achieved by stimulating the cochlea at different points with a surgically inserted electrode array. They are thus used to remediate congenital deafness or progressive hearing loss. Having restoration of sound facilitates speech sound discrimination and in turn provides the foundation for language development in children with profound hearing loss (Castellanos, 2015; Clark, 2015; Nicholas & Geers, 2007)

However, access to sound alone does not necessarily mean typical language development for congenitally deaf children (Levine, Strother-Garcia, Golinkoff, & Hirsh-Pasek, 2016; Pisoni, Cleary, Geers, & Tobey, 1999). Congenitally deaf children can receive a cochlear implant as early as 6 months of age, however not all of them do (Szagun & Schramm, 2016). The sound deprivation they experience until implantation affects the way these children develop language, and the linguistic level they can reach, before the window on language learning closes (Werker, 2015).

The literature on language development in hearing-impaired children is growing ever since Cochlear Implants (CIs) were invented. Scientists globally are studying how young CI recipients are acquiring language, after implantation (Nikolopoulos, Dyar, Archbold, & O'Donoghue, 2004; Schauwers, Gillis, Daemers, De Beukelaer, & Govaerts, 2004; Shojaei et al., 2016; Soleymani, Mahmoodabadi, & Nouri, 2016; Szagun, 2000; Szagun & Schramm, 2016; Wie, 2010). As a result, language development of young CI recipients has been the focus of scientists across the world. One of the questions asked frequently in the clinical setting and the research arena is, what is the right age for a child to be implanted and should a child be implanted later on in life.

1.2.1. Age at Implantation and Locke's Theory of Language Acquisition

Based on Locke's theory of language acquisition, it can be inferred that implantation should take place sooner rather than later. According to Locke (1997), children acquire language in four different phases. During the first phase, infants focus mainly on their caregiver's voice and face. During the second phase, children start learning vocabulary, mostly nouns, and verbs, through developing cognition and understanding of social interactions. The third phase is imperative in learning linguistic, grammatical constructs and producing complete syntactical forms resembling adult speech. During phase three the analytical mechanism is developed which allows the child to begin incorporating all the grammatical and syntactical rules of the language in its expressive language. Locke (1997) states that this phase does not remain active indefinitely and is mainly based on functions of the left hemisphere, which are responsible for morphology, syntax, and grammar. During the fourth phase, children integrate all the information that was previously acquired and expand their linguistic knowledge.

Phase two is largely dependent on external factors such as exposure to environmental stimuli. Input during phase two is imperative as it is unknown how much of the given input is stored in children's brains. If a delay is present during the second phase, the child will not have acquired enough utterances to enable the commencement of phase three (Marchman & Bates, 1994). This insufficiency will delay the emergence of the analytical mechanism of phase three. Therefore, phase three will not commence at the optimal biological time period. A late onset of phase three will manifest in expressive language delays and subsequently to receptive language delays. Since this phase is only active for a finite period, emerging past this optimal period will mean permanent inability to develop a complete language system. Therefore, these phases are interdependent (Ertmer & Inniger, 2009).

The analytical mechanism activated during phase three depends on internal factors. Mainly, on the variety of nouns and verbs the child has internalized and acquired, during phase two. Evidence of the analytical mechanism commencing is generalization of the use of regular past tense rules and regular noun plurals on irregular verbs and nouns. For example, when a child says '*leaved*' instead of '*left*' or '*mouses*' instead of '*mice.'* Such generalizations are not used in adult language. Therefore, a child is generating these generalized forms, not imitating them. Further evidence of this mechanism commencing is the use of morphologically altered existing vocabulary. Newly acquired morphological rules are applied to existing vocabulary to amend the meaning of the word according to context (Locke, 1997).

Phase two is claimed to be between 6 and 20 months of age and phase three between 20 and 37 months of age. Per Marcus et al. (1992) and Marchman, Plunkett, & Goodman, (1997), children begin to exhibit regularization of irregular noun forms around the age of 16 to 24 months of age. These studies lend support to Locke's theory in that the analytical mechanism he refers to seems to commence at the time he suggested.

Based on the aforementioned theoretical framework, children who are born with profound hearing loss and are deprived of auditory input should be expected to demonstrate delayed phase development. If they receive access to sensory input past this critical period of language acquisition, then they are expected to have fewer and incomplete syntactical forms. Children who are born with profound hearing loss usually receive hearing aids until they can undergo cochlear implantation. Having hearing aids with profound loss does not enable frequency resolution. In other words, children, in this case, have access to sound but cannot discriminate speech sounds (Govaerts, 2002).

A large body of literature attempts to answer the question of the optimum implantation age (Geers & Nicholas, 2013; Geers, Brenner, & Tobey, 2011; Levine et al., 2016; Nicholas & Geers, 2013; Nikolopoulos et al., 2004; Niparko, 2010; Schauwers et al., 2004; Tait, Nikolopoulos, & Lutman, 2007; Wie, 2010). There are considerable issues with studies involving cochlear implantation effectiveness including sample size. One of the most common issues found across studies is the representativeness of the sample obtained. These issues are comprehensively described and explained in a big body of studies by Geers, Brenner, & Tobey, (2011).

Despite these issues,, a considerable body of literature has been published that supports early implantation (Davidson, 2018; Szagun, 2004; Geers, & Nicholas, 2013; Geers, Brenner, & Tobey, 2011; Houston, 2012; Le Normand, 2013; Levine et al., 2016; May-Mederake, 2012; Nicholas & Geers, 2007; Nicholas & Geers, 2013; Nikolopoulos et al., 2004; Niparko, 2010; Schauwers et al., 2004; Sharma, Dorman, & Kral, 2005; Sharma, Dorman, & Spahr, 2002; Shojaei et al., 2016; Szagun & Schramm, 2016; Tait, De Raeve, & Nikolopoulos, 2007; Tait, Nikolopoulos, & Lutman, 2007; Tobey et al., 2013; Werker, 2015; Wie, 2010).

It has been shown that children implanted earlier versus later show a steeper increase in the rate of language comprehension development (Niparko, 2010). Earlier implantation can also contribute to faster vocabulary development (Nicholas & Geers, 2007). Most countries have 12 months as the earliest acceptable age for a child to be implanted, with the exception of some countries allowing cochlear implantation in children as young as 9 months old (Disorders, 2016). The language outcomes for implantation before the age of 12 months are mixed. However, an empirical study by Nicholas and Geers (2013), examined the benefits of implantation in 69 children who were implanted between the ages of 6 months and 11 months and between 12 and 18 months of age and were raised using the spoken language modality. No sign language was used at any point of their development. Receptive and expressive vocabulary, as well as syntax, was assessed at the age of 4.6 years old, using the Peabody Picture Vocabulary Test-III (PPVT-

III) and the Preschool Language Scale-IV (PLS IV). Children implanted before 12 months of age scored significantly higher than children implanted after the age of 12 months. Results of a regression analysis showed a significant effect of implantation age was on all three measures, receptive vocabulary, receptive language and expressive language.

Tobey et al. (2013) also provide support to early implantation. They carried out an empirical study with a large sample of 160 deaf children in total. The children were tested 4, 5, and 6 years post implantation. At 4 years post implantation, subjects had a mean age of 6.5 years. They were divided in two groups based on the age of implantation. The early implanted group consisted of 98 children that were implanted before the age of 2.6 years, while the late implanted group consisted of children implanted between the ages of 2.6 and 5 years. They looked at syntactical, grammatical and pragmatic development. Four subtests of the Comprehensive Assessment of Spoken Language (CASL) (Carrow-Woolfolk, 1999) were administered to measure spoken language development. Results revealed that spoken language development in the early implanted group as measured by syntax, grammar, and pragmatics, was significantly better than that of children implanted after the age of 2.5 years. However, despite the spoken language advantage in the early implanted group, it did not ensure them reaching typically developing levels by school age, i.e. 6 years post implantation. It was also interesting to see that, even though the late implanted group's overall mean composite standard scores improved at 6 years post implantation, they did not improve enough to mitigate the linguistic gap. Ergo, eventual implantation and consistent CI use cannot be viewed as alternatives to early implantation. This finding lends further support to Locke's language acquisition theory (Locke, 1997; Tobey et al., 2013).

This is further supported by Houston (2012) in a study aiming to examine word learning in young CI recipients compared to their typically-hearing peers. It was found that deaf children with more hearing prior to CI implantation and deaf children implanted up to the age of 12 months had similar word learning patterns and levels as their TH peers. This came in contrast to children with less hearing prior to implantation and children who were implanted past the first year of life. They did not demonstrate the same levels of novel word learning as typically-hearing children of the same age. A study carried out by Nikolopoulos et al. (2004) on the development of spoken language grammar found the age of implantation to be a significant contributor to language development. This study had a large sample of 82 prelingually deaf children who were implanted at a mean age of 4.2 years old +/- 1.3 years. The Test of Reception of Grammar (TROG) (Bishop, 2003) was used to assess children and the results revealed a considerable delay in children with CIs. There was improvement in comprehension of grammar in children implanted prior to the age of 4 years old as shown by the improved score on TROG, five years post implantation. Thirty-six percent of the children reached between 25^{th} and 75^{th} percentiles or higher than the 75^{th} percentile, as compared to their hearing peers. At five years post implantation, only 6% of children implanted after the age of 4 years, reached the range of 25^{th}-75^{th} percentiles. This supports the notion that children who are deprived of clear access to sound and are given access after the age of four years old develop language, but not in its adult-like form. Only a small percentage of children who are implanted late may develop language in its adult-like form. Consequently, they are considered delayed.

Based on findings like the ones described above, the critical window of 0-3 years old needs to be taken into consideration when deciding to pursue cochlear implantation. This is further reinforced by Schauwers et al. (2004) who conducted a study on babbling onset in prelingually deaf children implanted between 6 and 18 months old and found babbling to begin at a chronological age comparable to that of typically hearing infants. This finding supports not only early implantation but also Locke’s theory which claims that during phase 1 children pay attention to sounds and familiar faces so that they are ready by phase two, between 6 and 20 months of age, to begin using sounds and producing words. Participants in the aforementioned study, having gained access to sound early on, avoided the delay in the commencement of phases 1 and 2 and were able to begin producing sounds at a chronological age comparable to that of typically hearing and developing peers.

All underlying neural systems need to reach maturation if a critical period is to commence. Maturation and input are both necessary in facilitating a critical period (Werker, 2015). Consequently, for language learning to occur, congenitally deaf children need to be neurologically ready at the time of implantation to begin receiving auditory input. A study on premature infants demonstrated that there is activation of language areas in the Sylvian fissure at 28 to 32 weeks gestation, when phoneme discrimination takes place (Mahmoudzadeh, 2013). In other words, the neural basis for speech perception and language acquisition is established even before children are born. Therefore, all congenitally deaf infants need access to auditory input soon after they are born, so that the critical period can commence and language learning can take place. The necessity of auditory input for the jump start of a critical period is also supported by (Takesian & Hensch, 2013) who claim that environmental disruptions like hearing loss cause a delay in the commencement of a critical period.

Lastly, plasticity of the auditory system unveils the reason why early implantation is imperative to language learning and may also help explain why Locke's theory seems to apply well to congenitally deaf children and their language development. A study by Sharma, Dorman, & Spahr (2002), examined the plasticity of the auditory system through measurements of speech latency. This was done by measuring the P1 cortical auditory evoked potential (CAEP). CAEP shows how quickly the brain responds to auditory stimuli. The syllable /ba/ was presented to all subjects, ages 1.3 to 17.5 years old, via a speakerphone, to elicit the CAEP. It was found that the P1 latency in implanted children at the first activation of their CI resembled that of a new-born. Children who were implanted at a much older age, 11 years or older, were found to have little to no improvement in P1 latency as a response to speech 1 to 2 years post implantation. This was a stark contrast to children who were implanted before the age of 3.5 years old. Their P1 latency showed a considerable decrease within the first few months post implantation. Children who were implanted at the age of 7 years old also had a decreased P1 latency within a year of receiving their CIs. Despite this decrease in P1 latency their cortical responses to speech were still considered abnormal. This shows that auditory system plasticity decreases the longer the brain is kept without any auditory stimulation (Kral, 2012; Sharma, Dorman, & Kral, 2005). In other words, children who are implanted late miss out on activating the sensitive period for the central auditory system which remains maximally plastic for approximately the first 3.5 years of life.

It can thus be inferred that deprivation of auditory stimuli does not allow for typical language development as the sensitive period mentioned above fails to commence at the optimum time, i.e. when the central auditory system is maximally plastic. Having no or limited discrimination of speech sounds due to delayed P1 auditory cortical evoked potentials, will lead to limited vocabulary acquisition which would delay the commencement of phase three when grammatical acquisition begins. It is therefore imperative for these children to receive CIs as soon as possible so as to catch up and go through phase three during the optimal biological time.

Even though most of the literature (Davidson, 2018; Szagun, 2004; Geers, & Nicholas, 2013; Geers, Brenner, & Tobey, 2011; Houston, 2012; Le Normand, 2013; Levine et al., 2016; May-Mederake, 2012; Nicholas & Geers, 2007; Nicholas & Geers, 2013; Nikolopoulos et al., 2004; Niparko, 2010; Schauwers et al., 2004; Sharma, Dorman, & Kral, 2005; Sharma, Dorman, & Spahr, 2002; Shojaei et al., 2016; Szagun & Schramm, 2016; Tait, De Raeve, & Nikolopoulos, 2007; Tait, Nikolopoulos, & Lutman, 2007; Tobey et al., 2013; Werker, 2015; Wie, 2010) supports early implantation, there are studies that show that late implantation can also benefit children linguistically if they are exposed to a total communication system. In other words, sign language or cued speech and spoken language used simultaneously. Cued speech seems to benefit late implanted individuals more than sign language (Kos, Deriaz, Guyot, & Pelizzone, 2009; Leybaert & LaSasso, 2010). However, a consensus has not been reached on whether sign language aids in spoken language development in children with cochlear implants, or not. However, cued speech and sign language are not factors under investigation in this study. Therefore, such studies and their outcomes are not related to the design of the current study and do not directly contribute to the literature review supporting the current study's aim and necessity.

1.3. Development of Cognitive Skills

As explained earlier, lack of access to sound affects speech discrimination, which in turn has a snowballing effect on language acquisition as whole. Another aspect of language development that is affected by the lack of access to sound is the development of cognitive functions and most importantly, auditory attention, and in effect working memory.

'Executive functions' is a general term, the umbrella under which skills such as problem-solving, attention, concentration, fluency, decision making, and working memory fall (Diamond, 2013). Executive functions and language learning are intertwined. Children's ability to learn how to create meaningful sounds and units of language by chunking together auditory patterns, is an important ability in its greater extend, as it promotes the ability to sum up sequences into wholes. It also allows children to process, automatically, temporal patterns and auditory sequences (Hohm, Jennen-Steinmetz, Schmidt, & Laucht, 2007). These abilities can only be developed through audition. Access to sound and development of spoken language also builds in the formation of two important executive functions, namely, comprehension-integration, where language gains mental representations, and cognitive control (McClelland, Cameron, Connor, Farris, Jewkes, & Morrison,2007). Mental representation of language and cognitive control are important in that they help children and adults in using language in accordance to every social situation (Castellanos, 2015).

Kronenberger, Pisoni, Henning, and Colson (2013) examined the following executive functions: working memory, fluency-speed, and inhibition-concentration in 53 prelingually deaf children, adolescents and young adults who received a cochlear implant before the age of 7 years old. All participants had used their cochlear implant for more than 7 years. They were compared to normally hearing peers. CI participants scored lower on all measures assessing the aforementioned executive functions. On a subsequent study by the same authors, using the same sample, statistical analysis was done to examine the relationship between language skills and executive functions. A significant interaction between verbal working memory and language was found signifying the importance of age appropriate executive functions in language learning and use. CI participants had scored lower on verbal working memory compared to typically hearing peers (Colson, 2014; Nittrouer, Caldwell-Tarr, & Lowenstein, 2013).

1.3.1 Working Memory

Working memory is defined as a multicomponent system with a limited capacity. In an updated model by Baddeley (2003), working memory is said to be comprised of four components. These are: the visuospatial sketch pad, the central executive, the sub-vocal rehearsal, and the phonological loop. Daneman (1980) suggested working memory to be a resource-sharing system in that the same mechanism at work is in charge of storage and processing of information together (Asker-Árnason, 2015). This means that when the mechanism is taxed with processing, there is less capacity in the working memory system for keeping the information long enough to be understood. As a result, if processing is difficult because of unclear auditory input, as with hearing-impaired children and in particular late implanted children, then whatever capacity is left for holding on to newly processed information may be inadequate, in which case comprehension will be hindered.

The most important component for language enclosed in the working memory system is the phonological loop. It is imperative for novel word learning. For a new phonological representation to be established, the novel word presented to a child is held in temporal storage, while searching for an existing phonological representation that matches this novel word. When that is not found, a new phonological representation is formed. In typically developing children, phonological working memory is efficient in encoding new phonological representations into long-term memory (Asker-Árnason, 2015).

Studies have been conducted on deaf children with hearing aids and deaf children with CIs examining their phonological skills (Asker-Árnason, 2015; Geers, Brenner, & Tobey, 2011; Johnson, 2010). Children with CIs seem to have better phonological skills due to the early access to clear sound through the implantation of their cochlear implants. With early implantation comes better encoding of speech sounds and in effect the ability to accurately produce speech sounds (Blamey et al., 2001; Connor, Craig, Raudenbush, Heavner, & Zwolan, 2006). The overall performance on reading comprehension tests in deaf children with CIs was shown to be lower compared to that of typically developing children but better compared to deaf children with hearing aids (Geers, Mitchell, Warner-Czyz, Wang, & Eisenberg, 2017). Results on the phonological task showed a statistically significant poorer performance compared to their typically developing counterparts (Spencer & Tomblin, 2008). It can thus be inferred that, had their performance on the phonological task been equal to that of typically hearing peers, their reading comprehension level could have been equal to that of their TH peers.(Asker-Árnason, 2015; Geers & Hayes, 2011; Johnson, 2010)

It can be concluded that the absence or difficulty in forming novel phonological representations would suppress vocabulary expansion in all children. This applies to hearing impaired children as well. D. B. Pisoni and Geers (2000) examined children with CIs using measures of spoken language and digit span. They found that even though performance on spoken language measures and digit span correlated highly, performance on these two tasks also differed amongst CI participants. The authors claim that individual differences between CI participants may be accounted for by fundamental differences in how fast and efficiently novel information is processed by elementary operations. Elementary operations are used to encode, rehearse, retrieve, and manipulate phonological representation of spoken words.

In a study on the short-term memory of implanted Greek children, ages 4;6 to 8;6 years old, Talli (2018) added to the evidence showing that implanted children do not seem to close the gap between them and their typically hearing peers on their short-term memory phonological skills. This gap in phonological skills was shown to have an effect on their vocabulary. It was found that implanted children had poorer vocabulary compared to their typically hearing peers.

Based on the aforementioned studies and their outcomes, children with CIs are expected to have poorer vocabulary and thus poorer syntactical structures compared to their TH peers. This poorer performance could be attributed to deficits in the processing and storing of novel phonological representations.

Pisoni and Geers (2000), have established a correlation of .52 - .71 between spoken language abilities such as speech intelligibility, auditory comprehension, word recognition and digit span performance in children with CIs. This is further supported by other studies that showed that implanted children present with deficits in reasoning measures that encompass specific domains of verbal processing. This deficit seems to be due to the auditory deprivation they experience in the early years of life (Castellanos, 2015; Davidson, 2018; Nittrouer et al., 2013). Therefore, working memory contributes significantly to the language development of deaf children with CIs like it contributes to the language development of all children.

1.4. Acquisition of the Definite Article in Cypriot-Greek Children

Even though the literature on language development of children with CIs has been growing across languages there are some languages in which research remains limited. Greek is one of those languages and especially the Cypriot dialect of the Greek language. Very few studies have been conducted on Greek children with CIs. These studies, amongst others, have focused mainly on vocabulary acquisition (Oktapoti et al., 2016), training and knowledge of speech-language therapists who work with young CI recipients (Okalidou et al., 2014), short-term memory in children with cochlear implants (Talli et al., 2018) and speech production of hearing-impaired children (Sfakianaki et al., 2017). Studies on the Cypriot-Greek dialect, amongst others, published to the present date, examine mainly the acquisition and placement of clitics in typically hearing children and SLI children (Kambanaros, Grohmann, Michaelides, & Theodorou, 2013; Neokleous, 2015; Theodorou, 2015), and the linguistic phenotypes of language delays and factors that may affect language development of Cypriot-Greek pre-schoolers (Petinou & Spanoudis, 2014). Presently, there are no published studies examining the acquisition of the definite article in typically hearing or deaf children with CIs speaking the Greek-Cypriot dialect. Lack of such studies unveils the necessity of the current study.

Greek, unlike English, is a highly inflected language like German, Italian, French and Portuguese. What does the term ‘highly inflected’ mean and why is it important to consider when studying language acquisition? A highly inflected language is characterized with frequent obligatory contexts for grammatical morpheme use if meaning is to be conveyed and inferences are to be drawn. Inflection is one of the three main word-processes taking place aiding in word formation as language goes through the different developmental stages. The other two main word-processes are derivation and compounding (Ralli, 2003). While derivation is the process where additions are made to the core element, inflection is the process where additions are made to the periphery of the core element, the main form of the word (Tzakosta, 2015).

The importance of morphological development can be inferred through the purposes of these three main processes described above. The ability to add to the main word-form to convey meaning is integral to language acquisition. The importance of the acquisition of morphological rules of languages can be highlighted further, through them being linked with acting as a predictor to spelling abilities in school-aged children. Correct use of morphemes by preschool-aged children, is mirrored in their writing abilities later on in elementary school beginning at the end of first grade. Successful use and understanding of morphemes translates into higher levels of successful spelling skills in school-aged children when word spelling matches the rules determining their morphological structure (Grigorakis, 2016). It is assumed that in Greek, spelling requires the knowledge and ability to associate each morpheme to its respective grapheme or combination of graphemes, and each grapheme or combination of graphemes to its/their respective morpheme (Tsironi, 2016). In a longitudinal study by Grigorakis (2016), a sample of 215 children ages 5;1 to 6;1 years old participated in the study. The same children were tested again when they reached the first and second grade in elementary school. They studied how these children's metalinguistic morphological awareness, i.e. understanding the use and meaning of each morpheme, in preschool and first grade in elementary school affected or predicted their skills in spelling clitic suffixes using the correct corresponding grapheme. Results showed that good understanding of the meaning of morphemes in kindergarten and first grade in elementary school, makes it easier for children to begin spelling correctly the same morphemes at the end of the first grade of elementary school onwards.,

Morphemes in the Greek language can be described in four different ways. These are: a) Free and bound morphemes, b) lexical and grammatical, c) derivational and clitic morphemes, and d) root and non-root morphemes (Giadomenico, 2006; Holton, Mackridge, & Philippaki-Warburton, 2016). Following the broad discussion on language development in children with CIs across the world and the lack of research in Cypriot-Greek deaf children's morphosyntactic development and general development of the spoken language, one may wonder, rightfully so, why acquisition of the definite article was singled out and chosen for investigation. One of the main grammatical aspects that requires the addition of morphemes onto nouns and adjectives to convey meaning, is the definite article. The definite article is very frequent as it precedes nouns. Furthermore, it takes on different forms according to the case, number and gender of the noun. Therefore, the definite article carries heavy weight linguistic information and has high frequency. Clinical experience has demonstrated lack of use of the definite article in later implanted deaf children in Cyprus. It is therefore an interesting and important grammatical aspect to examine.

More specifically, the definite article in Greek, is declenated according to the gender, case, and number of the noun or adjective proceeding it. In other words, wrong declenation of the definite article would signify either the wrong gender, or the wrong case, or the wrong number, or all of the aforementioned aspects of the noun proceeding it. In the Cypriot dialect of the Greek language, there are three genders as in English. These are masculine, feminine, and neutral. These nouns can be in singular or plural forms. This is also common in English and the Cypriot-Greek dialect. English varies from the Greek language and consequently the Cypriot-Greek dialect, in that there are no cases. In Greek there are four cases, Nominative, Accusative, Dative and Imperative. Examples are given below.

The nominative case is used when the speaker wants to convey what someone did. For example:

The sentence,

“Anna went to the grocery store” would be
“**Η** Άννα πήγε στην υπεραγορά”

where the definite article ***H*** signifies Anna’s gender (feminine), that there is one of her (number singular), and that she is the main subject of the sentence (nominative).

Accusative is used when the speaker wants to say what happened when they went somewhere or did something. For example:

The sentence,

“I went to the grocery store today and ran into Anna.” would be
“Πήγα στην υπεραγορά και είδα **την Άννα.**”

The definite article here changes from ***H*** to ***την*** as Anna is no longer the main subject in the sentence. She is now part of an embedded clause. The speaker however, is still referring only to her (number singular).

Genitive case is used when the speaker appoints possession of something to someone. For example:

The sentence,

“These are Anna’s shoes.” would be
“Αυτά τα παπούτσια είναι **της Άννας.**”

The definite article has changed from ***H*** to ***της*** to signify possession and gender (feminine). It also establishes Anna as the main subject of the sentence, not the shoes. Thus the number appointed by the definite article is singular (Holton, Mackridge, & Philippaki-Warburton, 2016).

Evidence from other languages similar to Greek, like German, suggest that severely hearing impaired children with hearing aids and congenitally deaf children implanted late with no prior access to any kind of amplification have struggled with the use of such grammatical elements. Per Szagun (2002), German children with hearing impairment struggle in the use of definite articles and resort to using mostly content words without their accompanying definite article. This difficulty may occur because definite articles are less salient in running speech compared to content words (nouns and verbs), which are emphasized more. The German language is similar to Greek, as they share similar inflectional and morphological systems. Both languages have articles in prenominal sentence position. Therefore, the vocal emphasis in running speech will be on the noun and not the definite article preceding them. Definite articles in both languages carry meaning in that they define the gender and number (i.e. singular vs. plural) of a noun. Furthermore, definite article use and positioning in a sentence or lack of, defines the type of sentence being used (i.e., nouns in argument vs. non-argument position, in subject vs. object position, use of count vs. mass nouns, use of specific vs. non-specific nouns, and verb type) (Marinis, 2002). Like German, definite articles in Greek are salient and harder to discriminate but are imperative in grammar acquisition as they are the foundation for establishing a referent in a narrative and the basis upon which clitics can be formulated respective to the established referent (Szagun, 2004). The definite articles in the Greek language are as follows:

Table 1.4.1. *The form of the Definite Article in each of the genders, numbers, and cases*

	Singular			Plural		
	Masculine	Feminine	Neutral	Masculine	Feminine	Neutral
Nominative	***Ο φίλος***	***Η πόρτα***	***Το παιδί***	***Οι φίλοι***	***Οι πόρτες***	***Τα παιδιά***
Accusative	***Τον φίλο***	***Την πόρτα***	***Το παιδί***	***Τους φίλους***	***Τις πόρτες***	***Τα παιδιά***
Genitive	***Του φίλου***	***Της πόρτας***	***Του παιδιού***	***Των φίλων***	***Των πόρτων***	***Των παιδιών***
Vocative	-	-	-	-	-	-

Table 1.1.5.1 demonstrates the use of the definite article based on gender, case, and number. Notice that the form of the definite article in the singular number of the neutral gender in the nominative and accusative cases, remains unchanged, as does the ending of the noun as well. In both cases the noun ends in ***-ι***. The same is true for the neutral plural form of the definite article when in nominative and accusative cases. The ending of the noun, yet again remains unchanged, ***-ια***. Notice also the form of the definite article when all three genders are in plural in the Genitive case. Its from is the same for all three genders as is the ending of the nouns regardless of gender. Therefore, the ending of the nouns does not help in distinguishing gender in the plural number in the Genitive case, but does relay possession.

The measure used to analyse language samples is the Mean Length of Utterance, MLU hereafter. MLU is described in detail in the next section. When calculating a child's MLU in morphemes (MLU-m), each morpheme is appointed one point. Resemblances in morphemes as the ones evident in the endings of the definite article in the Greek language and consequently the Cypriot-Greek dialect, make coding challenging. Credit for such morphemes should only be given if the nouns used in the aforementioned numbers and cases are part of a complete and grammatically correct sentence indicating conscious declenation of the definite article and proceeding noun; or in the presence of evidence of using the noun in question in other cases or numbers. This would provide proof of having acquired the specific form rather than assuming the child has acquired it. This should be done to avoid falsely appointing credit and inflating MLU-m values in highly inflected languages like Greek, German, and Italian.

1.5. Language sampling and MLU

The *Mean Length of Utterance*, is a popular language measure as it is derived in a more naturalistic manner compared to standardized assessments. MLU is measured through the collection of a language sample. A language sample, is a sample of a child's spontaneous language, realised in a naturalistic setting. It does not require implementing and following rules of standardized tests; thus, the child is free to express their thoughts without any restrictions or prompting that may help elicit targeted grammatical forms. In earlier studies (Evans & Craig, 1992; Hadley, 1998; Heilmann, Nockerts, & Miller, 2010; Rowe, 2004), children's language samples were collected through play with one of the parents and the experimenter in a lab or at the child's house. Currently, this set up, collecting language samples in the clinic or the child's house, seems to be the most popular.

Another method used, is through the use of a recorder by the parent. Hardware has been developed to enable the recording of spontaneous conversations between caregivers and children while at home carrying out daily routines. The parent is asked to wear a recorder around their neck and begin recording according to the instructions given by the experimenter. This method seems to be the most naturalistic way of collecting a language sample as it does not add external factors, such as the presence of an experimenter or a foreign location for the child, that may impact the spontaneity of the child at the time of collection. However, some drawbacks have been observed. Parents often forget to turn on the recorder at the time when they are instructed to. This results in loss of data. Also, having the recorder on them immediately makes parents conscious of the fact that they are being recorded and may influence the type of language they use, the nature of the interaction with their child, and the stimuli they involve in the conversation.

Whether at home or a clinical setting, language sampling seems to be the most suitable method of studying children's language acquisition. It does not "force" the child to behave under constraints to keep the procedure standardised as with language assessments. Furthermore, any dialectal or cultural differences will be accounted for in a language sample in contrast to standardized assessments which may have not been developed to account for such differences (Stockman, 1996).

1.6. MLU-m and MLU-w as language development measures

Brown (1973) was the first to formulate MLU. He disagreed with the notion that language is acquired through memorization of sentence structures children hear from adults. He argues that there are semantic relations in the words children put together from very early on even if the combinations they come up with are not grammatically marked in any way. It is evident that parents will notice mistakes children make syntactically in the early stages of expressive language development but will not notice mistakes in semantic relations, or lack of morpheme use. Brown (1973) argued that the linguistic development of children should be studied on a deeper level, that is morphologically, rather than syntactically which is more superficial. This is because morphological development renders meaning and is needed for the development of pragmatics and metalinguistic skills. This is shown in the way MLU increases on average within Stage I. During the first stage, children's expressive language is largely described by single word or combinations of words. MLU at first increases because children begin stringing more and more words together within a single utterance. This increase in the number of words they combine, does not unveil the use of the grammatical rules that govern the child's native language. Further increase in MLU during the first stage is then due to the emergence of certain inflections followed by embedded small clauses in pre-existing simple structured sentences. It can therefore be concluded that morphological development reveals more of the child's linguistic knowledge than does syntactical development alone. This type of measurement is based on the notion that grammatical development emerges only after children's expressive vocabulary passes the fifty-word mark when children begin forming sentence. Past this critical point, grammatical morphemes begin to be added onto words that are already part of the child's mental lexicon (Marchman, Martinez-Sussmann, & Dale, 2004; Szagun & Schramm, 2019).

The development of MLU as a measure of linguistic knowledge based on the morphological development of the child, has been used across the world and is still being used clinically by speech-language pathologists mainly in English-speaking countries. The reason why MLU is used clinically mainly in English-speaking countries is because the rules formed on how to calculate MLU are based on the English language. This poses a small hinderance in that English has a much simpler morphological structure compared to other highly inflected languages like German, Greek, Italian, and Russian. For example, the word *he* would be counted as one morpheme. The same word in Greek, *αυτός*, would be counted as 4 morphemes because there are four aspects to look at; *Noun* + *Person* + *Number* + *Case*. As mentioned earlier, the endings of nouns in Greek change according to gender, number and case. Therefore, they would all have to be taken into consideration when calculating the MLU of a child's language. From this it can be inferred and expected that a Greek-speaking child's MLU at each of the proposed stages by Brown (1973), will be higher than that of an English-speaking child, if that child is making correct use of the aforementioned morphological markers.

A study by Padilla (1975) on the acquisition of bilingual children, learning Spanish and English, collected language samples to study their language acquisition. They used MLU-m as one of their language measures. They used the same set of rules Brown (1973) to code and analyse the language samples. However, having Spanish as one of the languages under investigation, they took into account the inflection of adjectives, nouns and verbs by adding rules to the already established set. One of the rules stated “Count as separate morphemes all inflectional endings on adjectives. Justification is that adjectives in Spanish agree in gender and number with the noun they modify” (pg. 41). The current study utilizes the same reasoning so that important inflections that render meaning in Greek are not excluded from the analysis.

A higher expected MLU by children who speak highly inflected languages, is one of the reasons many scientists investigating language acquisition of such languages, prefer to use MLU in words instead of MLU in morphemes, which seems to defeat the purposed of studying morphological development in the first place. That, and the lack of MLU-m norms in such languages make MLU in words more popular. Furthermore, calculating MLU in words is far simpler, easier, and faster than calculating MLU in morphemes. Norms for MLU in morphemes would be difficult to establish as they require large samples and language sample analysis, thus coding, and MLU-m calculations will be extremely time consuming. Systematic Analysis of Language Transcripts (SALT) is a transcription software that was designed to analyse language through pre-programmed standardized ways of transcribing and analysing language samples ("Salt Software LCC," 2019). Its use reduces transcription and analysis of language samples considerably making utilization of large samples, feasible. SALT is available in many languages. Unfortunately, it is not currently available for the Greek language. Therefore, language sample analysis is very time consuming if it has to be done by hand (Schuele, 2010).

Even though MLU-m is time consuming and more complicated for highly inflected languages, it is still more informative than MLU-w as to the grammatical structures a child develops at each stage. This information remains crucial in understanding the deficits of language delayed children so that proper intervention programs can be developed. It appears that its use in studies on linguistic development of highly inflected languages is increasing. A few studies in Italy have used MLU-m as one of their main measures of language development of Italian children (Majorano, 2018; Marques, 2011).

One study on the acquisition of the Cypriot-Greek dialect of the Greek language examined the mean length of utterance in children ages 36 to 48 months old in words (Voniati, 2016). This study used MLU in words instead of MLU in morphemes for the aforementioned reasons. Furthermore, several studies confirm the positive correlation between MLUm and MLUw and thus enable researchers to study language development cross linguistically. For a comprehensive review on this controversy please refer to Ezeizabarrena (2018a). A high correlation between the two allows scientists to use MLUw as a measure of language development in children with confidence. However, as mentioned before, even if the two measures are highly correlated, MLUw cannot and does not provide information as to the morphemes a child has acquired (Wieczorek, 2010).

In spite of the controversy between the two measures, MLUm is necessary for the current study as the investigator is mostly interested in the order in which the different definite article forms emerge in CI children’s language development, a linguistic aspect that cannot be detected using MLUw alone.

1.7. Study 2: Development of Test of Early Receptive and Expressive Language (TEREL)

A second sub-study of the current study was the development of a standardized language assessment; the Test of Early Receptive and Expressive Language (TEREL). Presently there are no language assessments developed to examine the language development of Cypriot-Greek children speaking the Cypriot-Greek dialect. TEREL was based on the method of the Pearson assessment Preschool Language Scale IV, in that it utilized both pictures and manipulatives to ensure a developmentally appropriate testing setup.

It was deemed necessary to develop such an assessment within the scope of this study to be able to make valid claims of typically hearing children's development as being typical. Furthermore, responses to items examining definite article acquisition can be used statistically to reveal similarities and differences when comparing CI children to this study's control group and TEREL's normative sample. Such comparisons will confirm or refute conclusions drawn from MLUm scores as well as the shape of their growth trajectories.

1.8. Aim and Hypotheses

The aim of this study will be to investigate when prelingually deaf children who received CIs between 12 and 15 months of age, acquire definite articles compared to their typically developing peers. As mentioned above, articles are an important grammatical aspect in the Greek language. The definite article is necessary for determining the gender of the noun, whether it is in singular or plural number and its case. Without knowledge of the definite article, correct clitic production is not possible as it is the definite article that will determine the gender, case, and number of the clitic in question. It can be said that the definite article is necessary for establishing a referent and thus draw inferences in more complex syntactical forms.

In Cyprus, omission of definite articles and other salient grammatical markers, has been clinically observed in older children with profound hearing loss who have hearing aids. Hearing aids offer amplification, however, definite articles are omitted from their natural language because of their low intensity in running speech compared to the intensity of content words. This phenomenon has been changing with the introduction of CIs. Therefore, this aspect of language development renders more in depth investigation to establish newly achieved norms within the implanted population.

Establishing a database for the aforementioned current unknowns is important because results will give speech pathologists and teachers of the deaf a better idea as to which grammatical elements require early intervention in an attempt to mitigate the gaps that form in the language development of Greek-Cypriot hearing-impaired children. At the initial stages of development, teachers, as well as mothers, make certain that the child understands and acquires vocabulary and basic concepts, such as prepositions, in an effort to build the child's receptive and expressive language. Omissions or errors in definite article use are usually remediated through modelling in routine linguistic settings. Explicit teaching of definite and indefinite articles, for older children who no longer learn solely by increased exposure to the targeted grammatical structure, begins in the elementary years where writing and reading skills, also, emerge.

Furthermore, results from TEREL's standardization will also be very useful. If this tool proves to have good construct validity and reliability it was designed to have, then it can be used in schools to better assess children with receptive and expressive language difficulties. Developing another tool that will measure the same constructs will provide professionals with an alternative and a validity check of the results they got from TEREL, thus providing reliable results and confidence in their interpretation.

A second aim of this study is to determine if hearing impaired children with CIs follow the same path of development and acquire the targeted grammatical morphemes, i.e. the definite article in all its forms, in the same order and stage of development as their typically hearing peers.

This study hypothesizes that:

a) Children with CIs will follow the same developmental path as their typically hearing peers. More specifically, it is expected that children with CIs will show emergence of use of all forms of the definite article outlined within this chapter, at the same age as their TH peers.

b) Children with CIs will show acquisition of the various definite article forms at the same rate of their typically-hearing peers.

c) There will be no statistically significant differences between the morphosyntactic skills of the two groups as measured using MLUm and MLUw, since all CI children in this study were implanted between the ages of 12 and 15 months.

d) Lastly, there will be no significant statistical significance in the raw scores on the Test of Early Receptive and Expressive Language of the two groups.

METHODOLOGY

This chapter will explore the way in which language development was documented and assessed in children with cochlear implants and children with typical development over the course of three years. Children were recorded during a language sampling session, a structured session where specific questions were asked in an attempt to elicit the targeted grammatical aspects, and tested using the Test of Early Receptive and Expressive Language (TEREL) during a third session. This chapter is divided into nine sections which will describe, the participants and demographics, how these participants were recruited, the equipment used, the four testing sessions, the language measures that will be used to assess children's language development, and lastly the procedure for the development of the language assessment TEREL.

2.1. Participants and Demographics

The sample consisted of two groups. The experimental group (CI) consisted of congenitally deaf children who had cochlear implants and the control group (TH) consisted of typically hearing developing children.

The CI group consisted originally, of six congenitally deaf Cypriot-Greek children from monolingual families speaking the Cypriot-Greek dialect. The six congenitally deaf Cypriot-Greek children were all the deaf children with CIs available at the commencement of the study. The inclusion criteria for CI children were: a) came from monolingual families speaking the Cypriot-Greek dialect, b) had deafness as their only disability, c) had a chronological age of 2 years old, and d) an implantation age, for at least one of their cochlear implants, between 12 and 15 months of age.

All but one congenitally deaf child received bilateral implants sequentially. Implantation of the first cochlear implant (CI) occurred between the ages of 12 and 14 months for all six deaf children. Implantation of the second cochlear implant occurred between the ages of 13 and 15 months for three of the six children.

Two of the CI children received the second implant at a later stage, between the ages of 24 and 36 months. One of the late implantations was due to parent denial in the benefits of getting a second implant and fear of submitting her child to a second surgery. The second child that received her second implant at 36 months was due to Ventricular Aqueduct syndrome (VA) that caused her hearing to be lost completely, leaving cochlear implantation as her only option. Prior to her hearing being lost, this participant had a hearing aid in that deafened ear from which she had fair gain in her hearing (a hearing threshold of 45dB (the metric unit for hearing threshold of all speech sound frequencies), equivalent to a moderate hearing loss).

There was only one CI child with bimodal amplification i.e. a cochlear implant on one side and a hearing aid on the other side. Even though this child's hearing thresholds were >90dB in both ears, she received very good benefit from her hearing aid as it reduced her hearing threshold to 30-35dB, equivalent to a mild hearing loss. Good benefit and her satisfactory linguistic development were the reasons why she remained bimodal.

There were two boys and four girls, all of whom were between 21 and 23 months at the commencement of the study. All but three children resided in the city of Limassol, one in the city of Paphos, one in the city of Paralimni, and one in Nicosia. The child residing in Nicosia was diagnosed with Cerebral Palsy as she was born prematurely at 26 weeks gestation. She was therefore excluded from the study as hearing loss was not her only disability. Participation of the child with VA, was discontinued due to continuous occurrence of tantrums at the first 4 time points. Even though, multiple attempts were made to create rapport with this child, tantrum occurrence would not subside leaving discontinuation of her participation as the only option. She was later diagnosed with severe sensory integration issues. The final group of CI children consistent of four children, two boys and two girls, three of whom received sequential CIs bilaterally, and one of whom had bimodal amplification.

The TH group consisted of eight typically hearing monolingual Cypriot-Greek children speaking the Cypriot dialect of the Greek language. The eligibility criteria for the typically hearing children were: a) came from monolingual families who speak the Cypriot-Greek dialect, b) they had no existent diagnosis or other disabilities, c) had a chronological age of 2 years old, d) their hearing was within normal limits, and e) they demonstrated typical language development as per teacher and parent report. This group consisted of four girls and four boys all between the ages of 21 and 23 months old. All children had unremarkable medical histories apart from one who was born prematurely at 32 weeks gestation with no further complications.

Their language development was typical for their ages as determined by a teacher and parent interview conducted by the primary investigator who was also a speech language pathologist. All children were at the 2-word stage as per parent and teacher report and followed directions with ease at home and in the classroom. No standardized tests were used to evaluate their language level as none are available for the Greek language in general.

For this reason, a second study within the realms of this doctoral dissertation was conducted during which TEREL was developed and is currently in the process of being standardized. It was used to determine participants' language level and to compare them against an emerging norm to ensure they are typically developing. It was also used to examine if CI group children had bridged the language gap between them and their normally developing peers. TEREL could not be administered at the beginning of the study as it was not yet developed. It was therefore administered at the end of the study when children were 5 years old. Since TEREL was unavailable at the beginning of the study, children were identified as typically developing through parent and teacher interview conducted by the investigator who was a speech-language pathologist. Children in this group had their hearing tested and was found to be within normal limits, <25dB in 500, 1000, 2000, and 4000Hz.

2.2. Recruitment of Participants

2.2.1a Hearing Impaired Children

All hearing impaired children were identified through an audiological center in Cyprus based on the degree of their hearing loss (profound), the age at which they were implanted (12 to 15 months old), their chronological age (2 years old), not having been diagnosed with any genetic syndrome, and having Cypriot-Greek as the sole dialect of the Greek language spoken in the home. Prospective participants' parents were contacted telephonically by the manager of the center informing them of the study. Once an interest to participate was expressed by the parents, the investigator contacted them telephonically and provided further details regarding the nature of the study. Further arrangements were made as to when the first session would take place with those who verbally consented to participating in the study.

Parents of all six congenitally deaf children available in Cyprus, who qualified for the study, consented verbally in having their child participate in the study. Each child's parents then received an information letter describing in detail the purpose and design of the study, and how any personal identifying data concerning their child would be stored and protected from unauthorized usage and display, to retain anonymity. They were also given a consent form stating that they consented to their child's participation which had to be signed and returned to the investigator before the experimental sessions could commence.

2.2.1b Typically Developing Children

Six of the 8 typically developing children were recruited from a preschool in Limassol. Of the two that were not recruited from the preschool in Limassol, one was recruited from a preschool in Nicosia, and the other from a preschool in Larnaca. They were identified by the teacher using the inclusion criteria of the study outlined above.

The parents of these prospective participants were contacted by the children's preschool principal. The same procedure was followed as with the parents of hearing-impaired children mentioned above. Once parents demonstrated an interest to have their children participate in this study, the investigator contacted them to provide more information as to the nature and goals of the study. An information letter was sent to the parents who verbally consented to their child's participation, describing in detail the purpose and design of the study, and how any identifying personal data concerning their child would be stored and protected from unauthorized usage and display, to retain anonymity. They were also given a consent form stating that they consented to their child's participation. The consent form had to be signed and returned to the investigator before the experimental sessions could commence.

2.3. Equipment

The Language Sampling Session (LS) and the Structured Session (SS) were recorded and videotaped for transcription purposes using the Tascam DR100MKII portable recorder, the Sony ECM88B microphone, and the Zoom Q3HD portable camera. These were specifically chosen for the clarity and precision recording they offer when recording speech in particular, after consulting with an HHB Communications specialist in London.

Prior to the commencement of LS and SS, the camera with a mini tripod attached, was placed on a chair or on the table, depending on the height of the child, across the child. The microphone was connected to the portable recorder. The child was then shown the microphone and was told that the microphone needed to be pinned to his/her clothes in order for the investigator to hear their voice better. The child was allowed and encouraged to touch the microphone before recording began so he could feel what it is like. This was done to avoid tampering with the microphone during the session to ensure good recording quality. All children accepted having the microphone pinned to their clothes.

2.4. Baseline Testing

Prior to carrying out the first language session, each child's language and auditory processing level was determined using two questionnaires; 1) The Communication Development Inventory questionnaire (CDI) (Taxitari, 2015; Thal, DesJardin, & Eisenberg, 2007) which evaluates receptive and expressive language and, 2) The LittlEARS® Questionnaire (Coninx et al., 2009) which assesses the auditory development in toddlers. In addition to CDI, parents were interviewed further regarding important language milestones for each of the typically developing children. Among other questions, they were asked to give the age at which the child began babbling, said his/her first words, and whether or not the child located frequently used objects and followed simple directions (Luinge, Post, Wit, & Goorhuis-Brouwer, 2006). CDI was then used to establish whether or not the child had approximately 50 spontaneous words expressively at the time of recruitment. All TH children's expressive vocabulary was comprised of >45 words.

The auditory development of each of the typically developing children was also evaluated using the LittlEARS® Questionnaire to ensure there were no issues with hearing during infancy (Coninx et al., 2009). Additional to the LittlEARS® Questionnaire, parents were asked to report if the child had passed the newborn hearing screening, and if the child suffered from ear infections. If the child had a history of recurring ear infections, parents were asked to state how often they occurred to ensure their hearing was not compromised during the first two years of their life. Since all typically developing participants attended preschool, their teacher was asked to state whether (s)he had any concerns about their linguistic development. As per teacher report, all typically developing children recruited for this study, raised no concerns regarding their language development.

Parents of children with CIs were given the two aforementioned questionnaires to fill out in an attempt to collect information on the child's initial language and auditory level.

Non-verbal intelligence and overall receptive and expressive language level were tested using Raven's test and the Test of Early Receptive and Expressive Language (TEREL) at the end of the study. They were tested at the end of the study as Raven's had to be modified to match the developmental level of the children and TEREL had to be developed. Both tasks required time which did not allow the investigator to test the children at the commencement of the study. There was no statistically significant difference between the two groups' Raven's total scores.

2.5. Language Sampling Session (LS)

Initially the language sampling session was piloted on a convenience sample to see which books and toys elicited most spontaneous language within that set-up. Three mini pilots on different toys and two different pilots on possible books were carried out on the same 3 children, each time, prior to piloting the final design.

The first pilot took place at the home of each child in their room where it was quiet with no external distractions. The toys piloted were various wind-up toys which included but were not exclusive to a ladybug that flipped over, a jumping frog, a speedy bus, a dying flower, and a falling-down butterfly. Amongst these wind-up toys there were some other toys as well which were not wind-up. These were bubbles, a soft ball, a mobile phone, and child-safe scissors. These toys were originally thought of being a good selection as they had been used in therapy with the investigator. Empirically, they had shown to attract attention and draw the interest of children. They also promoted elicitation of language such as requesting assistance to wind-up the toy, requesting to wind-up the toy again, asking questions as to how the toy worked and what it did, and commenting on which toy the child liked best. This type of language however, was proven to be elicited only within the setting of a therapy session. When the box of toys was given to the children and were told to open the box and see its contents, all three children opened the box, took a look at each toy, asked to wind-up each one, and commented on whether they liked it or not. However, once they went through all the toys, they lost interest and did not want to play with them anymore. Moreover, once they saw how you wind-up a toy, they managed to do it by themselves and ceased requesting assistance or to see it 'go' again. Lastly, the language elicited was limited, syntactically simple and only occasionally contained obligatory contexts for some of the definite articles. Since definite article, in all genders, cases, and numbers, is the main grammatical aspect this study is investigating, it was of utmost importance that the toys chosen promoted the elicitation of the definite article in all its possible forms. Having heard these children tell stories about their favorite cartoon characters, it was obvious to the investigator that these toys were not eliciting the realm of grammatical structures and vocabulary these children used in their spontaneous language or the main grammatical aspect targeted in this study.

Once this pilot was completed, the second pilot took place in the homes of the same three children. Since simplistic and inadequate utterances were the problem with the toys used in the first pilot, the toys used in the second pilot were meant to promote role playing and dialogue. During the second pilot, the children were given farm animals, a farmer, and a tractor to play with. Children were more interested in this set of toys and more utterances were elicited for a longer time period. This play scenario elicited articles in the nominative case for all genders for the most part. The definite articles in the nominative case were elicited through prompting questions posed by the investigator. Very little descriptive language was used. Additionally, children used the first person extensively as they made up pretend dialogues between animals. Genitive and accusative case forms were not spontaneously used at all, in none of the gender forms. However, with some redirection from the examiner and a few targeted questions, the definite articles were elicited with considerable ease.

The third mini pilot was carried out on the same three children at their homes in a quiet room. The examiner presented the same toys as in the second pilot with the addition of a farm house. The reasoning behind adding the farmhouse to the set was that the presence of the farmhouse would create opportunities for children to communicate where each animal would go and what each animal would do in the farmhouse; thus using the third person singular and in effect eliciting the definite article in all genders and numbers and possibly in all cases. Once this set was tried out, it was proved to be too interesting. Children were too engrossed in putting the animals to sleep in the farmhouse and feeding the animals. As a result, spontaneous language was reduced noticeably.

The fourth and fifth pilots focused on selecting the book that would be used during the language sampling. Both pilots were carried out on only two of the children of the convenience sample, as one of them was unavailable at the time of these pilots. A new participant was recruited. The first book that was piloted was “The Very Busy Spider” by Eric Carle. This book talked about a spider that was too busy for her friends. The pictures in this book were very simple and depicted mainly the spider building her web with a friend of hers standing on the side. The book was presented to the child and was instructed to describe to the examiner what he/she was looking at. All children went through the book very quickly and mostly named the animals that were depicted in the pictures. Therefore, this book was excluded. This was one of the books used in the study of Rowe, (2004) where a language sample was obtained from children while interacting with each parent separately in an attempt to see how individual interaction styles affect language development in children.

The second book piloted was “Frog, where are you?” written by Mercer Mayer. This book did not have any words. It is made up, solely, of black and white pictures which in a sense allows the child to make up his/her own story without being influenced by a pre-existing story. This book was used in the study of Sera (1992) where goal of the study was the use of copulas in children's spontaneous language. Children participating in this pilot were completely uninterested in this book as the pictures were colorless and too busy. As a result, this book was rejected as well. The investigator chose to pilot next a book called, "Monkey Puzzle" written by Julia Donaldson and illustrated by Axel Scheffler. The next paragraph describes how the pilot for this book was carried out and its results.

The design of the sixth and final pilot was based on the study of Rowe (2004) where the child was presented with three different bags. The first bag contained a book, the second bag contained play food items, pots and pans, and the third bag contained farm animals, a farmer, and a tractor. This pilot was run on four children, one boy and three girls all between the ages of 2 and 2;6 years old. These children were recruited from two different cities in Cyprus. All children were familiar with the investigator and all of them attended preschool; therefore, the piloting session was carried out at each child's preschool in a quiet room. Each child was alone with the investigator during the language sampling session. All children were recorded and videotaped during this session for transcription purposes. All confidentiality procedures were followed and parents were informed thusly.

Each child was given each of the bags consecutively and was allowed to interact with the contents of each bag any way they wanted for 10 minutes per bag. That amounted to a total of 30 minutes. This design proved to be the most suitable. Children were engaged throughout the 30 minutes and they enjoyed playing with the toys without reducing the language used to onomatopoetic sounds and short phrases. All children used longer utterances while interacting with the contents of each bag and included the examiner in their play scenario as well.

Based on the results of all the pilots carried out, it was decided to use Rowe (2004) design where the toys would be presented in three separate bags and the child would be allowed to play with the contents of each bag for 10 minutes.

The book chosen was “Monkey Puzzle” as it was the only one eliciting the longest utterances. It was also chosen for its vivid and clear illustrations. Moreover, an array of animals is presented in the book giving an opportunity for the definite articles of the Greek language in all genders to be used spontaneously by the child. The story was not read to the children during the language sampling to limit excess language input that could have incurred the child to use more imitative utterances than spontaneous. The second bag used contained food items, a stove, pots, pans, cups, plates, play-knives, spoons, and forks. Lastly, the third bag contained a tractor, a farmer and two of each of the following farm animals: dog, pig, sheep, cow, horse, and duck. The aforementioned toys were chosen for three reasons: 1) They were developmentally appropriate, 2) they were used in Rowe’s (2004) study, and 3) they were piloted and proved to elicit the definite article either spontaneously or with some prompting with considerable ease.

2.5.1 Procedure during LS

LS was the first session that was completed once the parent consented to their child’s participation and returned the two questionnaires (CDI and LittlEARS®) completed at the age of 2 years old. Initially the design of the study set out to have all children carry all sessions in the preschool setting. One of the children in the CI group had not yet begun attending preschool at the time of recruitment. The parents were asked if they could bring their child to a specific preschool for the study but refused because they lived far away from the preschool. As a result, the study had to be done in the child’s home. The rest of the participants attended preschool at the commencement of the study therefore all sessions took place at the child’s preschool in a quiet room with just the investigator and the child.

Prior to the commencement of the session, the investigator spent time with each child and established a rapport so the child could feel comfortable and safe enough to be in a room alone with the investigator. This was done to ensure consistency in the amount and type of language input given during this session. Having a teacher assistant come in with the child was considered but then rejected due to the variability it would bring into the data collected. The investigator prepared the child by telling them they were going to play with new toys. They then went into the room where the portable camera and recorder as well as the microphone used to record the session were already set up.

The examiner explained to the child what the microphone was and its purpose, and then asked the child's permission to pin it on his/her clothes. If the child was adamant about not wearing it then the microphone was left on the table; otherwise it was pinned on the child's t-shirt as close to his/her mouth as possible.

As mentioned earlier, three bags were presented to the child in a consecutive order. Ten minutes was allotted to each bag amounting to a 30-minute language sample. This was done to ensure equal time spent on each bag for every child so that the language sampling could be as standardized as possible.

The first bag contained the book, "Monkey Puzzle". The prompt, 'The monkey is sad because it lost its mommy and the butterfly is going to help the monkey find her' was given at the start of the session to instigate discussion and spontaneous commenting. At times when the child remained silent, prompts such as, 'What else do you see?' or 'What else did the butterfly show the monkey?' and 'What is the monkey doing here?' were given to encourage the child to comment some more on each page.

Once the allotted time for the first bag was reached, the investigator took out the second bag that contained kitchen utensils and food items. The investigator took out the contents of the bag and set them on the table. The child was then given the lead and allowed to play any way (s)he wanted with the toys. If the child was not interacting much with the toys, the investigator would trigger a play scenario by giving prompts such as 'I am hungry, I think I will have some eggs', or 'I am hungry, what should we cook?'

Once the allotted time for the second bag was reached, the investigator took out the third bag. The investigator took out the farm animals and the tractor and set them on the table. The child was again, given the lead and allowed to play any way (s)he wanted with the toys. If the child seemed uninterested or did not seem to know how to play with the toys prompts such, 'Let's take the animals for a drive with the tractor. Let's see, which animals want to go for a drive?' or 'I think the animals want to play a game. What are they going to play?' were given. Once the allotted time for the third bag was reached, the recording stopped, LS ended, and the child was returned to his/her classroom. Language samples were collected every six months, starting at the age of 2 years old +/- 2months until the age of 4.6 years old.

2.6. Structured Session (SS)

Prior to the commencement of the Structured Session (SS) the child was told that the investigator had some new toys she wanted to show them. Since children had already completed LS with the examiner, they were already familiar with her and so did not resist or refuse to participate.

2.6.1 Procedure for SS

For the realization of SS, the camera, portable recorder, and microphone were already set up and ready to record. The same procedure was followed with familiarizing or rather reminding the child in this case, what a microphone is and why it had to be part of the session. All but one child remembered that a microphone had to be used and readily accepted to have it pinned on their clothes. This session (SS) consisted of two parts.

2.6.1a Part One

Using the same book that was used in LS, "Monkey Puzzle", a script consisting of 19 items was created targeting all definite articles in Greek. Please refer to table 1.4.1 in the Introduction chapter for a detailed listing of the definite article in all numbers, genders, and cases.

Eight of these items were elicited with the use of incomplete statements that had to be filled in by the child. Each of these statements had to be completed with a missing noun along with the corresponding definite article whose form i.e. gender, number and case, was defined by the syntactical type of each sentence and the characteristics of the noun proceeding it, e.g. “The snake is wrapped around *(the tree).*” The rest of the items (11) were analogies such as, ‘These are *the butterfly’s* antennas. This is *(the monkey’s)* eye.” The child was given an example prior to administering the protocol to help them understand what was expected of them. If the child did not understand the task, two additional examples were given. In most cases children understood that they had to fill in the examiner’s sentences straight away.

To make the context obligatory for the definite article, the carrier phrase “Then the butterfly showed the monkey a/an ______” was given for each new animal presented in the book; for example, “Then the butterfly showed the monkey an elephant” thus, establishing common knowledge of the referent, i.e. the elephant. As a result when the child was given the statement “The monkey is looking at ____” and the child was asked to fill-in the blank by saying “*the elephant”*, the use of the definite article ”*the”* became obligatory (van Hout, Harrigan, & de Villiers, 2010). The child was given the statement once. If the child began talking during item administration, the investigator stopped stating the item, waited for the child to finish, and then repeated the item when the child was once again attentive.

Most items were in the form of analogies rather than direct questions. This was done because the ending of the questions ‘Who’, ‘Whose’, and ‘Which’ in Greek, changes according to the gender, number, and case of the noun that answers the question. In other words, the endings of the aforementioned questions, mirror the ending of the elicited noun and the definite article preceding that noun. Therefore, as that was considered to be a prompt for the child, direct 'who', 'whose', and 'which' questions were eliminated. Another reason why analogies were chosen as a way to elicit the definite article, was because they allow the delivery of the general mechanism of using the definite article in accordance to gender, number, and case of the noun, to the child through the item. The child is then asked to produce the definite article in its correct form based on the linguistic mechanism presented. As a result, if the child has acquired the specific definite article in the target gender, case, and number, then (s)he will be able to complete the analogy using the definite article in its correct form. Children generalize a specific grammatical structure they have been given in their spontaneous language after multiple exposures (Gentner & Namy, 2006). Additionally, "reading or hearing a sentence with a particular syntactic structure increases the likelihood of using the same structure instead of an alternative during the production of a successive sentence" (Segaert, Menenti, Weber, Petersson, & Hagoort, 2012).

2.6.1b Part Two

The second part of SS consisted of scripted play with a Playmobil set where the child was asked to help the farmer feed his animals (two dogs, two birds, one turtle, two butterflies). The investigator first stated the sentence and then presented the toy to the child, so the child could fill in the sentence while looking at the toy. Once the child completed the sentence, he/she was given the toy to play with. This was done throughout the script until all items had been presented. The script in this second part, as in part one, consisted of fill-in the blank sentences and analogies. The same reasoning behind using analogies used in part one, was applied to part two as well.

2.7. TEREL Testing Session (TTS)

During TTS, each child from the TH group and the CI group was given the Test of Early Receptive and Expressive Language (TEREL). Participants were administered this test between the ages of 4;10 and 5;0 years old. As mentioned earlier, a language measure assessing the development of the Greek language standardized in Cyprus was not available at the commencement of the study. As mentioned earlier, a standardized language measure was needed for this research project so that the results from definite article use emerging from the language sampling and structured sessions, could be compared to test items measuring this construct, i.e. the definite article. Therefore, within the following two and a half years, TEREL was developed to serve as the standardized language measure needed for the purposes of this research project.

This test used the same reasoning as PLS-5 in that both manipulatives and pictures were used during administration. This format was preferred over an only-pictures format as it is more developmentally appropriate for children 2-3 years of age. Even though participants were not tested at such young ages, items developmentally appropriate for such ages were developed nonetheless, to ensure detection of possibly lower language levels in CI children.

During TTS, TEREL was administered to each child from each of the two groups. The entire test lasted approximately 1 hour. Therefore, administration was completed in two sessions. During the first session, receptive language was tested. During the second session expressive language was tested. The testing began with receptive language in an attempt to give the child time to acclimatize with testing procedures without being put on the spot to answer questions. This ensured that the child would feel comfortable and safe enough to cooperate and answer test questions during the expressive language testing session. Lastly, this is the typical order in which language assessments of this nature are administered. All children from both experimental groups participated willingly and did not complain during the two testing sessions. If children were unable to cooperate on the scheduled testing day for whatever reason, the session was discontinued and resumed on a different day when the child was feeling well and up for it. The testing sessions were not video or sound recorded and took place at the children's preschool. Only one of the CI children had the testing sessions carried out at home. This was arranged so, in an attempt to keep switching settings from being a confounding factor in the research project.

2.7.1. Development of Test items

TEREL used pictures and manipulatives. The manipulatives were chosen based on developmental appropriateness and how frequently they are used by the ages tested. A soft cartoon character, unknown to children in Cyprus, was chosen as the main manipulative for the younger ages. The name of the soft cartoon character was decided based on the results of a short survey given to 10 children ages 4-6 asking them what they would name him. The most popular name was Mr. Banana. The rest of the manipulatives were wind-up toys that were appropriate for the older age-groups recruited for the standardization of this test. These were, a pair of butterflies, a pair of elephants, a pair of penguins, a duck, and a pair of bees. Some of the other manipulatives included but were not limited to a blanket, cups, colouring pencils, and a bouncy ball.

The questions focused on testing the comprehension of various basic, temporal, and quantitative concepts, as well as prepositions and personal pronouns. They also focused on the comprehension of a story, inferencing, mental verbs, and identification of rhyming words. The expressive language part aimed in testing various syntactical forms, such as hypothetical questions, use of embedded clauses, and use of the definite article in all genders, cases, and numbers.

The pictures were hand drawn prior to being coloured in and finalized using Photoshop Portable X6 software. They were then shown to 7 adults of various professions and 5 children and were asked to name them and describe what they are depicting. This was done for two reasons. First, to ensure that all pictures depicted what they were developed to depict, and second, to collect all the possible names a picture could be given so that the most popular name could be included as the accepted correct answer. Once it was ensured that all pictures were clear and depicted what they were supposed to depict, they were arranged in easels, one for receptive language and one for expressive language.

There were multiple parts to the majority of questions. The scoring was binomial. Each correct answer for each of the parts of the question received a score of 1 and each wrong answer received a score of 0. Each question had a specific criterion for receiving a score of 1 overall, e.g. the child had to give the correct answer to three of four parts to receive an overall score of 1 for a specific question. If this criterion was not met, they received a score of 0. The test was then piloted on 30 children. The following section will describe the piloting procedure and the changes made based on its results.

2.7.2 TEREL Pilot

Permission was granted by the Ministry of Education to recruit children from public preschools across the country for the piloting of TEREL. School-principals who accepted to meet with the investigator were given an information letter explaining what the research project was about, why TEREL had to be developed, and why it had to be piloted and standardized. The ones who consented to participating in the research project signed the consent form and gave to parents of monolingual, typically developing Greek-Cypriot children ages 2;6-6, an information letter with a parents' consent form attached. The consent forms explained to parents that children would be pulled out of class twice, each session lasting 45-60 minutes and that the child would take the test only if they were up for it and willing to do so. They were also informed that the child's personal data would be kept private and would not be publicized in any shape or form. Lastly, they were informed that they can opt to discontinue their child's participation at any time by informing the investigator telephonically. In such a case, data collected from the child would not be used if they discontinued participation prior to commencing data analysis.

Pilot data was analysed using Item Response Theory. Item Characteristic Curves (ICC) were derived to examine item difficulty range, and locate items that did not behave as expected, i.e. did not fit the normal distribution of the level of difficulty. Based on these results and the concepts tested, questions were excluded or modified to adjust the level of difficulty. If the content of questions could not be modified, the criterion for receiving a score of 1 for that question was modified accordingly. If it was deemed too difficult to attain it was made easier and vice versa.

2.7.3 TEREL Standardization

Permission was obtained from the Ministry of Education to administer TEREL to children in public and private preschools across the country to begin standardization. Schools were approached informing them of the research project. The schools that were interested to participate were given a consent form to sign along with an information letter debriefing them on the goals and purpose of the research project. The principle of each school gave consent forms and information letters to parents of monolingual, typically developing Greek-Cypriot children, ages 2;6-6 years old. Administration began once signed consent forms were returned to the principle.

Research assistants were hired to help with the realization of this part of the project. They were trained by the investigator on how to administer the questions, how to engage with the child and how to score the test. They underwent four private training sessions each with the investigator and were then supervised while administering the test to the first 4-5 children. When the investigator felt they were ready to be left unsupervised, they were left in charge of administering the test to the children at that specific school before moving on to the next one. A small percentage, 11% of the participants were doubled-scored by the research assistants. Only a small percentage of participants was double-scored due to time constraints and limited number of available research assistants at the time. Inter-rater reliability was obtained. Inter-rater reliability was 93%. If any problems or disputes arose between the research assistants and the school, the investigator was contacted and the issues were resolved.

A total of 231 Greek-Cypriot children aged 2;6-6 were recruited for the standardization process of this study. The results of the standardization are described and explained in detail in the third chapter.

2.8. Measures of language development used for analysis

Studying language acquisition involves a sample consisting of paediatric population. Research needs empirical evidence for it to be reliable, valid, and applicable for result generalization. This requires a big sample and standardized measures. Most longitudinal studies, like the current study, may begin with a large sample but more often than not, end up with a smaller sample due to attrition. The sample size of a study does not only depend on whether or not the study is longitudinal. It also depends on the assessments used, the funds available to the researcher and the type of analysis the researcher wants to employ. The object of interest in studies like the current study, is conducive to using the *Mean Length of Utterance* as a measure.

The language samples were analysed using the Mean Length of Utterance based on morphemes (MLUm) and words (MLUw), and Type Token Ratio. MLUm measures the mean length of child's utterance by looking at the number of meaningful morphemes used by the child, such as –ed which marks past tense and possessive –s in the English language.

As mentioned in the first chapter, the Greek language is a highly inflected language compared to the simple inflection used in the English language. As a result, MLUm was calculated taking into consideration how definite articles and the endings of words (nouns, adjectives, and pronouns) change according to case, gender, and number. The middle 100 utterances were used for MLUm calculation. The total number of morphemes within the selected 100 sentences were divided by the total number of utterances, i.e. 100. The general rules posed by Brown (1973) were used for the language sampling analysis in addition to several specific rules addressing the highly inflected nature of the Greek language developed for the purposes of this study. All additional rules are listed in Appendix A (see Appendix A, MLUm Coding Rules).

The Mean Length of Utterance in words was calculated for the same 100 middle utterances of each sample by counting the number of words per utterance. The total number of words was divided by 100, the total number of utterances used in the analysis. The rules for MLUw coding are also listed in Appendix A (see Appendix A, MLUw Coding Rules).

TTR measures the different types of words used spontaneously by the child, i.e. verbs, nouns, adjective, adverbs etc. This measure is used to determine if the child's spontaneous language is comprised of all necessary parts of speech according to the child's age and developmental stage. Fifty middle sentences of the 100 middle sentences used for MLUm and MLUw calculation were used for calculating TTR. Each word was classified according to the part of speech it belonged to. The total number of different words was divided by the total number of words to yield the ratio of different words to total number of words within those 50 utterances.

Results from both language sampling and structured session were analysed using linear mixed models. These will be explained and described in detail in the Results chapter.

RESULTS

Longitudinal studies are interested in looking at the long-term change or growth of a specific population in a specific developmental domain. This is carried out by collecting data from the same sample over the course of a predefined time period. A repeated measures analysis of variance (RM-ANOVA) would be the appropriate conventional statistical method for analysing data collected from the aforementioned design. However, because the sample size of the current study is small and independence between participants cannot be assumed, since they do share common characteristics, reliable statistical results using conventional RM-ANOVA cannot be obtained. Therefore, data was analysed using Mixed Linear Models (MLM). MLM allow for multilevel data analysis and account for small sample sizes and lack of independence between participants.

3.2. Multilevel analysis of data: How does it work and how does it apply to the current study?

Multilevel analysis of data analyses the same set of data on two main levels: between participants and within participants. Each level represents the type of variance that could possibly be detected. The levels or clusters, are defined by the way participants are chosen and recruited. Participants may share 'broad' characteristics, e.g. they all live in the same city, or may share more 'intimate' characteristics, for example they already know each other. Multilevel analysis of data does not discard these common characteristics participants may share on any level. It thus, accounts for the common variance that may be present between participants. This enables such analysis to correct for the error created when the sample in the study is small, thus giving a sound statistical outlook on how results will be shaped in a repeat study with a bigger sample.

Multilevel analysis does not assume zero variance between and within participants, unlike General Linear Models (GLM) which assume no common variance between or within participants. In other words, multilevel data analysis takes into account random variance between participants of the same cluster or group and between groups, unlike traditional statistical methods where it is assumed that such variance does not exist. Furthermore, it takes into account the random effects that are brought into the data by within-individual change of each participant. This type of analysis is done using multilevel linear models (MLM). The next few paragraphs will describe the differences between GLMs and MLMs to justify the use and prove the appropriateness of MLMs for the current data set.

In GLM the beginning value or initial status of participants, represented by the intercept, is thought to be the same for all subjects under study. The intercept is the expected mean value of the outcome variable when all independent variables are equal to zero. This assumes that all subjects begin at the same level, prior to applying the independent variable to the data and accounting for its impact on the outcome variable. The intercept in a GLM is assumed to be the same for all clusters or groups in the study. It will not account for variations in participants' or groups' initial status.

Multilevel modelling allows for variation between the intercept values of each group or each individual subject. MLM acknowledge that there are differences between participants and differences between clusters of participants. Each individual participant may be impacting the mean value of the intercept in a different way. The variation between subjects, cannot therefore be ignored, as it impacts the overall outcome and ignoring it would lead to result misinterpretation. The same holds true for the variance between clusters, i.e. the groups under investigation. Each cluster may impact the value of the intercept in a different way. Using a MLM, enables the investigator to take into account the variation between participants as well as the variation between clusters.

Furthermore, when using MLM, independence of observations cannot be assumed. For example, patients under the same doctor are more similar, thus observations cannot be completely independent. Consequently, MLM eliminate in a way, the 'weakness' of parametric statistical analysis methods, where effects of within-subjects variation are not accounted for. In summary, MLM takes into account the fixed effects in a model, which is the effect each individual cluster has on the dependent variable, as well as the within-subject effects, stemming from the variation of each individual from the mean value of the intercept. The equation below depicts what has been explained so far on MLM:

Equation 3.2.1

$$y_{ij} = \gamma_{00} + U_{0j} + \varepsilon_{ij}$$

where y_{ij} is the intercept value that is allowed to vary and its total variation is split between within individual participant variation (ε_{ij}) and between clusters variation (U_{0j}). γ_{00} is used to represent a general intercept value that remains the same across clusters. It can therefore be treated as a fixed effect since it remains constant across clusters. U_{0j} represents the variation value between clusters. It is treated as a random effect as it does not remain constant across clusters. In other words a MLM looks at the overall variation of participants from the general population mean when the independent variable equals 0, as well as the variation between the general population mean and the effects each cluster brings into the equation affecting the *y*-intercept value (Finch, 2014).

The degree to which participants are inter-related or correlated can be measured using Intraclass Correlation Coefficient (ICC) (Finch, 2014). Intraclass correlation takes into account this correlation (ρ_I) by calculating the amount of variance between clusters (τ^2) in a population, when divided by the variance sum, i.e., the variance between clusters (τ^2)

in a population plus the variance within clusters (σ^2) in that same population; depicted in the equation below.

Equation 3.2.2

$$\rho_I = \frac{\tau^2}{\tau^2 + \sigma^2}$$

The higher the value of ρ_I the stronger the correlation between participants of the same cluster. In other words, the common characteristic(s) shared by those participants has a bigger impact on the outcome, evident by the change in the dependent variable. It can, therefore, be an important confounding factor skewing the results when using traditional parametric statistical methods. This is because, as mentioned at the beginning of this chapter, traditional parametric statistical methods assume independence of observations.

3.2.2. How do MLMs apply to the data structure of this study?

Two types of data structures can be applied to multilevel models. The first type of data structure involves the clusters and nesting described below. The second data structure that can be applied to a MLM is one produced by a repeated measures design as described below.

A longitudinal study can also be viewed as a structure in which data is nested. The data structure of the current design is a combination of a nested data structure and repeated measures.

The sample of deaf children with CIs participating in this study was very small, even though it included 100% of all deaf children with CIs that met the inclusion criteria at the commencement of the study. All children with CIs except one, resided in the same city and were all family friends but were not related to each other. Furthermore, all children except for one, received speech and language services from the same speech-language pathologist. Therefore, these children are nested within a higher class, the city they resided in. The three children that received speech and language services from the same speech-pathologist also share common variance. Their language outcomes are affected and shaped in a similar way, since they were treated by the same professional.

The current study employs a longitudinal repeated measures design as mentioned earlier. A 30-minute language sample was collected from deaf children with CIs and their typically hearing peers, every six months using the same book and toys for two and half-years. During a second session, the structured session, the same participants answered questions on a play-based protocol every six months using the same book and toys each time over the course of two and half-years. The set of linguistic structures a participant uses during the first language sample will not differ greatly from those used during the second language sample. If anything, the linguistic structures used in each of the previous language samples, will be the foundation upon which new linguistic structures will be built and emerge in proceeding language samples. Therefore, time, i.e. the six different time points, acts as a predictor of the linguistic structures that will emerge. The increasing number and variety of new linguistic structures are the outcome variables.

The same applies for the structured session. The elicited definite article does not appear in all cases, genders, and numbers from Time1, i.e., at the age of 2 years old. However, Time1 will be the foundation for the emergence of definite article use in increasingly more cases, genders, and numbers until all its forms have been fully acquired. Therefore, a participant's responses during Time1 and Time 2 will not be independent of each other (Theobald, 2018). The interdependence within the same participant's responses in both sessions LS and SS, over the six time periods, are the random effects that GLMs usually do not take into account. However, these random effects may be impacting the outcome in a way that should be investigated. Investigation of such random effects may shed light on new evidence outlining the linguistic developmental path CI children follow during language acquisition. Since data on typical development in Cypriot-Greek children is also scarce, the same applies for typically hearing children and the developmental path they follow.

As mentioned earlier the sample size for this study was small obligatorily (four deaf children with CIs and eight typically hearing children) due to inexistence of more deaf children with CIs at the commencement of the study. This is an additional reason why it is crucial that random effects are taken into account as this population's linguistic developmental path is this study's main interest. Any individual differences will lay the foundation of how these children develop language; a foundation future studies can be based on. The same applies for typically hearing Cypriot-Greek children's morphological development. Analysis of random effects will add to the literature on how typical development occurs, i.e. by looking at any individual differences that may exist.

MLM were the most appropriate method of statistical analysis, as they do not require that the study design be balanced or have equally spaced measurements, they account for small samples, and lastly, they allow for between-individual variation in the timing of measurement *t*.

3.4. Design of the current study

The current study has two levels of variance, fixed (time and hearing status) and random (brought in by repeated measures design and interdependence of observations) that may impact the outcome of twelve dependent variables. MLM were used to investigate how the acquisition of the definite article in the Cypriot-Greek dialect, the mean length of utterance in morphemes (MLUm) and words (MLUw), and the diversity of vocabulary in deaf children with CIs and their typically hearing peers, is affected by: a) individual inherent differences, b) differences in their growth patterns across time, i.e. age, and c) differences accounted for by their hearing status, i.e. (CI and TH). Multilevel mixed effects models were fitted to this study's data as described below.

Level 1 of this analysis examines the random effects that are brought into play with the variance created by each individual's score at each time point, when comparing the scores of that individual to himself. Therefore, it examines how each individual participant changes, against himself across time.

Level 2 of the analysis examines the effect of fixed effects, i.e. the hearing status (CITH) of the children, cochlear implanted (CIs) vs. typically hearing (TH), and time (age), on the outcome. All participants were tested at the same ages +/- 2 months. At this level, the effect of predictors on each individual's change in growth is taken into account and the way in which this change differs between individuals. In other words, does the growth pattern change between individuals and if it does, does age (time) and/or their hearing status (CITH) account for that difference in the change between them?

3.4.1 Dependent Variables

The first three of the twelve dependent variables that will be examined in this section are the MLU-m, MLU-w, and Type Token Ratio. All three dependent variables were obtained through language sample analysis. Each language sample was transcribed and coded by a trained research assistant. Twenty percent of the transcriptions were cross-checked by the primary examiner by listening to the audio file and following the research assistant's transcription. Discrepancies were found and discussed with the research assistant. A 100% agreement was reached on all discrepancies. Transcription reliability was 95% which is satisfactory.

The middle 100 utterances of each language sample were coded by the primary examiner for the identification of morpheme use. Coding was done following the general rules of coding stated by Brown (1973). Several rules were developed and added to the general coding scheme to accommodate the highly inflectional nature of the Greek language. Due to the ambiguity of some phrases as to whether the child had used the right case and gender based on the noun following the definite article, it was decided to give full credit to phrases or sentences that did not fall into the category of route phrases and could stand alone semantically, syntactically, and grammatically. Another rule that was added stated that nouns, verbs, adjective, and pronouns can get a total of 4 points each when used correctly, as they have four aspects that change meaning if changed or used erroneously. This method of coding follows that of G. Szagun, Schramm, A. S. (2019). The reasoning behind this method of coding is that, for example, when a child changes the definite article from ***Η*** to ***Τις*** it means (s)he has acquired the form of the feminine gender in plural number, in the genitive case. MLUm for each child, was determined by adding all the morphemes and dividing the total number by 100, i.e., the total number of utterances transcribed for the purposes of this study. Twenty percent of the samples were coded by another certified speech-language pathologist who has extensive experience with paediatric population given the full updated set of rules. Coding reliability was 95%. Instances of difference in coding were identified and discussed. An agreement percentage was calculated by dividing the number of agreed upon utterances with the total number of utterances on which disagreement was identified.

MLU-w was calculated by counting all the words used within the 100 utterances analysed from each sample. Participles and subjunctives *θα* (*/θa/*) and *να* (*/na/*) were counted as one word with their adjoining verb as they cannot stand alone as words that carry meaning. Twenty percent of the language samples were coded for MLU-w by the same certified speech-pathologist who coded language samples for morphemes. Coding reliability for MLU-w was 100%. MLU-w for each child, was calculated by dividing the total number of words by 100, i.e. the total number of utterances transcribed for the purposes of this study.

Type-Token Ratio was the measure used for calculating the ratio of the total number of different types of words used to the total number of words used. The middle 50 utterances within the 100 utterances used for MLUm and MLUw analysis, were used for calculation of TTR as per Templin (1957). This was used to determine how diverse children's vocabulary was. The higher the TTR score the more diversity in a child's vocabulary.

The next nine dependent variables that will be described were elicited during the Structured Session through the use of a protocol. As mentioned earlier, its aim was to elicit the definite article in all its forms based on all cases (Nominative, Accusative, Genitive), genders (masculine, feminine, neutral), and numbers (singular and plural). Analysis was done only on the elicitation of the definite article in the three cases and three genders. Singular and plural forms were not analysed separately, as the raw scores of each number's total use were very small. Plural and singular forms were therefore combined. The nine dependent variables measured during the Structured session are summarized in the following table.

Table 3.3.1. ***Names for the nine dependent variables obtained during the Structured Session***

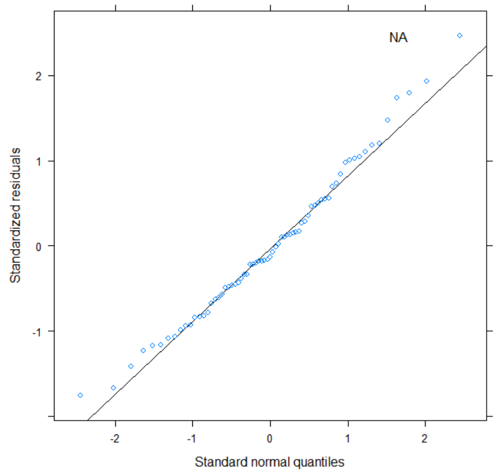
	Masculine	**Feminine**	**Neutral**
Nominative	SSMNT*	SSFNT	SSNNT****
Accusative	SSMAT	SSFAT**	SSNAT
Genitive	SSMGT	SSFGT	SSNGT***

*SS= Structured Session, M=Masculine, N=Nominative, T= Total # occurrences with a max # occurrences=2 **SS=Structured Session, F=Feminine, A=Accusative, T=Total # occurrences with a max # occurrences=2 ***SS=Structured Session, N=Neutral, G=Genitive, T=Total # occurrences with a max # occurrences =2 ****This variable was the only one with a Total maximum # occurrences = 1

3.4.2 Were MLM assumptions met?

The assumption that residuals are normally distributed was checked by plotting a Q-Q plot of the standardized residuals against the standard normal quantiles. As can be seen in Figure 3.4.1 the assumption has been met as the majority of points are around the line apart

Figure 3.4.1 Distribution of residuals



for some deviation on the tails. However, since deviation is not major, it can be inferred that the assumption was not violated.

The second assumption, homogeneity of variance was tested using Levene's test. Levene's was found to be insignificant, p >.05 therefore the assumption has been met. The third assumption of homoscedasticity was also met. A scatterplot of the residuals against the fitted model was plotted and there was a random distribution of points. The assumption of the sample normality was not met due to the small sample size. However, like parametric regression the model needs to meet the assumption of normally distributed residuals, since it is investigating what percentage of the outcome can be explained by each type of variance.

Furthermore, transformations to fix the non-normal distribution of the population were not performed as it is being argued that transformations complicate the interpretation of results. This is because once transformed, all results are based on changed data and not the actual raw data collected. In addition, once transformed, they cannot be generalized to the population. Lastly, more often than not, small samples are unable to meet the assumption of normality due to their size. As mentioned earlier, this was one of the reasons why this statistical method was chosen for the analysis of this study's data, i.e., it accounts for small sample size.

3.5. Models Used

Four different types of models were used to examine and explain the variability in the data accounted for by random effects and the fixed effects of age (time) and hearing status (CITH), i.e. cochlear implanted children vs. typically hearing.

The first model that was used was the unconditional means model where overall differences across all subjects and their performance on each of the dependent variables were investigated keeping the impact of the predictors, i.e. time and CITH constant. The purpose of fitting this model to the data is to determine if there is variation in the outcome that needs to be explained and whether a portion of this variation lies within participants, between participants or both. This is achieved by excluding all independent variables that may have an effect on the outcome. It therefore consists of two levels. Level 1 will determine the amount of variation that lies within individuals while level 2 will determine the amount of variation that lies between individuals. Level 1 determines within-person variation by examining the differences between the observed outcome values from the individual's true mean. It assumes that an individual's trajectory is flat as there is no temporal component, since time is kept constant and does not provide a tilt in the slope. Since there is no temporal component to the first level, magnitude of differences on outcome values between time points are not taken into account. The differences revealed by the first level are in the true starting values of individuals. The changes are therefore only in the elevation of their growth trajectories. Level 2 of this model, determines the amount of variation that is due to differences in the true means between participants and the population true average mean. Any variations revealed by level 2 are therefore between participant deviations.

Establishing whether there is variation at each of these levels and its amount, will determine whether or not further testing will be performed to reveal how much of that variance accounts for predicting the outcome at that level.

Once considerable variation is found to exist in both levels by the fitting of the aforementioned model, the unconditional growth model will be fitted to assess how much of that variation is accounted for by change in time, i.e. children's increasing age. Time is therefore included in this model as the first predictor explaining a portion of the variation in outcome value. Level 1 in this model examines the deviations of each individual's observed outcome values around their respective true change trajectories instead of deviations from their respective means, like in the first model, across time. Level 2 in this model examines the variability in individual rates of change and intercepts, i.e. initial status, between individuals across time. It will determine whether differences between individuals are due to differences in their true initial status or true rate of change. If introduction of time into the model, reduces Level 1 variation, then it can be inferred that time explains part of the outcome variation. In other words, participants' true growth trajectory changes over time and time is therefore the reason why that change occurs. If differences between individual's true rate of change and true initial status exist, then predictors added to level 2 of the model may be able to explain part of that variation.

The two aforementioned models aim to locate any variation present in the data and determine whether this variation resides within individuals or between individuals. As mentioned earlier, any variation between individuals' true rate of change and true initial status will need to be explained by the predictors. A third model is therefore applied where the first predictor is added at level 2.

The third model was the conditional growth model where the second independent variable, CITH, was added hierarchically, to assess its effect on each of the outcome variables. Interactions between time and CITH were also examined. This model assesses how much of the variability in the outcome variables is accounted for by the fixed effects of CITH and its interaction with time. In other words, this model aims to answer the question of whether the difference in children's hearing status explains part of the variability in the outcome found at level 2 of this model. This is done: 1) by estimating the initial status between hearing and cochlear implanted children in each of the outcome variables, 2) by examining differences in the initial status between hearing and cochlear implanted children in each of the outcome variables, 3) by estimating the rate of change between hearing and cochlear implanted children in each of the outcome variables, and 4) by examining the differences in the rate of change between hearing and cochlear implanted children in each of the outcome variables.

The fourth model used, was the conditional growth model again only this time, the differences between each individual's observed outcome values and their respective true change trajectories across time, are kept constant. In other words, the temporal component is kept constant within individuals and only the intercept is allowed to fluctuate. This model assumes that any increase in the outcome variables within the tested time period, i.e. 2;0 to 4;6 years old, will only affect the outcome variables' intercepts. Furthermore, it aims to determine if variability in the changes between each child's initial status, can be explained by the effects of time, CITH, and/or any interactions between them, when comparing participants, i.e. variability between-individuals.

3.6. What do the MLMs reveal?

When running each of these multilevel models in R (Bates, 2015), a table with Akaike's an information criterion (AIC) and Bayesian Information Criterion (BIC) or the Schwarz's Bayesian criterion (SBC) is produced. AIC and BIC are criteria against which models are fitted to investigate the fit of each model. These criteria are based on a log-likelihood value. AIC takes into account the number of parameters in the fitted model whereas BIC takes into account the number of observations. When comparing models fitted using the log-likelihood, smaller AIC and BIC values represent a better fit. Therefore, when comparing two models, the one with the lower AIC or BIC value is the one that fits the data under investigation best. In each succeeding model, an additional independent variable is added in an attempt to find which variable or combination of variables, best explains the variability detected by the unconditional means model in each of the outcome variables. Therefore, smaller BIC and AIC values of subsequent models, mirror the contribution of the added independent variables in explaining outcome variability.

Even though these values are used to determine goodness of fit, the nature and effectiveness of these tests are not without doubt. Larger differences in these values between models offer stronger evidence for stating a particular model as having the better or best goodness-of-fit. AIC and BIC values do not require that models are nested within each other to be able to compare them reliably. Using these values, makes it easier for the investigator to compare two un-nested models as long as both models are fit using the same set of data (Singer, 2003) . This study fits all models to the same of data, therefore BIC values will be used to compare the models on their goodness-of-fit.

The unconditional means model is compared to the unconditional growth model to examine if addition of time as a predictor makes the model a better fit for the data. This comparison is performed on each of the outcome variables to investigate if time acts as a predictor to outcome variables. BIC values and their significance for each of the dependent variables are summarized in the following two tables.

Table 3.6.1 *BIC values of Unconditional means model and Unconditional growth model for Structured Session outcome variables - Definite Article production*

Models	**Outcome variables for Definite Article production (Structured Session)**								
	SSMNT	***SSFNT***	***SSNNT***	***SSMAT***	***SSFAT***	***SSNAT***	***SSMGT***	***SSFGT***	***SSNGT***
Unconditional means model (m1) (BIC value)	258.52	260.12	179.13	242.28	265.35	264.16	228.52	213.25	195.57
Unconditional growth model (m2) (BIC value)	215.90	218.75	166.87	202.71	226.04	218.04	154.55	164.55	162.46

SSMNT= Structured Session Masculine Nominative Total # occurrences, **SSFNT**=Structured Session Feminine Nominative Total # occurrences, **SSNNT**=Structured Session Neutral Nominative Total # occurrences **SSMAT**=Structured Session Masculine Accusative Total # occurrences, **SSFAT**=Structured Session Feminine Accusative Total # occurrences, **SSNAT**=Structured Session Neutral Accusative Total # occurrences, **SSMGT**=Structured Session Masculine Genitive Total # occurrences, **SSFGT**=Structured Session Feminine Total # occurrences, **SSNGT**= Structured Session Neutral Genitive Total # occurrences

Table 3.6.2 *BIC values for Unconditional means model and Unconditional Growth model for Language Sampling outcome variables – Mean Length of Utterance and Vocabulary*

Models	**Outcome variables for Utterance length and Vocabulary (Language Sample Session)**		
	MLUm	***MLUw***	***TTR***
Unconditional means model (m1) (BIC value)	349.80	199.72	-118.38
Unconditional growth model (m2) (BIC value)	294.01	173.12	-127.27

MLUm=Mean Length of Utterance in morphemes, MLUw=Mean Length of Utterance in words, TTR=Type Token Ratio

Tables 3.6.1 and 3.6.2 depict the BIC values for the first two models fitted to the data; the unconditional means model, here on after m1, and the unconditional growth model, here on after m2. Variability in all outcome variables is explained better by the addition of time as a predictor, i.e. m2. In other words, each of the dependent variables outlined in the tables above, change as a function of time. This is shown by the difference in the BIC values of the two models under comparison. The difference in BIC values for each of the outcome variables is >10 points which provides very strong evidence that time explains part of the variability in the outcome. This criterion was set by Raftery (1995). BIC values can be interpreted in terms of how weak or strong evidence they provide for the model selected, by looking at how much they differ between models. Raftery (1995) suggests that difference in BIC values between 0-2 points is weak evidence, 2-6 positive, 6-10 strong, and >10 very strong. The smaller BIC values in all outcome variables outlined in the tables above, reach significance when compared to the χ^2 distribution, $p < .001$. The null hypothesis is therefore rejected, as time does impact the observed outcome values of all dependent variables across participants.

It should be noted that all children are included in each of the models. Model 1 and m2 do not separate participants as to their hearing loss, therefore participants are not separated in two groups, i.e. Typically Hearing children (TH) and Cochlear Implanted children (CI). Differences that will be discussed are within and/or in between each individual child irrespective of their hearing status. Results for m1 on each of the 12 dependent variables will be explained first, depicted in tables 3.6.1. and 3.6.2. As mentioned above m1 aims to determine the presence of variation within and between individuals by looking at their initial status, changes in the initial status of participants and whether these variations in initial status lie within individuals, between individuals or both. The intercept value for fixed effects, reaches significance, $p<.001$ in all dependent variables revealing a difference in the true outcome value observed and each person's initial status compared to the true mean of the population. This shows that there are deviations between subjects across all dependent variables. Between-participant variation is therefore present in all outcome variables. Variation between-participants refers to the variability detected at level 2 of this model. Level 2 detects the differences between-participants, if any exist, while keeping time constant. Children are compared to each other and the true population mean only at the first temporal point, i.e. at the age of 2 years old.

The variation explained by random effects differs across variables, with half of them exhibiting no variance due to random effects. It ranges from 0-8%; a range of low values attributing variability in changes in the initial status of each individual to inherent individual differences. None of the variance in the initial status of participants can be explained by random effects for six of the 12 dependent variables as mentioned above; TTR, MLU-w, SSFAT, SSNAT, SSMGT, and SSFGT. It can therefore be inferred that, variance in children's initial status on the aforementioned outcome variables can only be attributed to interindividual differences in initial status. This could be interpreted as participants showing independence of each other on the aforementioned measures since variance in the first level of this model, i.e. random effects, is 0 as shown by σ^2 value.

The unconditional growth model adds the temporal component of age in six-month increments, to determine whether differences in the rate of change are present within each individual irrespective of their hearing status. On a second level it determines whether there are differences between individual participants irrespective of their hearing status and if these differences are due to variability in their true initial status or true rate of change. Table 3.6.3. depicts the variation explained by time in each of the outcome variables and its p-value to establish the presence or absence of significance.

Table 3.6.3 *Significance values of Time as a predictor of outcome variability within and between individual participants irrespective of their hearing status*

		Time			
Outcome Variables	***Estimate***	***Std. Error***	***Df***	***t-value***	***Pr(>|t|)***
SSMNT	0.586	0.066	10.912	8.829	.000*
SSFNT	0.611	0.072	10.959	8.466	.000*
SSNNT	0.231	0.047	21.816	4.877	.000*
SSMAT	0.530	0.075	11.139	6.994	.000*
SSFAT	0.651	0.089	11.249	7.301	.000*
SSNAT	0.654	0.075	17.305	8.620	.000*
SSMGT	0.574	0.042	44.287	13.603	<.0001*
SSFGT	0.449	0.044	39.594	10.198	<.0001*
SSNGT	0.321	0.061	12.685	5.233	.0001*
MLUm	1.267	0.138	9.834	9.184	0.000*
MLUw	0.353	0.067	10.389	5.211	0.000*
TTR	0.021	0.008	11.157	2.429	0.033*

*Significance reached when p<.05., **SSMNT**= Structured Session Masculine Nominative Total # occurrences, **SSFNT**=Structured Session Feminine Nominative Total # occurrences, **SSNNT**=Structured Session Neutral Nominative Total # occurrences, **SSMAT**=Structured Session Masculine Accusative Total # occurrences, **SSFAT**=Structured Session Feminine Accusative Total # occurrences, **SSNAT**=Structured Session Neutral Accusative Total # occurrences, **SSMGT**=Structured Session Masculine Genitive Total # occurrences, **SSFGT**=Structured Session Feminine Total # occurrences, **SSNGT**= Structured Session Neutral Genitive Total # occurrences, MLUm=Mean Length of Utterance in morphemes, MLUw=Mean Length of Utterance in words, TTR=Type Token Ratio

As can be seen by the values in Table 3.6.3, all outcome variables reach high significance levels as a function of time. It seems that there is a linear relationship between the values of all outcome measures and age. As children get older the number of correct definite article forms produced, increases as well. There also seems to be an increase in the mean length of utterance measures in morphemes as well as the one measured in words as age (time) increases. As children get older, the number of morphemes they use as well as the number of words, increases linearly. The use of the definite article in genitive case for both masculine and feminine genders generates the two highest t-values out of all dependent variables depicted, t=13.603, p <.000 and t=10.198, p<.000, respectively (Table 3.6.3).

TTR's significance is not as high as the rest. This is compatible to the observed data at each time point where the increase in this measurement is not dramatically different. In other words, for every 1-point increase in time, i.e. six months, the increase in TTR is only 0.02.

Ultimately m2 shows that the null hypothesis can be rejected as initial status and the rate of change do not equal 0. There is variability in the initial status of participants on each of the outcome variables as well as their rate of change depicted by the slope of their growth trajectories.

Variability present in both levels, within individuals and between individuals justifies the use of the conditional growth model, where the role of CITH in explaining a portion of interindividual variability will be examined.

Before moving on to the results generated by the fitting of the conditional growth model, here on out m3, goodness-of-fit will be examined by looking at the BIC values generated by m2 and m3 and the difference between them. Tables 3.6.4 and 3.6.5 depict these values for each of the outcome variables.

Table 3.6.4 *BIC values for Unconditional Growth model and Conditional Growth modelfor Structured Sesseion outcome variables - the Definite Article*

Models	**Outcome variables for Definite Article production (Structured Session)**								
	SSMNT	***SSFNT***	***SSNNT***	***SSMAT***	***SSFAT***	***SSNAT***	***SSMGT***	***SSFGT***	***SSNGT***
Unconditional growth model (m2) (BIC value)	215.90	218.75	166.87	202.71	226.04	218.04	154.55	164.55	162.46
Conditional Growth model-CITH(m3) (BIC values)	223.42	226.43	175.21	210.84	233.06	226.41	159.75	175.74	170.10

SSMNT= Structured Session Masculine Nominative Total # occurrences, **SSFNT**=Structured Session Feminine Nominative Total # occurrences, **SSNNT**=Structured Session Neutral Nominative Total # occurrences, **SSMAT**=Structured Session Masculine Accusative Total # occurrences, **SSFAT**=Structured Session Feminine Accusative Total # occurrences, **SSNAT**=Structured Session Neutral Accusative Total # occurrences, **SSMGT**=Structured Session Masculine Genitive Total # occurrences, **SSFGT**=Structured Session Feminine Total # occurrences, **SSNGT**= Structured Session Neutral Genitive Total # occurrences

Table 3.6.5 *BIC values for Unconditional Growth model and Conditional Growth modelfor Language Sampling outcome variables – Mean Length of Utterance and Vocabulary*

Models	**Outcome variables for Utterance length and Vocabulary (Language Sample Session)**		
	MLUm	***MLUw***	***TTR***
Unconditional growth model (m2) (BIC value)	294.01	173.12	-127.27
Conditional Growth model-CITH(m3) (BIC values)	302.39	182.48	-119.00

MLUm=Mean Length of Utterance in morphemes, MLUw=Mean Length of Utterance in words, TTR=Type Token Ratio

According to Singer (2003), smaller differences in the BIC values of two models are harder to interpret. As mentioned above, Raftery's criteria on interpretation of BIC values, place a difference of 6-10 points as being strong evidence that the model with the smaller value fits the data best. As can be seen by the tables above all variability in all outcome variables seem to be explained better by m2, i.e. the model where CITH is not entered as a predictor of the variability in the data, except for TTR. For TTR, m3 seems to be a better fit as it has a value loser to 0, indicating a smaller value. The significance values for the contribution of CITH in explaining variability in the outcome are shown in Table 3.6.6.

Table 3.6.6 *Significance of CITH as an independent variable based on m3(Conditional Growth model)*

		CITH			
Outcome Variables	***Estimate***	***Std. Error***	***Df***	***t-value***	***Pr(>|t|)***
SSMNT	0.1959	0.5993	9.9002	0.327	.751
SSFNT	0.3303	0.4859	9.6608	0.680	.513
SSNNT	0.0309	0.3297	15.1031	0.094	.927
SSMAT	-0.0224	0.5283	9.8524	-0.043	.967
SSFAT	0.3537	0.5148	12.0682	0.687	.505
SSNAT	0.1831	0.6279	10.4546	0.292	.776
SSMGT	0.440	0.294	16.3772	1.496	.154
SSFGT	0.311	0.288	49.0545	1.080	.285
SSNGT	-0.156	0.261	48.4606	-0.599	.552
MLUm	-0.231	1.133	10.0196	-0.204	.842
MLUw	0.011	0.316	52.8761	0.033	.973
TTR	0.012	0.063	9.4292	0.195	.850

*Significance reached when p<.05, **SSMNT**= Structured Session Masculine Nominative Total # occurrences, **SSFNT**=Structured Session Feminine Nominative Total # occurrences, **SSNNT**=Structured Session Neutral Nominative Total # occurrences, **SSMAT**=Structured Session Masculine Accusative Total # occurrences, **SSFAT**=Structured Session Feminine Accusative Total # occurrences, **SSNAT**=Structured Session Neutral Accusative Total # occurrences, **SSMGT**=Structured Session Masculine Genitive Total # occurrences, **SSFGT**=Structured Session Feminine Total # occurrences, **SSNGT**= Structured Session Neutral Genitive Total # occurrences, MLUm=Mean Length of Utterance in morphemes, MLUw=Mean Length of Utterance in words, TTR=Type Token Ratio

As can be seen in Table 3.6.6, addition of the hearing status of children as an independent variable, does not reach significance for any of the outcome measures. The intercepts for TTR and MLUw remain significant, both at p<.01. The aforementioned results are comparing each individual child within itself and between each other while taking into account their hearing status.

Time as a predictor remains significant in MLUm scores (*t*=2.288, p=.049), SSFGT (*t*=2.692, p=.029), SSMGT (*t*=5.524, p<.001), SSNAT (*t*=2.553, p=0.022), SSFNT (*t*=2.277, p=0.046), and SSMNT (*t*=3.270, p=0.009).

The fourth model fitted to the data is the conditional growth model, here on after m4, where differences in the rate of growth within individuals is kept constant. In this model as explained earlier, children's hearing status and their age were entered as predictors for each of the 12 outcome measures. Children's hearing status does not affect any of the outcome variables. Time however, remains a significant predictor for all (SSMNT *t*=3.583 p=0.00072, SSFNT *t*=2.654 p=0.0104, SSMAT *t*=2.905 p=0.00528, SSFAT *t*=2.557 p=0.0129, SSNAT *t*=2.892 p=0.00546, SSMGT *t*=5.586 p=<.001, SSFGT *t*=3.510 p=0.00901, MLUm *t*=2.876 p=0.00575) but four outcome variables; SSNNT, SSNGT, MLUw, and TTR.

Intercept significance is lost in all outcome variables except for MLUm, MLUw, and TTR, where significance reaches the values of p=.031, p=.012, and p<.00 respectively. This indicates a difference in the starting levels of each of these variables with the highest significance found in their vocabulary diversity. Table 3.6.7 depicts the BIC values for the third and fourth model.

Table 3.6.7 *BIC values for Conditional Growth model with the addition of hearing status as a predictor and Conditional Growth model where random effects are held constant for Structured Session outcome variables - the Definite Article*

Models	**Outcome variables for Definite Article production (Structured Session)**								
	SSMNT	***SSFNT***	***SSNNT***	***SSMAT***	***SSFAT***	***SSNAT***	***SSMGT***	***SSFGT***	***SSNGT***
Conditional Growth model-CITH(m3)(BIC values)	223.42	226.43	175.21	210.84	233.06	226.41	159.75	175.74	162.46
Condition Growth model-dropping random slope(m4)(BIC values)	214.97	218.87	169.12	204.13	225.56	220.18	151.44	164.08	170.10

SSMNT= Structured Session Masculine Nominative Total # occurrences, **SSFNT**=Structured Session Feminine Nominative Total # occurrences, **SSNNT**=Structured Session Neutral Nominative Total # occurrences, **SSMAT**=Structured Session Masculine Accusative Total # occurrences, **SSFAT**=Structured Session Feminine Accusative Total # occurrences, **SSNAT**=Structured Session Neutral Accusative Total # occurrences, **SSMGT**=Structured Session Masculine Genitive Total # occurrences, **SSFGT**=Structured Session Feminine Total # occurrences, **SSNGT**= Structured Session Neutral Genitive Total # occurrences

Table 3.6.8 *BIC values for Conditional Growth model with the addition of hearing status as a predictor and Conditional Growth model where random effects are held constant for Language Sampling outcome variables – Mean length of Utterance and Vocabulary*

Models	**Outcome variables for Utterance length and Vocabulary (Language Sample Session)**		
	MLUm	***MLUw***	***TTR***
Conditional Growth model-CITH(m3)(BIC values)	302.39	182.48	-119.00
Conditional Growth model-dropping random slope(m4)(BIC values)	294.73	175.34	-118.87

MLUm=Mean Length of Utterance in morphemes, MLUw=Mean Length of Utterance in words, TTR=Type Token Ratio

Looking at the BIC values for the two conditional growth models it is evident that m4 has the lowest BIC values and can therefore be considered as a better fit for the data. However, the difference between the two models, ranges from weak to very strong when all outcome variables are taken into account. It is clear that fixed effects have a stronger impact on some of the variables versus others. For variable SSFGT, where BIC values differ by >10, it can be assumed that the variability in the outcome is primarily due to differences between participants, rather than differences within them.

3.6.1. Output: Random Effects and Intraclass Correlation Coefficient values

Intraclass correlation was calculated for each of the outcome variables to determine whether random effects were present and to what extend. Nine out of the 12 variables examined, indicated the presence of random effects by yielding an intraclass correlation coefficient >.10. These variables were SSMNT, SSFNT, SSNNT, SSMAT, SSFGT, SSNGT, MLUm, MLUw, and TTR. The Intraclass correlation coefficient was calculated for all models. This was done to determine the exact participant characteristics that carried the most inherent variability within each participant, thus affecting definite article acquisition the most. In other words, did age for an individual participant affect his/her definite article acquisition rate or direction? Did the hearing status of one participant have an effect on the definite article acquisition for that specific participant? It is evident from the substantial increase in the ICC value range when time, i.e. age, is added into the model, that variabilility within each participant increases across time and thus accounts for a larger percentage of outcome variability. The range of ICC values reported in the table below show the substantial increase reached after adding time to the model. There was a significant difference between the 6 time periods for each of the children in each of these 6 ouctome variables. Therefore, random effects are present as each child's response on a given ouctome variable, at each time point, is correlated with the response given at the preceding time point. The ICC values do not increase sginificantly with the addition of the hearing status as a predictor into the model. The ICC values remain constant. The following table summarizes the changes in ICCs in each of the variables in the three models. The conditional growth model detects random effects in all depicted variables except SSNNT.

Table 3.6.1.1 *Intraclass Correlation Coefficient indicating the presence and increase in random effects as Time and hearing status (CITH) are entered as predictors in m2 and m3*

Models	**Outcome Variables (ICC values)**								
	SSMNT	**SSFNT**	**SSNNT**	**SSMAT**	**SSFGT**	**SSNGT**	**MLUm**	**MLUw**	**TTR**
Unconditional model (m1)	0.11	0.02	0.26	0.00	-	0.13	0.03	-	-
Unconditional Growth model (m2)	0.40	0.28	0.40	0.33	-	0.45	0.41	0.24	0.35
Conditional Growth model (m3)	0.42	0.30	-	0.36	0.32	0.46	0.44	0.27	0.38

SSMNT= Structured Session Masculine Nominative Total # occurrences, **SSFNT**=Structured Session Feminine Nominative Total # occurrences, **SSNNT**=Structured Session Neutral Nominative Total # occurrences, **SSMAT**=Structured Session Masculine Accusative Total # occurrences, **SSFAT**=Structured Session Feminine Accusative Total # occurrences, **SSNAT**=Structured Session Neutral Accusative Total # occurrences, **SSMGT**=Structured Session Masculine Genitive Total # occurrences, **SSFGT**=Structured Session Feminine Total # occurrences, **SSNGT**= Structured Session Neutral Genitive Total # occurrences

Random effects explain outcome variability to a large extent since percentages range from 27 to 46%. Looking at m3 ICC values, it is evident thatalmost half of total variability is explained by random effects in 3 out of 9 variables (SSMNT, SSNGT, and MLUm) where random effects were present, and more than a third of the variability explained can be attributed to random effects for four of the variables (SSFNT, SSMAT, SSFGT, and TTR) where random effects were present. The presence of random effects is also evident by the variations in each individual trajectory and between individual trajectories found in Appendix B.

3.7. Individual and Group Growth Trajectories

3.7.1a Individual Trajectory Growth: Masculine in Nominative

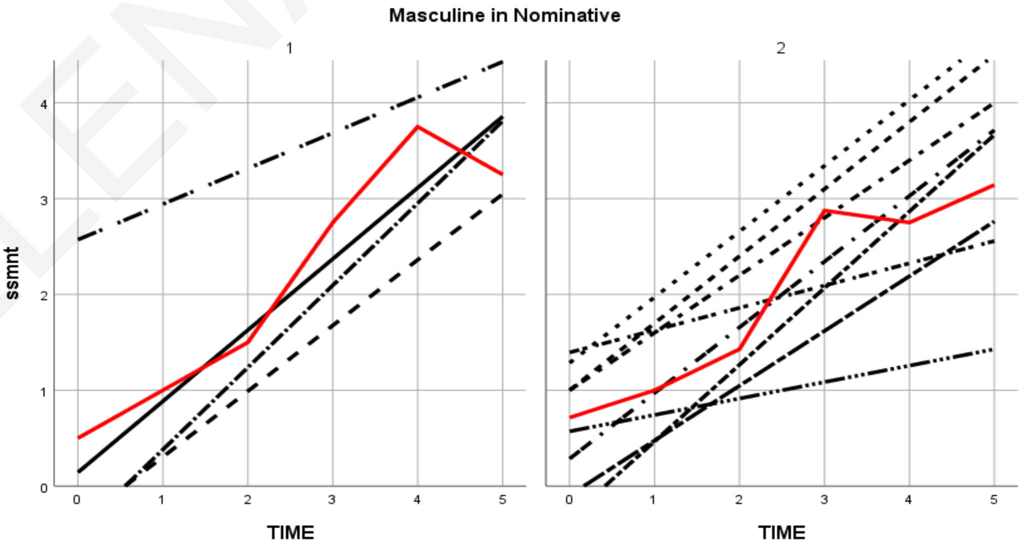
As can be seen in Figure 3.7.1a (Appendix B), five of the 12 children have a different starting point indicated by the intercept of their growth trajectories. The differences between their intercepts reaches significance as shown by m1, where the significance for the intercept is $p<.001$. Participant 2, has the highest intercept out of all participants.

Participants 2, 6 and 9 project a less steep slope in their growth trajectory compared to the rest of the children. The rest of the children demonstrate a faster rate of growth. As children's age increases over time so does the number of correct occurrences of the use of the definite article for the masculine gender in the nominative case.

The solid line in Figure 3.7.1a is the exact growth trajectory plotted using children's raw scores. It is interesting to see that the majority of children abruptly achieve a high rate of success use of SSMNT between the ages of 2;6 and 3;0. Participants 6, 9, and 10 are an exception to this observation evident by the flat or dipping slope of their growth trajectories. For almost half of the participants, there is a drop in their rate of success indicated by a downward sloping growth trajectory at the age of 3;6 and 4;0. Upward and downward trends within individual growth trajectories are also present. The graphs below depict the growth trajectories of the children grouped in experimental and control (CI vs TH), where 1 at the top panel of the graph on the left is for CI group and 2 at the top pane of the graph on the right is for TH group. This holds true for all group growth trajectories that are to follow.

Figure 3.7.1b *SSMNT Group Growth Trajectories showing each group's mean growth trajectory for the acquisition of the definite article used for the masculine gender in the nominative case*

Graph 1 = CI GROUP   Graph 2 = TH GROUP



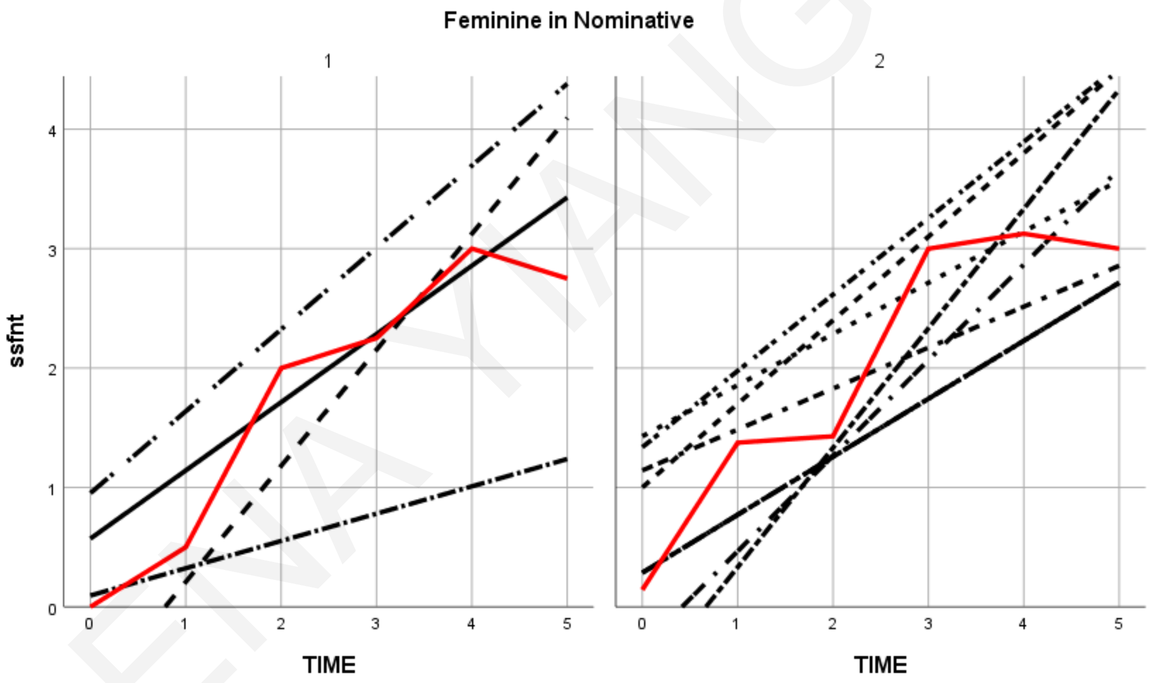
Looking at the mean growth trajectories of the two groups, we can see that there is no striking difference between them. This is also supported by m3 where CITH was added as an independent variable and no significance was reached (*t*=0.327, p=.751). They have similar rates of growth and the collective differences in their initial status does not reach significance, (*t*=0.260, p=.800). The only outlier is participant 2 (the highest dotted line in graph 1) who has a higher intercept than all other children She also has a flatter rate of growth which may be expected since her initial status is considerably higher. Furthermore, she reaches 100% of correct usage of the SSMNT like some of the typically hearing children do. The solid line in each of the graphs, indicates the mean growth trajectory of all participants in each group. CI children as a group have an increasing rate of growth between the ages of 2;0 and 3;0 as TH children do, with the only difference being that TH children have a higher accuracy percentage in SSMNT use than CI children. The rate of growth for both groups continues in the same direction and similar rate up until the age of 3;6 years old where CI children continue to demonstrate an increase in the percentage of accurate responses. This comes in contrast to TH children who show a small decline in their rate of growth and accuracy level during that time. This antithesis in the direction of growth continues at 4;0 years old where CI children show a small but sharp decline in their accuracy levels as opposed to TH children who show an increase in accuracy levels during that time. It is worth noting that CI children reach a higher accuracy level at 4;0 years old and while there is a sharp drop in their accuracy level, they remain at a slightly higher accuracy level than TH children at the age of 4;6.

3.7.2a Individual Growth Trajectory: Feminine in Nominative

Acquisition of SSFNT (feminine gender in nominative case) is more similar across children. As can be seen in Figure 3.7.2a in Appendix B, the difference between their intercepts, i.e. starting point, is not as stark as the differences in SSMNT intercepts, however they still reach significance, $p<.001$. The rate of growth shown by the slope of the growth trajectories are also similar except for participant 4 who has a gentler slope indicating a slower rate of SSFNT acquisition. The individual growth trajectories plotted using the raw scores of participants are marked by the solid line. Four out of 12 participants demonstrate no emergence of SSFNT between the ages of 2;0 and 2;6 years old (see participants 4 and 8) and 2;0 and 3;0 years old (see participants 3 and 12). All other participants show emergence of SSFNT from 2;6 years old and a fast rate of increased accuracy in SSFNT spontaneous use from there on. The differences between the two groups are depicted in the plots below.

Figure 3.7.2b *SSFNT Group Growth Trajectories showing each group's mean growth trajectory for the acquisition of the definite article used for the feminine gender in the nominative case*

Graph 1 = CI GROUP Graph 2 = TH GROUP



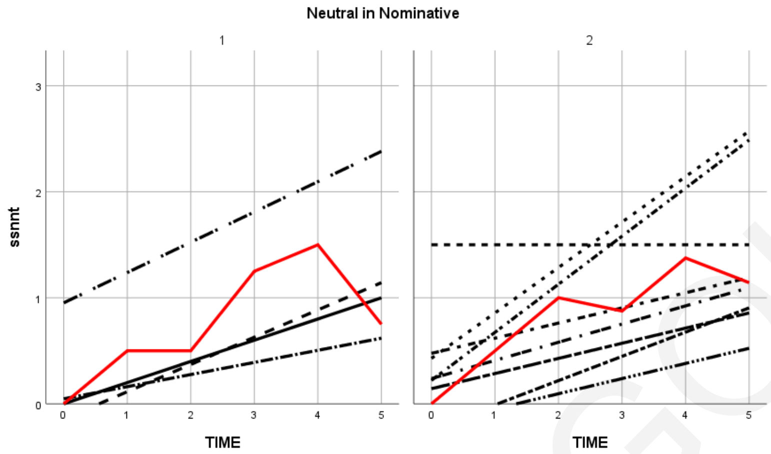
There are no significant differences between the initial status of the two groups and their rate of growth. All children seem to be acquiring SSFNT at similar rates of growth and have similar intercepts. The differences in their intercepts, when examined collectively grouped in their constituent groups, do not reach significance (*t*=-0.139, p=.892). The mean growth trajectory of each group is depicted by the solid line in each of the graphs. There is a steeper increase in the rate of growth for the CI participants between the ages of 2;6 and 3;0 (time values 1 and 2), whereas TH children seem to have no growth in that time period. TH children show a steeper rate of growth between the ages of 3;0 and 3;6 (time values 2 and 3) where CI children continue to show growth but not as fast as TH children. Where CI children show a fast rate of growth, TH children show a slower rate of growth to none. This pattern is repeated again between the ages of 3;6 and 4;0 (time values 3 and 4). Despite the opposite trends in the rate of growth between the two groups, CITH does not reach significance when added to the conditional growth model (t=0.680, p=.513).

3.7.3a Individual Trajectory Growth: Neutral in Nominative

Seven of 12 participants demonstrate no emergence of SSNNT at the age of 2;6 years old compared to SSMNT and SSFNT where the majority of children do demonstrate growth at that age. Despite the similarity in their starting values, the differences still reach significance, t=5.277, p=<.001. The rate of growth of SSNNT, depicted by the dashed lines has a wider range compared to SSMNT and SSFNT. For example, participant 11 demonstrates a flat rate of growth across time and participants 2, 5, and 9 have the steepest slopes and hence the fastest rates of growth across time. Individual growth trajectories plotted with participants' raw scores demonstrate a wide range of rates of success across participants and within individual participants as age increases. The differences in growth trajectories between the two groups is depicted in the plots below.

Figure 3.7.3b *SSNNT Group Growth Trajectories showing each group's mean growth trajectory for the acquisition of the definite article used for the neutral gender in the nominative case*

Graph 1 = CI GROUP   Graph 2 = TH GROUP



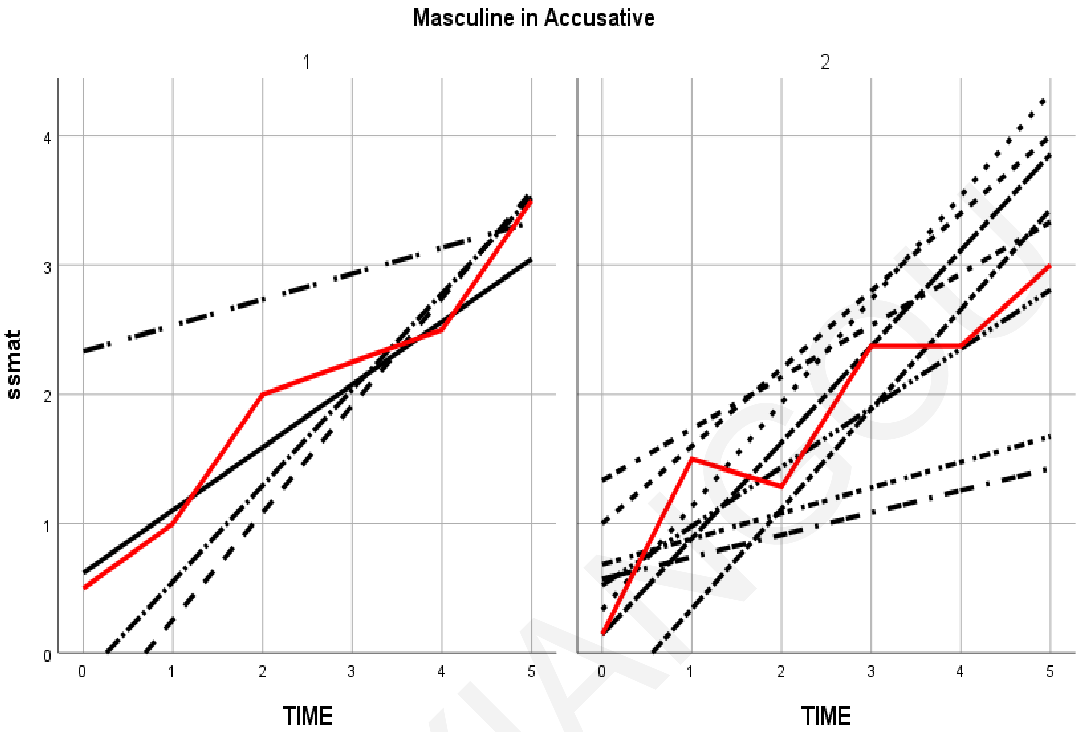
The plots above, depict children's growth trajectories plotted together in their respective groups. These plots indicate the overall slower rate of growth for all children across time when compared to the acquisition of SSMNT and SSFNT, where slopes are steeper, indicating a bigger growth between ages. Participant 2 (the highest dotted line in Graph 1) has the highest intercept, indicating that acquisition of SSNNT has emerged at a younger age compared to all other CI participants. The two mean growth trajectories are characterized by opposing intermittent patterns of growth. CI children and TH children have an upward sloping trajectory between ages 2;0 and 2;6 years old with slightly different rates. Growth continues in the same rate for TH children up to the age of 3;0 years old as opposed to CI children whose growth plateaus during that time. CI children demonstrate a faster rate of growth between the ages of 2;6 and 3;0 where their growth trajectory gains a fairly steep slope. This comes in contrast with TH children whose mean growth trajectory during that time shows a small declining slope, indicating a slight drop in their accuracy levels. The mean growth trajectories of both groups synchronize at the age of 3;6 and remain in sync until the age of 4;6 years old. There is no significant difference between the two groups. CI and TH children seem to follow the same path and rate of development and have similar starting points. This is also evident by the insignificance of their collective intercepts, *t* =0.323, p=.751, and the insignificant group effects (p=.927).

3.7.4a Individual Growth Trajectories: Masculine in Accusative

Acquisition of SSMAT behaves in a similar way as SSMNT, in that, most participants' growth trajectories are characterized by a steep slope, hence a fast rate of growth, between ages. Participant 2 (the highest dotted line in Graph 1) continues to have the highest intercept and a slower rate of growth. Participants 8 and 9 also demonstrate a slower rate of growth compared to other participants. Differences in their initial status reaches significance, *t* =11.84, p<.001. There are less breaks in the upward sloping pattern within individual trajectories compared to SSNNT, indicating that SSMAT has a more predicable path of acquisition, similar to SSMNT and SSFNT. For half of the participants there is a sharp increase in their success levels. That increase and rate is maintained up until the age of 4;6 years old. The group growth trajectories are depicted in the figure below.

Figure 3.7.4b *SSMAT Group Growth Trajectories showing each group's mean growth trajectory for the acquisition of the definite article used for the masculine gender in the accusative case*

Graph 1 = CI GROUP   Graph 2 = TH GROUP



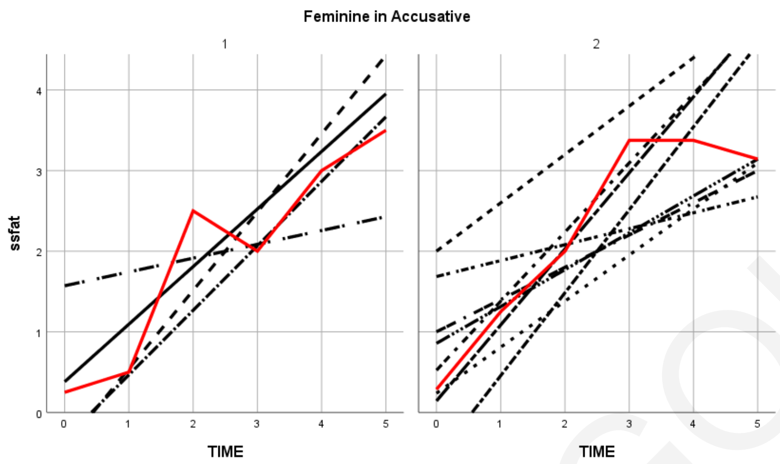
The rate of growth for the two groups is similar as well as their initial statuses. The similarity in their initial statuses is verified by the lack of significance in their collective intercepts, *t*=0.627, p=.545. Similarity in their rates of growth is confirmed by the conditional growth model where CITH does not reach significance when added as an independent variable, *t* =-0.043, p=.967. There is no significant difference between the two groups. SSMAT emerges around the same time and continues to grow at similar rates. Again, participant 2 has the highest intercept indicating that acquisition for this participant has progressed more compared to her peers and has more occurrences of correct use at a younger age. Opposing intermittent rates of growth are evident between the ages of 2;6 and 3;0. CI children demonstrate a fast increase in their growth as opposed to TH children who demonstrate a decline in their accuracy levels at a slow rate during that time. Both groups seem to synchronize in growth direction from the age of 3;0 to the age of 4;6 years old. This is demonstrated by the mean growth trajectories of the two groups.

3.7.5a Individual Growth Trajectories: Feminine in Accusative

Similar acquisition patterns are formed in SSFAT acquisition. As seen in Figure 3.7.5a in Appendix B, most participants acquire SSFAT at a steep rate with participants 2, 8 and 9 showing a gentler slope and hence a slower rate of growth across time, indicated by the dashed line. Participants differ in their initial status. These differences reach significance, t =11.8, $p<.001$. It should be noted that participants 2, 8, and 9 have higher intercepts indicating that acquisition of SSFAT emerged at a younger age compared to their peers. Their individual growth trajectories plotted using participants' raw scores, indicated by the solid line, show the path of acquisition of SSFAT across ages. Some participants demonstrate a steadier rate of growth without depletion of accuracy levels within the time span of 2;0 and 4;6 years old (see participants 3, 7, 10, and 12). Some participants have ups and downs in their growth patterns ending with an abrupt drop in their accuracy levels of SSFAT use (see participants 2, 6, and 9). The group growth trajectories for feminine in accusative are depicted below.

Figure 3.7.5b SSFAT Group Growth Trajectories *showing each group's mean growth trajectory for the acquisition of the definite article used for the feminine gender in the accusative case*

Graph 1 = CI GROUP   Graph 2 = TH GROUP



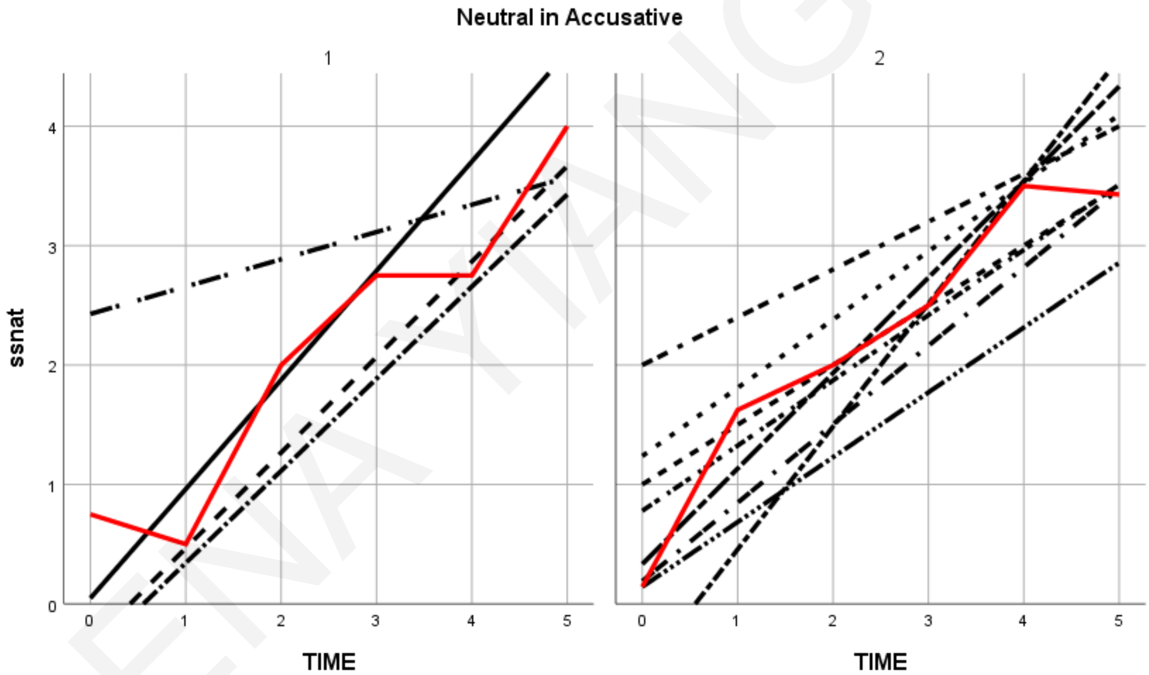
Comparison of the two groups shows no significant differences in initial status, *t* =-0.063, p=0.950. The rate of growth loses its significance but continues to remain very close to significant (*t*=2.033, p=.070). As per the conditional growth model, CITH as an independent variable reaches no significance (p=.505). CI children seem to have a sharp increase in their rate of growth between the ages of 2;6 and 3;0 followed by a decline in this rate between the ages of 3;0 and 3;6 followed by a steep increase in the rate of growth again between the ages of 3;6 and 4;6. This is different to that of TH children where the rate of growth is not as steep and remains steady up until the age of 3;6 followed by no growth at the ages of 3;6 and 4;0 and a slight decline in growth and accuracy of SSFAT use, from the age of 4;0 to 4;6 years old. This demonstrates yet again the opposing intermittent patterns in the rate of growth between the two groups.

3.7.6a Individual Growth Trajectories: Neutral in Accusative

SSNAT acquisition is more uniform across participants. Please refer to Figure 3.7.5a in Appendix B for all SSNAT individual growth trajectories. All participants demonstrate a similar rate of growth and similar starting points with the only exception being participant 2 who demonstrates a higher intercept and a slightly slower rate of growth. Even though their initial status is similar, the differences in that still reach significance, *t* =12.06, p<.001. Participants 6 and 9 show considerable decreases in their accuracy levels at the age of 2;6. Participants 3, 5, 7, and 10, show a small decrease in the levels of accuracy between the ages of 3;0 and 3;6 and then again at the age of 4;0 for participant 10. The group growth trajectories are depicted in the figure below (Figure 3.7.6b).

Figure 3.7.6b *SSNAT Group Growth Trajectories showing each group's mean growth trajectory for the acquisition of the definite article used for the neutral gender in the accusative case*

Graph 1 = CI GROUP   Graph 2 = TH GROUP



Adding CITH as an independent variable to the conditional growth model reaches no significance (p=.776). Both CI and TH children acquire SSNAT at similar rates and neighbouring intercepts with the exception of participant 2. The similarity in the collective intercepts of the two groups is also supported by the insignificance of the intercept, *t* =0.227, p=.825. The similarity in the rates of growth of participants is also shown in how similar the slopes of the two red lines are for the two groups. The opposite intermittent rate of growth pattern between ages for the two groups is evident for SSNAT as well. CI children show a steeper rate of growth between the ages of 2;6 to 3;0 as opposed to TH children whose rate of growth at that same age interval is a lot slower, indicated by the flatter slope. This pattern is repeated throughout their growth trajectories where CI children show steeper rate of growth between the ages of 3;0-3;6 and 4;0-4;6 as opposed to TH children whose rate of growth is slower at those ages. CI children demonstrate a slow rate of growth at the age of 3;6 and 4;0 where TH children demonstrate a fast rate of growth. TH children show a steeper rate of growth between ages 2;0 and 2;6 while CI children show an invert relationship of SSNAT acquisition across time, at that same time interval. The higher intercept of CI children’s mean growth trajectory at the age of 2;0 years old, is due to the much higher intercept achieved by participant 2, who is driving up the mean intercept as well.

3.7.7a Individual Growth Trajectories: Masculine in Genitive

SSMGT seems to have more common intercepts than any other variable indicating that acquisition of this grammatical form emerges at the same age with similar rates of success. None of the intercepts exceed the value of 1. Therefore, the differences between participants’ intercepts is smaller compared to the differences seen in other variables. Even though the difference in intercepts is small, it still reaches significance, t =11.58, p<.001. The rate of growth across participants is also similar with no participants falling in the two extremes, i.e., too fast or too slow rates of growth. Participant 10 has a slightly slower rate of growth compared to the rest as indicated by the flatter slope. Growth trajectories plotted by participants’ raw scores, marked by the solid line, are not characterized by frequent dips in the success levels of participants within their individual trajectories. This comes in contrast with the acquisition of masculine gender marking in the accusative case where unstable accuracy levels characterized a few of the participants’ individual growth trajectories. SSMGT is characterized more by periods of no growth between the ages of 3;0 and 4;0 years old (see participants 1,7, and 8) and between 3;6 and 4;0 years of age (see participants 3, 4, and 12). Participant 6 is the only participant with an acquisition pattern similar to that of SSMAT, where the increases and decreases within the individual trajectory are multiple. The group growth trajectories are depicted in the figure below (Figure 3.7.7b).

Figure 3.7.7b *SSMGT Group Growth Trajectories showing each group's mean growth trajectory for the acquisition of the definite article used for the masculine gender in the genitive case*

Graph 1 = CI GROUP   Graph 2 = TH GROUP

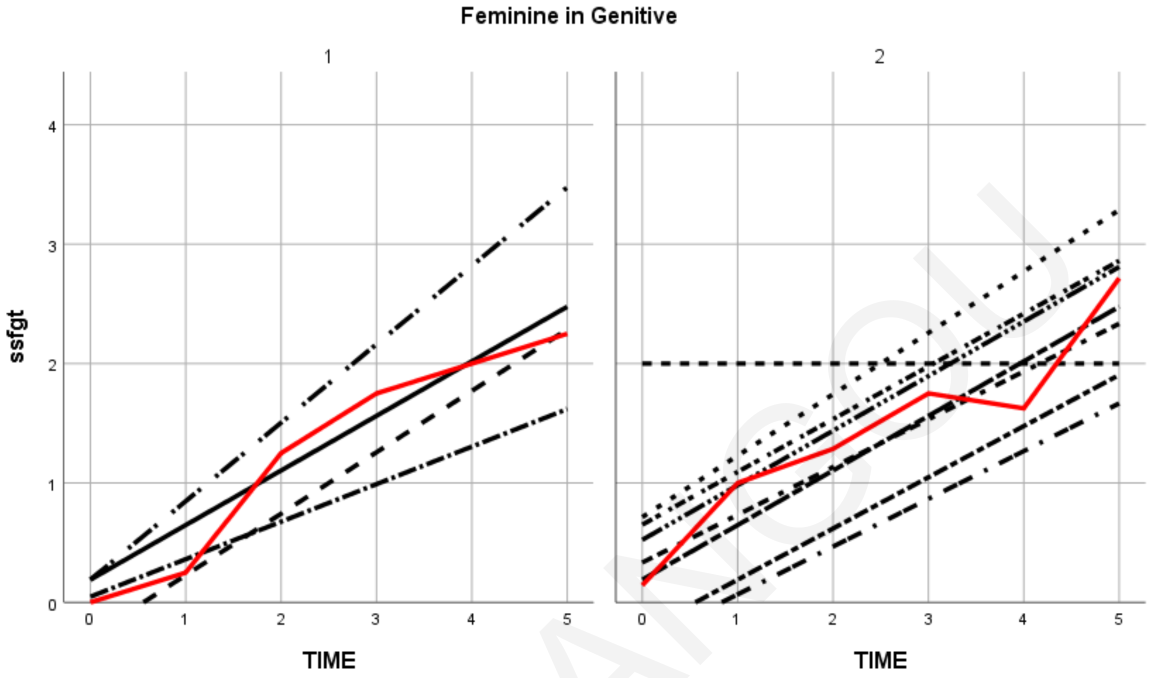
All individual growth trajectories fall very close to the mean growth trajectory of all participants of each group respectively. The mean growth trajectory seems to break the pattern of opposing intermittent rates of growth as CI and TH children portray a constant increase in their rate of growth from the age of 2;0 years old to the age of 3;6. This is repeated again for the age interval of 4;0 and 4;6 years old, where both groups move in the same direction at similar rates. Between the ages of 3;6 and 4;0 the CI group demonstrates slight growth whereas the TH group demonstrates no growth. There are no differences between the two groups as indicated by the lack of significance in group differences when CITH is added to the model as a predictor, t =1.496, p=0.154. The significance in the differences to their initial status is lost when intercepts are examined collectively in their constituent groups (*t* =-1.059, p=0.305).

3.7.8a Individual Growth Trajectories: Feminine in Genitive

Acquisition of SSFGT is not as uniform as SSMGT. As seen in Figure 3.7.8a in Appendix B, participants' rate of growth differs considerably. There is a wide spectrum of slope steepness in their growth trajectories. Participant 11 shows no growth across time in the correct use of SSFGT and consequently has a flat growth trajectory slope. Looking at the growth trajectories based on participants' raw scores, it is evident that SSFGT emerges and continues into acquisition at different ages, for almost all participants. There is no common or predictable pattern of acquisition across participants at specific ages. Half of the participants show no growth up until the age of 3;0 years old. This shows that SSFGT is a late developing grammatical aspect with most participants showing inconsistencies in their rates of success once spontaneous use of this grammatical aspect has emerged. Participants' initial statuses also differ significantly ($p<.001$). The group growth trajectories are depicted below.

Figure 3.7.8b *SSFGT Group Growth Trajectories showing each group's mean growth trajectory for the acquisition of the definite article used for the feminine gender in the genitive case*

Graph 1 = CI GROUP   Graph 2 = TH GROUP



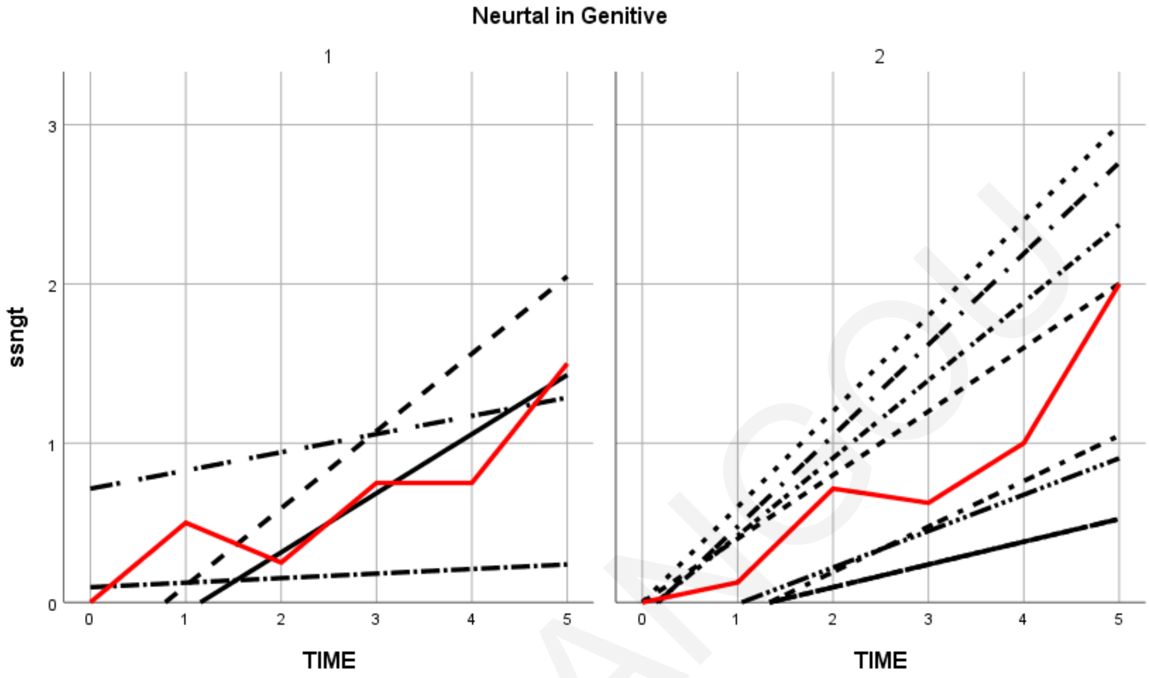
Comparing both groups, it seems that their average growth trajectories are similar showing a slower growth rate compared to the three genders in the nominative and accusative cases. The intermittent opposing rate of growth at certain ages is evident here as well where CI children show a slower rate of growth between the ages of 2;0 and 2;6 years old as opposed to TH children whose growth rate between those ages is faster, indicated by a steeper slope. Furthermore, TH children seem to show an invert rate of growth between the ages of 3;6 and 4;0 years old, as opposed to CI children whose rate of growth is increasing at a steady pace up until the age of 4;6 years old. TH children have an abrupt increase in their rate of success in the correct use of SSFGT between the ages of 4;0 and 4;6 years old, another instance of the intermittent opposing pattern in the rate of growth in the two groups. Children's hearing status is not significant (p=.285) in explaining the variation in their rate of growth. CI and TH children seem to acquire SSFGT with a similar rate despite the difference in their hearing age. The significance in the difference of initial status is lost when intercepts are examined collectively in their constituent groups, *t* = -0.558, p=.579.

3.7.9a Individual Growth Trajectories: Neutral in Genitive

SSNGT has the lowest success rate as shown by the volume of flat portions in participants' growth trajectories indicated by the solid line (Figure 3.7.9a, Appendix B). As mentioned earlier, the solid line is plotted based on the raw data regarding success levels for each participant. Participants 1, 3, 4, 6, 7, 10 and 12, a little more than half of the participants, do not begin using SSNGT correctly, up until the age of 4;0 and 4;6. SSNGT seems to be even more later developing than SSFGT. It is interesting that all participants except participant 4, demonstrate an abrupt change in the rate of growth between non-existence and emergence of SSNGT, indicated by the steep slope, close to vertical at times (see participants 1,3, 5, 7, 8, 9, and 11). The inconsistency in accurate correct productions is also evident in the inclines and declines within the growth trajectories of some participants (see participants 2, 4, 8, 9, and 11). This shows the variability in how each participant acquires SSFGT. The differences in their initial status reaches significance (*t* =4.901, p<.001). The group growth trajectories are depicted in Figure 3.7.9b.

Figure 3.7.9b *SSNGT Group Growth Trajectories showing each group's mean growth trajectory for the acquisition of the definite article used for the neutral gender in the genitive case*

Graph 1 = CI GROUP   Graph 2 = TH GROUP



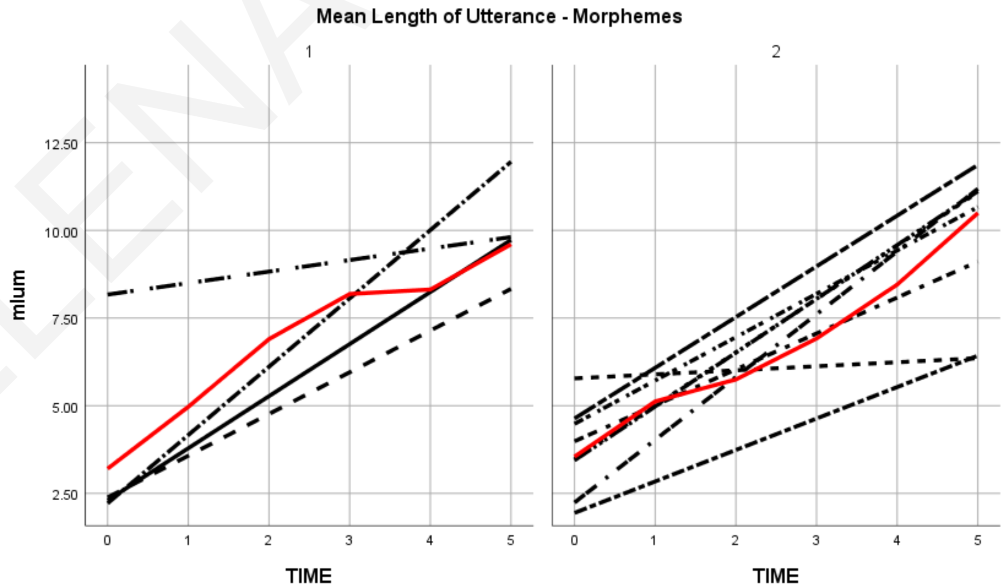
Even though the differences between the two groups do not reach significance (p=.552), comparing the growth trajectories graphically, it is evident that more TH children have growth trajectories with a steeper slope than CI children. The mean growth trajectory for each of the groups, indicated by the solid line, shows the intermittent opposing pattern in SSNGT acquisition as age increases. Up until the age of 4;0 old, CI and TH groups seem to be moving in opposite directions (2;6-3;0, 3;0-3;6, 3;6-4;0) with different rates of growth at age intervals 2;0 to 2;6 and 4;0 to 4;6 years old. CI children seem to show a faster rate of growth in the first time-interval in contrast to TH children who show a slower rate of growth. TH children show a faster rate of growth between the ages of 4;0 and 4;6 compared to CI children. The significance in the difference in their initial statuses is lost when all intercepts are examined collectively in their constituent groups, (*t* =0.350, p=.728).

3.7.10a Individual Growth Trajectories: Mean Length of Utterance in morphemes

Growth in the use of morphemes is characterised by a general upward slope for all subjects, except for participants 2, 11, and 12 (Figure 3.7.10a, Appendix B). These participants demonstrate an unsteady rate of growth evident by the dips in their growth trajectories produced by the raw data. Participants' 2 and 11 growth trajectories end with an upward slope, whereas participants 5 and 12 end with a downward sloping growth trajectory. The downward sloping trajectory for these two participants is between the ages of 4;0 and 4;6. All other participants demonstrate an increase in the correct % use of morphemes as age progresses. There are some dips followed by inclines in some participants' growth trajectories. Similar to participants 3 and 12, participants 2, 6, 7, and 9 show a decline in their MLUm at the age of 4;0. The initial status of each participant is different reaching statistical significance, t=17.76, p<.001. The group growth trajectories are depicted in Figure 3.7.10b below.

Figure 3.7.10b *MLUm Group Growth Trajectories showing each group's mean growth trajectory for the Mean Length of Utterance in Morphemes*

Graph 1 = CI GROUP   Graph 2 = TH GROUP



The growth trajectories of the two groups are similar in rate, but different in their starting points. Even though significance in their initial status is lost, when participants' intercepts are examined collectively in their constituent groups (*t* = 2.048, p=.068), they remain close to significant. In the CI group, participant 2 has a much higher intercept than the rest of the CI children. Children's hearing status does not reach significance, p=.842. CI and TH children have a linear increase in the correct use of morphemes across time. The mean growth trajectories of the two groups is also similar with an opposing rate of growth between the two groups between the ages of 2;6 and 4;0 years old. Where CI children demonstrate a faster rate growth, TH children demonstrate a slower rate of growth and vice versa.

3.7.11a Individual Growth Trajectories: Mean Length of Utterance in words

Development of mean length of utterance in words follows the same general pattern of increasing upward slope across time for the majority of subjects as mean length of utterance in morphemes. Participants 2, 11 and 12 demonstrate the same behaviour as in their readings of MLUm where there are sudden dips in their growth trajectories as indicated by the solid line which is a plot of the actual data, as mentioned earlier. The inconsistencies in the rest of the participants in the upward sloping direction characterizing their growth trajectories are also very similar to those observed in their MLUm growth trajectories. The group growth trajectories are depicted in Figure 3.7.11b.

Figure 3.7.11b *MLUw Group Growth Trajectories showing each group's mean growth trajectory for the Mean Length of Utterance in Words*

Graph 1 = CI GROUP   Graph 2 = TH GROUP

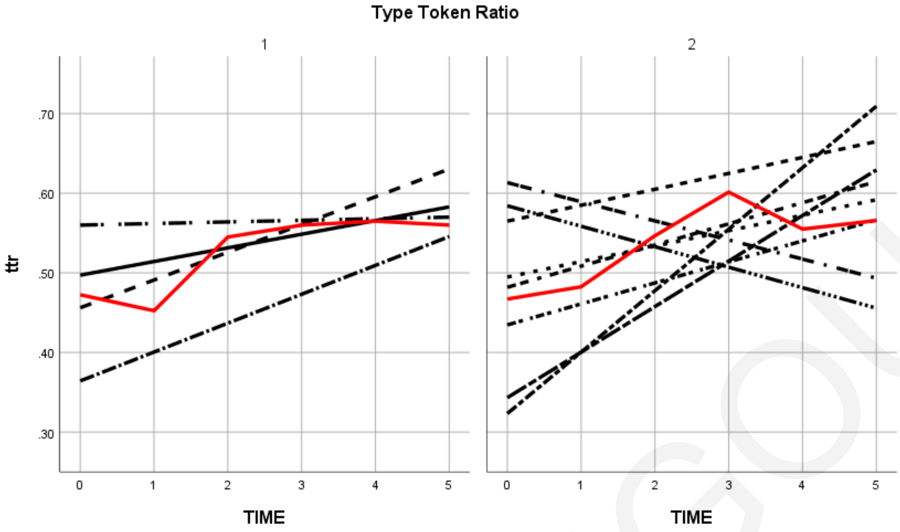
The growth trajectories of TH children are not as uniform within the group as the growth trajectories of CI children. CI children with the exception of participant 2 who begins with a higher intercept and follows a slower rate of growth, have similar intercepts and similar rates of growth. The number of words used per sentence increases linearly as age increases. TH children's intercepts vary more than those of CI children. Moreover, their rate of growth even though linear for the majority of children, two TH participants show a negative linear relationship between the two variables. The difference in their starting points remains significant when the two groups are compared to each other, *t* =2.897, p=.005. Their mean length of utterance in words decreases as their age increases. The mean growth trajectories for each of the two groups demonstrate similar mean rates of growth but at different ages for each of the groups. This is consistent with the other opposing intermittent growth patterns observed between the two groups in the growth trajectories of the previous outcome variables discussed earlier in this chapter. CI children demonstrate a faster rate of growth between the ages of 2;6 and 3;6 years old, as opposed to TH children who demonstrate a slower rate of growth during that same age interval. The differences between the two groups did not reach significance, p=.973

3.7.12a Individual Growth Trajectories: Type-Token Ratio

A general non-uniformity characterizes the type token ratio growth trajectories across participants. Looking at the solid lines, depicting the raw data (Figure 3.7.11a, Appendix B), it is evident that the instability in the direction of the growth trajectories is across all participants. The majority of participants demonstrate an up-and-down pattern across time within their individual growth trajectories. Some participants demonstrate a negative relationship of how their vocabulary diversity develops across time (see participants 6 and 8). The diversity for these participants seems to decrease as they get older. The rest of the participants seem to have a rather slow rate of growth in their vocabulary diversity as their growth trajectory slopes are gentle to flat. Participants 10 and 12 seem to be the exception to this slow rate of growth, evident by the steep slope of their growth trajectories. Starting points of participants vary considerably reaching significance, t =47.47, p<.001. The group growth trajectories are depicted below (Figure 3.7.12b).

Figure 3.7.12b *TTR Group Growth Trajectories showing each group's mean growth trajectory for vocabulary diversity as measured by the Type Token Ratio*

Graph 1 = CI GROUP   Graph 2 = TH GROUP



The mean growth trajectories depicted by the solid lines in each of the graphs confirm the opposing pattern in the rates of growth between the two groups yet again. Even though the trajectories are characterized by a very shallow slope, where CI children demonstrate a slow rate of growth (3;0 to 4;6 years of age) TH children demonstrate an increasing rate of growth followed by slight decline in their growth. The opposing directions of participants' growth trajectories within the TH group are evident where participants' growth trajectories cross. The differences between the two groups did not reach significance, p=.850. The difference in their initial status, when intercepts are compared collectively in their constituent groups, remains significant, *t* =4.218, p=.002.

3.8. TEREL Development and Standardization

As stated earlier, an assessment for typical development was developed under the scope of this research project. TEREL (Test of Early Receptive and Expressive Language) was administered to 231 children ages 2;6 to 6 years old. A large sample was recruited in an attempt to create a first preliminary normative sample.

The experimental group and control group were compared to this preliminary normative sample to establish their level of development at the age of 5 years old. The CI group was compared to the normative sample to examine whether or not they had reached typical language levels by the age of 5 years old. The control group was compared to the normative sample to confirm parent and teacher report, as well as clinical informal observations indicating normal development. The experimental and control groups were assessed at the age of 5 years old and not earlier, due to the time-consuming process of developing a language assessment and attempting to standardize it.

Item response theory was applied to run the statistical analysis on TEREL's psychometric properties using the Rasch model. Each item was analysed as to its difficulty and reliability using the IRT program in R. The test is divided into receptive and expressive language. The receptive section consists of 39 items, whereas the expressive section consists of 43 items.

The normative sample of 231 children was divided into 8 groups in 6-month increments starting at the age of 29 months up to the age of 81 months. All groups were 6 months apart, except for the last group which was comprised of a wider range of ages, 71-81 months. This was done due to the very small number of the children falling within the age range of 77-81 months old, which was the age range for the 8th group. Reliability and separation for items and ability was examined for each group separately. Outliers falling outside the range of 2 standard deviations above or below the mean were examined and was determine on a case by case basis whether they would be included or excluded from the analysis. The distribution of person to item was examined through the use of a variable Wright map produced using Winsteps software. Due to space limitations, the variable maps will be discussed but will not be included in the results section. Please see Appendix C for these variable maps.

Item reliability refers to the items' ability to reproduce the same range of difficulty every time a normative population is tested. In other words, items that are considered difficult remain difficult across the normative population and scores on these specific items do not vary considerably or constantly. Item separation refers to the items' hierarchy, i.e. levels of difficulty: low, medium, high. A balanced test should be comprised of a set of items that have varying degrees of difficulty to increase its sensitivity to identifying children with low, medium, or high language levels.

Person reliability refers to the test's ability to identify consistently children with high language abilities as children with high language abilities across the testing population. The probability that if retested these children will fall into the same ability level needs to be high for a test to be considered a reliable language measure. Person separation refers to the test's difficulty range. A test comprised of items with a wide range of difficulty will be better at identifying all children's abilities consistently and reliably. In other words, it will not misidentify children as having a high language level when in fact they are below average.

3.8.1 TEREL: Expressive Language

TEREL's expressive language section yielded encouraging results as to its items and person reliability and separation for all age groups.

Item reliability for the first group ages 29-34 months was .76 which is considered low. Item separation was also low, reaching a value of 1.76. This group consisted of only 10 children. Person reliability for this group was high, .94 which shows that the children's wide ability range is identified by the test. The person separation value is also high, 3.97, indicating the test's ability to classify children into their true ability levels. The variable map for this age group (see Appendix C, Wright Map 3.8.1E) revealed an outlier which was not removed from the analysis. When removed the item reliability decreases to .73 and item separation decreases to 1.63. Person reliability decreases to .90 and person separation decreases to 2.93. This child was not removed from the analysis because it has an extremely low expressive language raw score. The high person separation with this child's data included in the analysis, shows how well TEREL can identify and separate children into categories according to their true language abilities. The wright map (see Appendix C, Wright map 3.8.1E), depicts a well-formed distribution of persons around the items' mean, falling within +/- 1SD from the mean apart from this child which falls 4SD below the mean items' difficulty. The variable map further supports the high person separation value. It is evident that the test classifies participants according to their true abilities as there was no clustering of participants on either end of the measurement axis.

The second group, ages 35-40 months, was comprised of 18 children. Item reliability for this group was higher compared to the first group. It reached .82. This was verified by the higher item separation value, 2.16. It is evident that items comprising this test range widely in their difficulty level. Furthermore, items with higher level of difficulty identify children with higher language levels and items with low level of difficulty identify children with lower linguistic abilities and they do so consistently. Person reliability was even higher, .92, as was person separation reaching a value of 3.48. As per this group's variable map (see Appendix C, Wright map 3.8.2E) participants fall within +/- 2SD around the items' mean difficulty level.

The third group, ages 41-46 months, was comprised of 33 children. Item reliability reached .91 accompanied by a high item separation value of 3.21. Person reliability and person separation were also high for this group reaching .95 and 4.28 respectively. This group's variable map (see Appendix C, Wright map 3.8.3E) revealed two outliers that were not removed from the original analysis for the same reasons stated for the first group outlier. A repeat analysis yielded without the outlier showed a very small decrease in the item and person reliability and separation values. Item reliability and separation decreased to .91 and 3.21 respectively. Person reliability decreased to .94 and person separation to 4.12; a decrease which is deemed insignificant. All participants, apart from the two children scoring 4 and 5SD below the mean, fell within +/- 2SD from the items' mean difficulty value indicating a balanced distribution with no clustering in each of the two extremes of the measurement continuum.

The fourth group was comprised of 38 children ages 47-52 months. Item reliability and separation values were not as high for this group when compared to the fourth group. Item reliability reached .89 and item separation reached 2.89. Person reliability and person separation were a bit lower, .85 and 2.41 respectively. The variable map for this group (see Appendix C, Wright map 3.8.4E) shows a bigger clustering around the items' mean difficulty level while all participants fall within +/-1 SD from the mean.

The fifth group was comprised of 40 children ages 53-58 months, one of which had an extremely low raw score on the expressive language measure. Item and person reliability and separation are not significantly affected with the removal of this outlier. Item reliability falls from .90 to .88 and item separation falls from 2.97 to 2.76. Person reliability falls from .92 to .87 and person separation falls from 3.33 to 2.64. It was decided to include the outlier in the analysis, not for the sake of presenting the more favourable results but due to the nature of the outlier and what it represents. This child had a raw score of 6. This indicates atypical development. Children with such low abilities should be identified by the test if it is to be considered a reliable language measure. The fact that this child's score raises the test's item and person reliability and separation values shows that the test achieves what is was set out to achieve, identification of typical and atypical development. The variable map for this group (see Appendix C, Wright map 3.8.5E), shows the majority of children falling within -1 and 2SD from the items' mean difficulty level. Only one child falls 1SD below the items' mean difficulty while the aforementioned outlier falls 3SD below the items' mean difficulty level.

The sixth group was comprised of 37 children, ages 59-64 months. Item reliability and separation was satisfactory, .89 and 2.80 respectively. Person reliability and separation were higher, .91 and 3.12 respectively. The variable map (see Appendix C, Wright map 3.8.6E) places participants +/-2SD above and below the items' mean difficulty level.

The seventh group was comprised of 25 children ages 65-70 months. Two of the children were towards the lower end of the measurement continuum. Item and person reliability and separation are not significantly affected with the removal of this outlier. Item reliability falls from .89 to .86 and item separation falls from 2.84 to 2.43. Person reliability falls from .97 to .93 and person separation falls from 5.87 to 3.77. It was decided to include the outliers in the analysis for the same reasons stated in the discussion for group 5. These two children were identified as atypical from informal observations, parent and teacher report. Their extremely low raw scores confirm the test's ability in identifying children based on their true abilities. It does not over- or underestimate children's true language abilities. The variable map for this group (see Appendix C, Wright map 3.8.7E) shows the majority of children falling within -2 and 2SD from the items' mean difficulty level. The two children identified as outliers fall 4SD below the items' mean difficulty level.

The eighth group was comprised of 19 children ages 71-81 months. Item reliability and separation values were not high for this group compared to the rest of the groups. Item reliability reached .72 and item separation reached 1.60. Person reliability and person separation were a slightly higher, .83 and 2.18 respectively. The variable map for this group (see Appendix C. Wright map 3.8.8E) shows this group's participants falling within -1 and 1SD from the items' mean difficulty level. The two children identified as outliers fall 4SD below the items' mean difficulty level.

3.8.2 TEREL: Receptive Language

The same procedure was followed for the receptive language aspect of this measure. Item and person reliability and separation were examined to investigate the item behaviour of the items comprising the receptive part.

The item reliability and separation for the first group ages 29-34 months was low, .72 and 1.59 respectively. Person reliability and separation values were even lower, .63 and 1.30 respectively. This group was comprised of only 11 children. All children's scores fell between 3 and 5SD below the items' mean difficulty level, as per this group's variable map (see Appendix C, Wright map 3.8.1R). This may indicate atypical development or insufficient sample resulting in low item and person reliability and separation values.

The second group, ages 35-40, demonstrates better values as to the test's ability to identify children based on their true language abilities compared to the first group. This group has a slightly bigger sample as it is comprised of 18 children. Item reliability and separation values reach .81 and 2.05 respectively as do person reliability and separation values, with person separation being insignificantly lower, 2.03. As per the variable map for this group (see Appendix C, Wright map 3.8.2R) all children fell within 1SD below the mean and 2SD above the mean, with the majority of children being within +/-1SD above and below the items' mean difficulty level.

Item and person reliability and separation values increase compared to the first two groups. This group was comprised of 36 children. Item reliability reaches .89 lending evidence to the fact that difficult items are answered correctly only by children with higher language levels and easy items are answered correctly only by children with low language levels. The range of difficulty seems to be a clear hierarchy of high, medium, and low categories as item separation reaches a value of 2.79. The variable map for this group (see Appendix C, Wright map 3.8.3R) confirms the well-formed distribution of persons around the items' mean difficulty level. All 36 children are +/-1SD above or below the items' mean difficulty level. Person reliability and separation reach the values of .86 and 2.50 respectively; values that are favourable.

A slightly bigger group of 38 children for group 4, ages 47-52 raises item reliability to .90 and item separation to 3.07. Person reliability is .87. Person separation reaches a value of 2.63. The variable map for this group (see Appendix, Wright map 3.8.4R), places children's abilities 3 to 5SD below the items' mean difficulty level. Looking at the raw scores for this group, they range between 9 and 30 which does not differ greatly from the raw scores of groups 2 and 3. The raw scores for groups 2 and 3 range from 8 to 21 and 7 to 24 respectively. This may indicate that participants of group 4 may not be within the typical range of development. Since groups 2 and 3 are +/-1SD above or below the mean, this groups' performance cannot be attributed to a limiting item difficulty range but rather to the children's skill levels.

The fifth group ages 53-58 months and was comprised of 40 children. The item reliability and separation values are higher than the younger age groups reaching .91 and 3.27 respectively. The person reliability and separation values remain the same as those of group 4, .87 and 2.62 respectively. The variable map (see Appendix C, Wright map 3.8.5R) places children within 2 and 6SD below the items' mean difficulty level.

Group 6 was comprised of 37 children ages 59-64. Item reliability and separation values were lower compared to groups 4 and 5. They reached .81 and 2.10 respectively. Person reliability and separation values reach .88 and 2.76 respectively. The variable map for this group (see Appendix C, Wright map 3.8.6R) places children scores between 0 and 3SD above the items' mean difficulty level.

Group 7 was comprised of 25 children, ages 65-70 months. Item reliability and separation values reached .84 and 2.29 respectively. Person reliability and separation values were much higher reaching .93 and 3.79 respectively. The variable map for the group (see Appendix C, Wright map 3.8.7R) places children 2 to 5SD below the items' mean difficulty level. Two of the children fall 5SD below the items' mean value. These two children may be considered outliers. However, looking at their raw scores, it is evident that their language development is atypical. These children also achieved really low raw scores in the expressive language measure. Their language development is atypical all around. The high person reliability and separation shows that the test was able to identify their atypical developmental level. They were therefore not removed from the analysis.

Group 8 was comprised of 19 children of a wider age range, 71-81 months old. The item reliability and separation values for this group are low, reaching .51 and 1.01 respectively. The person reliability and separation are considerably higher, reaching .79 and 1.95 respectively. The variable map (see Appendix C, Wright map 3.8.8R) places children up to 3SD higher than the items' mean difficulty level.

3.9 How do the two groups compare to the normative TEREL sample

The total scores of definite article use were used to compare the two groups, CI and TH, to the normative TEREL sample. These scores were chosen because definite article use was the main grammatical aspect that this study set out to investigate.

Pearson's chi-square was used to compare each of the two groups to the normative sample. The first total that was used for comparison was the plural form of the feminine gender in the genitive case. No significant difference was found between the two groups and the normative sample, χ^2 (2, N = 238) =1.192, p=.551. The two groups seem to fall in line with the normative sample since the majority of the TH children and all of the CI children did not correctly produce this form of the definite article. The singular form of the feminine gender in the genitive case almost yielded a significant difference, χ^2 (2, N = 238) = 4.964, p=.084, between the two groups and the normative sample. Fifty percent of CI children succeeded in its use whereas the other 50% failed. All of the TH children achieved correct production of this form of the definite article. This comes in contrast to the normative sample where almost 40% of children failed in the correct production of this definite article form and a little over 60% succeeded in the use of this definite article form.

The second and third definite article forms that were used for comparison were the plural forms of the feminine and neutral genders in the accusative and nominative cases. Both these forms where examined by the same test item(s). Again, chi-square yielded no significance, χ^2 (4, N = 239) = 4.721, *p*=.317, between the two groups and the normative sample. The majority of TH children and all of the CI children correctly produced this form of the definite article. This motif, where CI children achieve higher percentages of accuracy is also seen in the production of the plural form of the neutral gender in the genitive case. A rather difficult case to acquire as shown by the individual and group growth trajectories earlier. CI children achieve a 75% accuracy level as opposed to TH children who achieve a 50% success rate and the normative group where the majority of children, nearly 60%, fail to correctly produce this form of the definite article. The motif applies for the accurate production of the plural form of the masculine gender in the genitive case where CI children demonstrate 100% accurate productions whereas TH children only achieve 50% and the normative group 45%. Even though there is a difference in the percentage success demonstrated, this difference was not statistically significant, χ^2 (2, N = 238) = 4.903, *p*=.086.

The plural form of the masculine gender in the accusative case also yielded non-significant differences, χ^2 (2, N = 238) = 4.065, *p*=.131. It is interesting that CI children behave in the exact same way as the normative sample where the success and failure of this form's production is 50-50. The TH group seems to have a better performance than both the CI and normative groups, as TH children achieve a success rate of 80%.

The singular and plural forms of the masculine gender in the nominative case as well as the singular form of the neutral gender in the nominative case yield no significance difference (χ^2 (2, N=239) =1.410, *p*=.494, χ^2(2, N = 239) =4.049, *p*=.132, and χ^2 (2, N = 238) =2.767, *p*=251 respectively) between the three groups since all three groups behave in the exact same way. All three groups demonstrate the same trend in successful productions for both definite article forms.

DISCUSSION

The aim of this longitudinal study was to examine the acquisition of the definite article in all genders, cases, and numbers, as well as the mean length of utterance in morphemes and words, and vocabulary diversity as measured by Type Token Ratio in deaf children with CIs. The sample was comprised of four two-year-old congenitally deaf children with CIs and eight typically hearing children, speaking the Greek-Cypriot dialect. Data was collected through the use of 30-minute language samples and a structured session. The structured session was developed to elicit the definite article in all its forms through the use of a protocol. The language sample and structured sessions were carried out every 6 months until the children reached the age of 4;6 years old. The Test of Early Receptive and Expressive language, TEREL, was developed and standardized within the scope of this study to measure the language level of participants. Both groups were compared to the normative sample of 231 children to establish typical and atypical development where present.

This study hypothesized that: a) children with CIs follow the same developmental path as their typically hearing peers, b) CI children acquire the various definite article forms at the same rate as their TH peers, c) both groups demonstrate similar levels of morphosyntactic ability as measured using MLUm and MLUw, and d) CI children's raw scores on TEREL do not differ significantly from those of their TH peers.

Mixed Linear Models (MLM) were chosen as the method of data analysis as they account for the small size (McNeish, 2017). Furthermore, the nature of data, i.e. repeated measures, creates fixed as well as random effects since data is repeatedly collected from the same participants (Finch, 2014; Willet, 2003). Hence, it was of interest to the investigator to determine whether or not inherent individual variation contributed to differences and/or similarities in definite article acquisition between the two groups.

The rest of this chapter will discuss the findings supporting or refuting each of the hypothesis stated above.

4.1. Do deaf children with CIs follow the same developmental path as their typically hearing peers?

This first hypothesis was investigated using four mixed linear models; the unconditional means model, the unconditional growth model, the conditional growth model and the conditional growth model where the rate of growth is kept constant. Specifics of each model are described in detail in the results chapter.

The unconditional means model was used to detect variability between and within individual participants without specifying which factors increase the presence of random and fixed effects. In other words, it was used to detect random effects and fixed effects in general. As explained in chapter 3, random effects are brought in by inherent differences in participants while fixed effects represent differences between participants.

Results from this model yielded significant difference in the intercepts between participants. All participants had a different starting point at the commencement of the study for all of the dependent variables. In other words, the level of correct use of the definite article when it first emerges in each of the forms investigated, differed for each participant at the age of 2 years old compared to the true population mean. This shows variability between participants in their initial status. Even though there is a difference between participants in the number of correct occurrences of definite article use, all participants show emergence of definite article acquisition at the age of 2 years old. This supports the first hypothesis that children with CI begin using the various definite article forms at the same age as their typically hearing peers. Furthermore, definite article forms emerging at a later age, such as SSMGT, SSFGT, and SSNGT, happens so for both groups. This model does not look at differences in the rate of acquisition at each time point.

As seen in section 3.6.1 in the Results chapter, random effects are unveiled when time is added into the model as a predictor. It seems that time, i.e. children's increasing age, carried enough inherent variability that contributed to outcome variability in 9 out of 12 outcome measures, namely, SSMNT, SSFNT, SSNNT, SSMAT, SSFGT, SSNGT, MLUm, MLUw, and TTR. Table 3.6.1.1 depicts the ICC values obtained from the three models; unconditional model (m1), unconditional growth model (m2), and conditional growth model (m3). There is a substantial increase in ICC values when time is added into the model (m2). This shows that children's responses during the language sampling session and on the protocol used during the structured session, are not independent of each other when going from time point 1 to time point 2 and so on. Each preceding linguistic structure used, seems to act as a basis upon which new linguistic structures are added, indicating the presence of random effects since the responses of each child across the different time points are not independent of each other.

There is an insignificant increase in ICC values when children's hearing status is entered into m3 as an additional predictor to the outcome. This insignificant increase shows that children's hearing status did not carry significant additional inherent variability in children and ICC values remained rather constant. In other words, hearing status does not contribute to the pattern of variation within an individual child during definite article acquisition. Each child compared to itself, seems to differ in the number of correct occurrences of definite article use, but the variation in the number of correct occurrences of definite article use is not affected by the child's hearing status. Even though the reason behind this variation was not one of this study's goals, the difference in the amount of variability each child portrays may be an indication in the difference of parenting styles conversationally and linguistically. It can therefore be inferred that external environmental factors seem to affect how inherent variability changes within each child, more so than their hearing status would. This falls in line with early implantation benefits in that additional inherent variability accounted for by hearing status, is eliminated due to the early implanted children's ability to bridge the linguistic gap rather quickly. As a result, deaf implanted children and hearing children are not so different as the disability would lead us to think.

Having ICC values ranging from .27 to .46 justifies the use of MLMs. This is so, as such ICC values show that random effects account from 27% to 46% of the total variability in the outcome. That is, nearly 50% of the total variability for 3 out of the 9 measures, is accounted for by individual differences each participant exhibits in definite article acquisition, when moving from time point 1 to time point 2 and so on. The remaining 6 outcome measures, present with random effects that account for 33% on average, of the total variability in the outcome. These values cannot be ignored as they show how significant inherent variability is in each individual child and how it helps shape result interpretation.

Lastly, the fact that the range of ICC values remains steady with the addition of children's hearing status as an independent variable and when the rate of change in growth is kept constant (.23 to .46) shows that age (time) is the factor that accounts more for the inherent variability in individual children rather than their hearing status.

The unconditional growth model as mentioned earlier, was used to investigate how well time predicts the variability in the outcome variables as well as the rate of growth within and between participants. The number of correct occurrences of all the definite article forms under investigation, increased as children's age increased, revealing a linear relationship. This linear relationship confirms the hypothesis that children with CIs follow the same developmental path as their typically hearing peers. The increase in the number of correct occurrences of the various definite article forms as well as MLUm, MLUw, and TTR as children's age increased, reached significance. This shows that age is an important predictor of the different definite article forms a child will use, as well as the MLUm, MLUw, and TTR levels they will reach.

Significance of time with positive t-values for all dependent variables validates the fact that CI children follow the same developmental path as their typically hearing peers. In other words, there is a positive growth in all children across all outcome measures. Even though the sample is small and such findings cannot be generalized, they still show that some if not all children with CIs speaking the Greek-Cypriot dialect, follow the same developmental path, as their typically hearing peers, in the acquisition of the definite article and growth of the mean length of utterance, enabling them to potentially reach typical language levels. This has an important clinical implication, as speech-language pathologists and teachers of the deaf should and potentially could expect more linguistically, from deaf children with CIs.

4.2. Do CI children demonstrate acquisition of the various definite article forms at the same rate as that of typically hearing peers? Is there a statistically significant difference in CI children's MLUm and MLUw when compared to typically hearing peers?

This section will provide evidence that confirm the second and third hypotheses. These two hypotheses were tested using the conditional growth model where children's hearing status was entered into the analysis as a predictor in a stepwise manner.

As mentioned above ICC values were calculated to examine the presence of random effects, i.e. within-subject differences entering both time and hearing status into MLMs. Significance of time as a predictor increased the ICC values, indicating the presence of within-subject differences, but did not unveil significant differences between the two groups. Hearing status was then added to the conditional growth model to examine the change in within-subject differences and the emergence of differences between the two groups, i.e. CI vs TH. Does hearing status account for outcome variability between the two groups? As mentioned before, the addition of hearing status as a predictor to the analysis yielded no significant within-subject differences in any of the outcome measures. It did not yield significant differences between the two groups either. Children with CIs did not have a different rate of growth over time when compared to their typically hearing peers. It can therefore be concluded that CI children seem to acquire the various definite article forms at the same overall rate as their TH peers. Even though the sample for this study included all who could have been recruited at the commencement of the study based on the inclusion criteria, it was still a small sample. Therefore, generalization of results should be done with caution. It is however, noteworthy that this small sample of Cypriot-Greek CI children, does not demonstrate any statistically significant differences in the overall rate of growth when compared to their typically hearing peers. Therefore, this data should be considered, an initial foundation for the compilation of data to follow, concerning Cypriot-Greek CI children's grammatical development.

The small sample size compromises statistical power and may consequently prohibit significant differences between the two groups from showing. It is therefore important to delve deeper into these results, qualitatively, through the use of individual and group growth trajectories for more precise interpretation.

Individual and group growth trajectories were generated using the raw data of each participant. This was done to see the minute differences in the rate and direction of growth of each participant, for a more thorough description and result interpretation. As mentioned earlier, it was deemed important, considering the small sample of the study and compromised statistical power.

4.2.1 Group growth trajectories: Interpretation

The aforementioned ICC values are validated by the shape of the group growth trajectories that reveal an interesting qualitative difference between the two groups. It should be noted that this difference may seem contradicting to the aforementioned argument which states that both groups have the same direction in growth when acquiring definite articles. All mean individual growth trajectories have the same direction (please see Appendix B, Individual Growth Trajectories). However, when the mean growth trajectory of each group is examined separately at each time point, it is obvious that there are differences in growth direction and rate between groups (please see, Chapter 3, 3.7 Individual and Group Growth Trajectories). In other words, direction and rate of growth is not identical for both groups at all individual time points, i.e. age. The changes at individual time points are mirrored by the ICC values obtained with the unconditional growth model. The small differences in rate and sometimes direction of growth at certain time points revealed by the growth trajectories, map out an interesting pattern. This pattern may act as an explanation as to how CI children manage to bridge the linguistic gap with their TH peers as far as definite article acquisition is concerned.

The overall shape of the mean growth trajectory based on each group's raw data does not differ greatly. However, the direction and the rate of growth at some of the time points appears to be inverse between the two groups. CI children demonstrate a faster rate of growth, in nearly all definite article forms, when TH children demonstrate a drop in their rate of growth and vice versa. When the growth trajectory slopes inversely in relation to time at certain ages for the TH children, it slopes linearly for CI children. This inverse sloping shows that the number of correct occurrences of the various definite article forms decreases at certain ages for the typically hearing children. While this decrease occurs, an increase in the number of correct occurrences of the same definite article forms arises for CI children at that same age. This may be due to the fact that children with CIs, having late access to sound, exhibit language growth spurts at different times to those of typically hearing children while maintaining the same overall rate and direction of growth in the acquisition of the definite article. These findings cannot however be generalized due to the small sample size.

This is evident at the age of 2;0 years old when TH children's growth trajectory slopes downwards indicating a decrease in the use of SSMAT (see Figure 3.7.4b). CI children's growth rate increases during that time as well as the use of SSMAT. The opposite trend is seen in the use of SSFAT (see Figure 3.7.5b) at the age of 3;0 years old when CI children's mean growth is lower compared to that of TH children and downward sloping indicating a decrease in the use of SSFAT. This is seen again at the age of 2 years old with the use of SSNAT (see Figure 3.7.6b). TH children at this time demonstrate a fast rate of development, indicated by the steep upward sloping trajectory.

The inverse motif in the rate of growth is also evident in the use of the feminine gender in the nominative case (see Figure 3.7.2b) where CI children's mean growth increases rapidly between the ages of 2;6 and 3 years old while TH children's mean growth plateaus. The same trend appears in TH children's use of SSNNT (see Figure 3.7.3b). TH children have a higher mean growth and an upward sloping trajectory between the ages of 2;6 and 3;0 years old in antithesis to CI children, whose mean growth in the use of SSNNT plateaus between those ages. The plateau is indicated by the flat slope in their trajectory.

It is also interesting that CI children's mean rate of growth on the use SSMAT and SSFAT is higher compared to TH children at certain ages. CI children's mean rate of growth in the use of SSMAT and SSFAT at the age of 3;0 is higher compared to TH children. Mean rate of growth for SSNAT is at the same level for both groups at the age of 3;0. CI children have a higher rate of growth at the age of 4;6 for all three genders in the accusative case. What is even more interesting is that, TH children's mean rate of growth at the age of 4;6 for these three forms of the definite article is not only lower than that of CI children, but there is also a decrease in the use of these forms indicated by the downward slope of the mean growth trajectory between the ages of 4;0 and 4;6 years old. This shows the aforementioned inverse motif in the acquisition of the various definite article forms between the two groups.

There are no other studies, to the best of my knowledge, where individual and group growth trajectories were generated for this population in an attempt to investigate CI children's definite article acquisition. One study generated individual growth trajectories to compare CI children's receptive and expressive language to that of profoundly deaf children with hearing aids. Apart from the linear relationship between age and growth for CI children, which is yielded by the current study's results as well, none of the other results were relevant to the aims of the current study (Yoshinaga-Itano, 2010). A second study focused on the effect of maternal linguistic input on the language of children with CIs. Growth trajectories showed a linear relationship between language development and time for CI children and their TH peers (Quittner et al., 2013). The inverse growth motif was not observed in this study; however, it should be noted that they did not examine acquisition of specific grammatical aspects like the definite article. Therefore, their results are not directly comparable to the current study's results.

The inverse motif is thus an interesting phenomenon. It ought to be investigated further with a bigger sample to negate or confirm that this is in fact why CI children manage to close the language gap by the time they start preschool. It appears that the decrease in the rate of growth in TH children at certain ages gives CI children the chance to make head way in the use of definite article forms and thus enables them to reach typical language levels in time for preschool. This difference in the rate of growth within the range of 2 and 4;6 years old may thus, be the reason why CI children manage to reach typical language levels by the age of 5 years old.

The inverse motif is evident in all definite article forms described in the paragraphs above, except for the masculine and feminine genders in the genitive case. Emergence of acquisition of the genitive case for the masculine and feminine genders seems to differ in both groups when compared to emergence of the rest of the definite article forms. Use of both genders in the genitive case reach much higher levels of significance and t-values compared to the rest, (*t*=13.603 and p<.000 and *t*=10.198 and p<.000 respectively). These much higher significance and t-values, show a higher degree of difficulty in acquiring the definite article in these two genders in the genitive case, compared to the rest of the genders and cases. This is supported by the emergence of SSMGT and SSFGT at an older age (4;0 and 4;6 years old) and the upward sloping growth trajectories from there on (see Figures 3.7.7b and 3.7.8b). The abruptness in the upward slope of the growth trajectory may be indicative of the maturity level a child has to reach before they can start using SSMGT and SSFGT correctly.

Evidence of nominative and accusative emerging earlier, falls in line with other highly inflected languages where the cases of nominative and accusative are the first ones to be acquired versus dative and genitive that emerge later on. This is because use of the latter cases differentiates the role of the subject(s) and hence the meaning of the sentence, i.e. differentiating the possessor from the recipient (Clark, 2017). Furthermore, emergence of these two cases seems to occur past the two-word stage, as is evident in the current study's results as well.

In addition, children first acquire the singular form of words and then the plural form. Acquisition of the plural form also depends on how clearly each gender is marked for genitive plural (Clark, 2017). In the case of Greek and the Greek-Cypriot dialect, the ending marking genitive plural is the same for all three genders. Paradoxically, it appears to be harder for children speaking the Greek-Cypriot dialect to assign the same ending to all genders of plural nouns in the genitive case, even though it should be easier since the ending does not differ. This apparent difficulty may be the reason why they emerge at an older age compared to the genders in the rest of the cases. Even though the totals used for plotting the growth trajectories are of both numbers, plural and singular, looking at the raw data for correct occurrences of the plural form of SSMGT and SSFGT alone, it is evident that the majority of children at the beginning of the study, i.e. at the age of 2 years old, show no use of SSMGT and SSFGT. It is only after the age of 4 years old when the plural form of SSMGT and SSFGT, begins to emerge. This is based solely on observations of the raw data, as analysis did not differentiate between plural and singular forms of SSMGT and SSFGT due to the small number of trials. Nonetheless, the results for the acquisition of SSMGT and SSFGT fall within the acquisition findings described by Clark (2017).

A second factor that may be impacting the acquisition of the plural form of SSMGT and SSFGT, is the frequency of use. These two forms of the definite article are not used frequently in the Cypriot-Greek dialect. Adults use SSMAT and SSFAT for SSMGT and SSFGT. Use of sentence structures supporting the use of genitive plural is not frequent. Instead, speakers of the Cypriot-Greek dialect use plural accusative to convey possession. Despite the fact that possession is not accurately conveyed with the use of the accusative case, genitive in its plural form is scarcely used. This ill-use of the accusative plural, seems to be established and accepted amongst the Greek-Cypriot population. This falls in line with Shi and Melançon (2010) who state that frequency with which children hear a specific sentence structure or morpheme, impacts its acquisition. In other words, the more a child hears a morpheme being used in adult speech, the easier its acquisition will be. In this case, infrequent use could be a possible explanation to its late emergence.

Evidence on how children use grammatical information to perceive language meaning, support further the tie between frequency of morpheme use and acquisition. Perception studies present evidence of how children use grammatical information to process linguistic input before they reach the age of 2 years old (i.e., before they produce multiword utterances) (Shi & Melançon, 2010). Perception is not the focus of the current study but evidence of grammatical perception before the age of two would explain the early emergence of grammatical aspects like the use of the definite article at the age of two years old.

Furthermore, Locke's theory suggests that, during phase two, children learn predominantly nouns and verbs. In inflected languages like Italian and Greek, nouns are preceded by their constituent definite article. Therefore, young children are repeatedly exposed to the use of the definite article by default, since most grammatical contexts make its use obligatory. Consequently, definite articles appear frequently in adult speech. According to Shi and Melançon (2010) children born in such linguistic environments, pair nouns to their definite article, and are in a position to spontaneously begin using it early on. The current study lends support to this notion.

It was mentioned earlier, that accusative plural seems to be misused amongst Greek-Cypriots to convey possession. It would be interesting to study perception of the genitive case in all genders to determine whether late emergence of genitive plural in children's spontaneous language and eventual substitution, is due to delayed perception of what the genitive case signifies.

Lastly, as mentioned earlier, both groups' mean trajectories follow the same direction without any instances of the inverse motif, noticed in the acquisition of the other definite article forms. This may signify that CI children reach typical development and hence continue grammatical acquisition in synchrony with their TH peers. Differences are observed in the rate of development between the two groups at certain time intervals, where one of the groups may be demonstrating a greater increase in their rate of growth compared to the other. However, due to the small sample, differences between time points could not be analysed statistically. Therefore, future studies should recruit a bigger sample and examine differences in the rate of development between different ages. This will help determine the optimum age for acquiring each of these definite article forms. Consequently, speech language pathologists as well as special education teachers will know when to target acquisition of each, for best possible results.

Acquisition of the neutral gender in the genitive case, differs from acquisition of the masculine and feminine genders in the genitive case. It is obvious that it does not follow the same trend as the masculine and feminine gender acquisition in the genitive case. The two mean group growth trajectories present with an opposing direction in their slope at all age intervals except for two time-intervals where both groups move in the same direction; 2;0 and 2;6 years old, and 4;0 and 4;6 years old. At the age of 4;6 years old, TH children reach a higher mean value of correct instances in SSNGT use, compared to CI children. This may be an indication of a delay in CI children or it could again be due to the small sample. Each form, singular and plural need to be investigated separately in both groups before investigators can claim a delay in SSNGT acquisition in CI children.

MLUm group growth trajectories also move in synchrony between the two groups. It should be noted that CI children's MLUm mean value is higher compared to that of TH children at the age of 3 and 3;6 years old. It plateaus between the age of 3;6 and 4;0 and continues to increase until the age of 4;6 years old reaching a lower mean value compared to that of their TH peers. These results come in contrast with a study examining grammatical development in German children with CIs versus TH peers (G. Szagun, 2002). Data collection started at 16 months of age and ended 36 months later. Results indicate that TH children reached an MLUm value of nearly 6.0 between the ages of 38 and 41 months old. CI children fell behind with a wider range in their MLUm values (<2 to 4.00). The mean age of implantation for the CI group in the aforementioned study was 29 months. There were children implanted close to the age of 4 years old (G. Szagun, 2002). This range of age at implantation is now considered as being implanted rather late. Therefore, the difference between the two studies and their opposing results, add to the pool of evidence supporting implantation before the age of two years old as early-implanted CI children seem to move in synchrony with their TH peers. Furthermore, not only do they not fall behind their TH peers but there are ages at which their MLUm values exceed those of their TH peers. These results are mirrored in their MLUw values as well. CI children reach higher MLUw values compared to those of TH children between the ages of 2;6 and 3;6 years old. TH children reach an MLUm mean value slightly > 10.00 at the age of 4;6 whereas CI children reach an MLUm mean value slightly < 10.00. These findings do not fall in line with the value range of Brown's Stage V, 3.75 – 4.5, which is expected to be reached between 41-46 months old. However, they do fall in line with the upper bound value of 13 (Ezeizabarrena, 2018b). The higher mean values for both groups of this study are closer to the upper bound value of Brown's Stage V. This is expected and coincides better with the nature of the Greek language and consequently the Cypriot-Greek dialect.

These findings are better supported by another study investigating Italian, another highly inflected language, where MLUm values range from 8.7 to 15, for children of a younger age range, 32-38 months old (Tedeschi, 2017). It can therefore be inferred that the mean MLUm values obtained in this study are not over-inflated but reflect, rather, the highly inflected nature of the language. Furthermore, there is evidence to suggest that monolingual German children also achieve higher MLUm values due to the language's highly inflected nature. Even though this evidence was obtained from only three children, it should still be reported. These three German speaking children, 1;7- 1;11 years old, demonstrated a range of MLUm values starting at 2.57 and reaching 3.85; values expected to be reached at an older age in monolingual English-speaking children (Ivir-Ashworth, 2011).

4.3.2 Individual growth trajectories: Interpretation

As mentioned above, group growth trajectories were plotted to see small differences in the rate and growth of each group that were detected by the MLMs through the intraclass correlation coefficient. It was deemed important to examine differences within individual children to see if any of the children varied uniquely. Individual growth trajectories were therefore generated for each participant, to see the overall acquisition pattern of each of the dependent variables and the expansion in the mean length of utterance measured both in words and morphemes. Furthermore, it was of interest to the investigator to examine graphically the incidence of random effects, detected statistically, with the unconditional growth and conditional growth models.

It was interesting to see that the majority of children follow a similar acquisition pattern as far as the rate of growth is concerned. All except one child, demonstrated a significant difference in the number of correct occurrences at the commencement of the study in all dependent variables except for all genders in the genitive case, SSFNT, and SSNNT.

Participant 2 was a congenitally deaf child who was fitted with hearing aids, bilaterally, at the age of 2 months old. She remained with bilateral hearing aid amplification up until the age of 12 months when she proceeded with cochlear implantation unilaterally. She remained with a hearing aid on the other side. The hearing aid provided good benefit. It decreased her profound hearing loss to a mild hearing loss of 30-35dB. Therefore, the family decided to remain with bimodal amplification and did not proceed with bilateral cochlear implantation. The intercepts for this child for the majority of definite article forms, as shown by the individual growth trajectories, were significantly higher than the rest of the children in the CI group. Higher intercepts show earlier emergence of correct definite article use and therefore a head start in definite article acquisition. Shi and Melançon (2010) argue that children born in an environment where the native language is highly inflected, learn from early on to attach determiners to nouns. It is argued that this happens due to the frequency with which determiners are used in spontaneous adult speech. They therefore appear in children’s spontaneous language earlier. Since Participant 2 had close to normal hearing levels in both ears early on, exposure to linguistic input is mirrored in the higher intercepts achieved.

Participant 2 demonstrates higher intercepts compared to the rest of the CI children in all dependent variables, except for SSMGT, SSFGT, SSNGT, SSNNT, and SSFNT as mentioned earlier. It should be noted that although she begins at the same level as her CI peers in the number of correct productions of SSNGT, the rate of growth from the age of 2 to 2.6 years old is much faster compared to the rest of the CI children. This is indicated by the much steeper slope in her individual growth trajectory. This difference in the starting point of definite article use of nearly all its forms, based on the literature, may be due to parental input and early amplification.

Studies have shown that amplification within the first year of life help children develop prelinguistic communication skills which are the basis for spoken language acquisition (Houston, 2012; Nicholas & Geers, 2013; Nikolopoulos et al., 2004; Tait, De Raeve, & Nikolopoulos, 2007; Tait, Nikolopoulos, & Lutman, 2007). The importance of and necessity for prelingual skill acquisition within the first year of life, is highlighted in the study by Levine et al. (2016). It was demonstrated in this study that typically hearing children learn novel words, syntax rules, meaning of verbal and nonverbal communication cues within the first year of life. Acquisition of these language facets are robust predictors of children's language development later on. This foundation is missing from congenitally deaf children as they have no access to sound when they are born. Therefore, they are not in a position to build the necessary foundation in communication for further facilitation of language development. This is in part verified by evidence showing that deaf children implanted before the age of 12 months begin babbling at the same age as their normally hearing peers. Unfortunately, lack of follow-up studies of these children, does not allow researchers to conclude that emergence of babbling at the expected age also ensures bridging of the gap in language development (May-Mederake, 2012; Schauwers et al., 2004).

Lastly, a study by Wie (2010) lends evidence to early amplification helping bridge the language gap by the age of 48 months. Early emergence of definite article use by Participant 2, falls in line with the aforementioned literature. The very good benefit she received from her hearing aids at the age of 2 months old gave her the opportunity to lay the foundation for language development comparable to that of her typically hearing peers.

Another factor that differentiates this participant from the rest in her group is the language input she received from her parents. Her mother was diligent in following the speech-therapist's instructions and building upon those.

Auditory Verbal Therapy (AVT) is the main type of therapy in facilitating language acquisition in children with CIs whose parents want to follow the oral route. One of the principles of AVT is to coach parents in becoming the main facilitators of language acquisition by helping the child use audition as the main modality for acquiring language. This is done by teaching the parent specific techniques that are to be used in every day interactions with their child. These techniques help parents expand on what the child says, promote listening comprehension, and vocabulary development. Parents are therefore asked to talk to their children constantly using these techniques to help their child acquire spoken language (SYC Lim, 2005). There is only one certified AV therapist in Cyprus and two speech language pathologists who practice aural rehabilitation based on AVT principles. This participant's mother was directed by one of the speech-pathologists, who practices aural rehabilitation, to follow AVT principles. The effect the mother's input had on this participant's language development is supported by the literature. Studies have shown parental input to be positively related to the language development of children with cochlear implants as well as predict language outcomes in children with CIs (Boons et al., 2012; DesJardin, 2007).

Participant 2 also demonstrated higher MLUm and MLUw intercepts compared to the rest of the participants. It can be inferred that all of the aforementioned factors, early amplification, early implantation, bilateral amplification, language intervention and parental input, contributed in achieving these much higher intercepts and maintenance of higher levels in the use of the various definite article forms, except for all the genders in the genitive case.

It is interesting how the intercept for Participant 2 does not differ from the rest of the participants in the emergence of SSMGT, SSFGT, and SSNGT. This links back to the discussion about late acquisition of the genitive case in all genders. Even though Participant 2 seems to be ahead linguistically compared to the rest of the children in her group and most of the TH children, she begins using definite articles in the genitive form at the same time as the rest of the children. It can thus be inferred that SSMGT and SSFGT emerge later on during language development and it seems that children may need to reach a certain maturity level before they can acquire these definite article forms. Even though SSNGT emerges earlier than SSMGT and SSFGT its acquisition does not follow the same pattern as the rest of the genders in the nominative and accusative cases. This indicates that earlier emergence of the definite article for all genders in the nominative and accusative case are the foundation for the acquisition of all definite article forms in the genitive case. Having an earlier emergence of the definite article in all genders in the nominative and accusative case, does not mean however, earlier emergence of SSMGT and SSFGT. It can therefore be concluded that emergence of SSMGT and SSFGT acquisition could indeed be marked chronologically, with 4 years old being the youngest age possible for its emergence. Naturally, this would have to be verified using a larger sample.

4.3. TEREL Standardization Results: Interpretation

As stated earlier, typical development has not been investigated and documented adequately. There is a big gap in the literature as far as the acquisition of the Greek language is concerned, and an even bigger one on the acquisition of the Cypriot-Greek dialect of the Greek language; justifying thus, the need for this study. Furthermore, assessments differentiating typical from atypical development in the Greek language have not been developed, making differential diagnosis difficult for professionals and researchers. Classifying a child as being typically developing, requires a standardized assessment over which the child in question can be compared linguistically against a normative sample. Since none are available, an assessment for typical language development was developed under the scope of this research project. TEREL (Test of Early Receptive and Expressive Language) was administered to 231 children ages 2;6 to 6 years old. A large sample was recruited in an attempt to create a first preliminary normative sample.

As mentioned in the Results chapter, TEREL's psychometric properties were examined using Item Response Theory analysis. Item and person reliability and separation values were calculated to show if the test discriminates between children based on their true language abilities and if the items developed are spread widely enough to capture a wide range of degrees of difficulty.

As stated in the Results chapter, despite the small size of the normative subgroups, TEREL seems to be behaving in a promising way. In other words, it seems to be assessing children's language skills based on their true language abilities both expressively and receptively. Some of the item reliability scores were low for the groups with the smallest sample and the one group with the widest age range. These two obligatory limitations may have skewed the results in an unfavourable way. However, it is interesting and important to point out that, the groups with low item reliability had high person reliability ensuring that the results depicted the children's true language skills despite the obvious limitations of the normative sample. This shows that items did indeed perform well even if item reliability was lower than expected, adding to the conviction that item reliability would have been higher had the sample been bigger. The items were able to test children reliably and ensure that children identified as having a low language level will indeed demonstrate the same level of achievement if retested, reaching higher person reliability scores, reinforcing the promising results on TEREL's performance. The same trend was found for both receptive and expressive language scores.

In both parts examining expressive and receptive language, there were children who performed really poorly, up to 4SD below the mean. After examining these children's raw data, it was deemed necessary to keep them in the analysis as their really low raw score, indicates atypical development. The fact that item and person reliability and separation increased with the inclusion of these children in the analysis, demonstrates the test's ability to correctly identify atypical and typical development. Therefore, the primary purpose and function of this test appear to have been achieved.

4.3.1 TEREL raw scores and how the two groups compare to the normative sample: Answer to the fourth hypothesis

There was no significant statistical difference between the two groups, CI and TH, compared to the TEREL normative sample. As discussed in the third chapter, scores on the different forms of the definite article tested were compared as well as the raw scores of participants. Lack of statistical significance in the difference of their scores contributes to the findings of this study in two ways. First, it offers a statistically sound measurement that enables the investigator to confirm the typicality in the development of the typically hearing children. This adds to the validity of the comparisons and the inferred conclusions, drawn throughout the previous and current chapter, making this study noteworthy. Secondly, it confirms the tentative conclusions drawn from the discussion on the growth trajectory results and the lack of significant differences between the two groups.

This confirmation comes about, as CI participants behave in the same way in definite article acquisition as the normative sample does. Furthermore, where CI children reach a higher mean value in their group growth trajectories compared to TH children, the same reverse trend is noticed when they are compared to the normative sample. In general, it appears from this pool of evidence that the control and experimental group acquire the various forms of the definite article in the same order. This is demonstrated by the similarity in the percentage of success and the ratio between success and failure between the three groups. Based on these results, the fourth hypothesis is also supported. CI children do not differ significantly from TH children. This is shown by the lack of statistical difference in the TEREL raw scores of the two groups and the commonality in their directionality of success and failures on the items targeting definite article acquisition.

4.4. Contributions and Limitations of the study

The current study is the first study on language development of congenitally deaf children with CIs speaking the Greek-Cypriot dialect. It lays the foundation on which future studies can build to create a rich and meaningful pool of data concerning this understudied population as well as typically developing children. More data on normal development are very much needed to enable valid and reliable comparisons with understudied populations like CI children speaking the Greek-Cypriot dialect. Even though this study employed a small sample, the trends that arise through the data are consistent with wider international bibliography lending further support to already existing theories of development and expected language outcomes for CI children.

It is the first study to have developed within its scope, the first language assessment targeting children who speak the Greek-Cypriot dialect, for typical development verification purposes; an assessment that appears to be behaving in a highly promising manner. This research project lends evidence to the wider bibliography for the benefits of early implantation for an understudied variety of the Greek language: the Greek-Cypriot dialect; the only dialect derived from Ancient Greek that still exists today and remains unchanged. Furthermore, it adds to the initial pool of evidence that the Greek-

Cypriot definite article and its various forms follow the same order of acquisition as definite article acquisition of other inflected languages.

The main limitation of this study was the small sample size. Even though there were no more children meeting the inclusion criteria available at the commencement of the study, generalization of conclusions and inferences needs to be done cautiously. Future studies are urged to recruit a larger sample or employ a cross-sectional design to obtain generalizable results and consequently build on this study's results. Another limitation was limited funding. Had more funding been available, TEREL's standardization sample may have been considerably larger offering more statistical insight as to how well or poorly it assesses children's language level. Furthermore, the small sample size of the eight groups was also a limitation. TEREL's performance cannot be stated as reliable for all age groups with confidence because of the lower person and item reliability and separation values on two of the groups that were most probably due to the insufficient sample and wide age range.

Lastly, lack of norms on typical development in children speaking the Cypriot-Greek dialect was also a limitation. Conclusions were based solely on similarities found with other highly inflected languages and the small group of TH children recruited for this study.

Possible future studies could attempt to examine definite article acquisition in both singular and plural numbers with a bigger number of trials so that each number can be examined separately. Future studies with bigger samples could refute or confirm the inverse motif phenomenon arising from this study's results. Also, more could be invested in examining children's level of understanding of such constructs as definite articles and what they represent linguistically. Does limited comprehension of what they mean and represent linguistically, play a role in definite article correct spontaneous use? Does this differ between cases? There is an abundance of unexplored areas in language acquisition for Cypriot-Greek CI children. Futures studies could focus on unravelling little by little the language learning ‘mystery’ around Cypriot-Greek CI children

In conclusion, this small pool of data has opened the door to bigger pools of data that will be invaluable future sources of information, on how Greek-Cypriot CI children develop language. The overall number of Greek-Cypriot CI children that have participated in ineffective intervention programs over the years, due to lack of knowledge on how they acquire grammar, will hopefully decrease significantly, now that the beginning of a promising path has been marked. Future studies, expanding on and adding to the findings of the current study, will be invaluable guiding tools to teachers of the deaf and speech-language pathologists who work with Greek-Cypriot CI children. Evidence-based practice will no longer be wishful thinking but rather, a reality.

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Appendix A

MLUm Coding Rules

1. Each morpheme gets 1 point
2. In NOUNS there is a maximum of 4 points: 1 – Noun (just saying the word), 1- Gender (M, F, N), 1 – Number (Sn or Pl), and 1 – Case (Nom, Acc, or GEN) e.g. the word κροκόδειλος will be coded as follows: **N:M:Sn:Nom;**
3. The same applies for ADJECTIVES. E.g., μεγάλος will be coded as follows: **Adj:M:Sn:Nom;** Again there is a max of 4 points a child can get
4. The Definite Articles (DA) are scored in the same way as outlined above. The only difference is the coding will start with DA: ….

5. The same applies for personal, possessive and indefinite pronouns (της, την, των, τους, μου, σου, άλλα, άλλους, κάποιοι κτλ.) The indefinite pronoun 'κάτι' is always undeclenated. Again, there is a max of 4 points. E.g. Η αγελάδα μου, the possessive pronoun μου will be coded as follows: **PossPr:1^{st}:Sn:GEN;** (1-PossPr; IndPr; PersPr; 1- person (1^{st}.2^{nd}.3^{rd}.), 1 – number (Sn or Pl, and 1 – Case (Nom, Acc, GEN).
6. For VERBS there is again a maximum of 4 points: 1- Verb(V), 1 – person (1^{st}. 2^{nd}. 3^{rd}), 1 – number (Sn or Pl), 1 – tense (Present Tense (PrsT), Past Tense (PT), Future Tense (Raftery), Present Subjunctive (PrsSubj), Future Tense (Raftery)). E.g. the verb παίζει will be coded as follows: **V:3^{rd}:Sn:PrT;**
7. For each of the four aspects for the parts of speech outlined above, the child gets wrong, he/she loses that point. The correct gender, number, case, or tense needs to be put in parenthesis before the incorrect form used by the child. E.g. Να ο παπαγάλο will be coded as follows: N:M:Sn:(Nom)Acc; In this case the child has put the noun in the wrong case. Therefore, this word receives 3 points instead of 4.
8. IF the child uses the wrong definite article (DA) and the ending of the word cannot determine the gender because it could be feminine or neutral then the gender is not considered correct in either of them (definite article or noun) E.g. Ο πεταλούδα will be coded as follows: DA:(F)M:Sn:Nom; N:(F)M:Sn:Nom;
9. If the DA and the ending of the word match the gender of the noun, but one of the two indicates a different case then the error is in the choice of case. As in the example above 'Να ο παπαγάλο'. There is an obligatory context for the use of Nominative case. The DA article is in Nom but the ending of the noun indicates use of Acc. The error is therefore in the use of case.
10. Every other part of speech is appointed one point. These include adverbs, Interrogative pronouns, and conjunctions.
11. IF the child uses the wrong adverb, interrogative pronoun, or conjunction do NOT deduct the point. The point is awarded for simply using that particular part of speech.
12. Stereotypes: Έπεσε, μπάνιο, ένα λεπτό, περίπατο, βόλτα, και έννε are awarded only 1 point.
13. The route phrase πούντο is awarded 1 point if it is not declenated according to gender and number. It is awarded 2 points if it is declenated according to gender and number.
14. For single word utterances where the child does not demonstrate knowledge of gender, number and case, do NOT award points assuming the child knows the gender, number or case of the noun. For example, for the noun αλογο, the coder will award points for N(noun), Sn (Number). The coder will not award points for case as the noun is not preceded by a definite article indicating the case. For the noun τραπέζι, the coder will award points for N(noun) and Sn (Number) only as the ending -ι, of the noun, phonemically, could be either feminine or neutral. Case will not be granted 1 point as it is not evident due to the lack of the definite article.
15. Fillers such as εμμμ, να να να, το το το, ε..να...το..μα.., do NOT receive any points
16. Animal sounds do NOT count.
17. Phrases such as γεια σου, γεια σας are not given any points.
18. IF the child repeats what the examiner said without adding to the phrase or adapting it according to his/her intended utterance, it does not receive any points. It is coded as 'repetition' and are not included in the final utterance total count.

19. If the child repeats a specific phrase within his/her utterance then only one instance of that phrase should be coded.
20. Incomplete utterances are coded as ‘Incomplete’ and are not included in the final utterance total count.
21. For the phrase ‘δικό σου/μου/του’ etc., count as 1 possessive pronoun.
22. For ‘εν να’ count as one and code as Participle (Partic)
23. Phrases like ‘να παίξει’, να is the subjunctive and the verb is in Future Simple tense. For phases like ‘να παίζει’, να is subjunctive and the verb tense is Present Subjunctive.
24. Verbs preceded by the participle ‘θα’ or ‘εννα’, are in the Future tense.
25. The verb ‘είναι’ is awarded 1 point as this is the standard form for children. IF it is declenated then it is awarded all the necessary points as any other verb.
26. All word in the Cypriot dialect are counted correct and are awarded the necessary points as are words in Standard Modern Greek.
27. Any words in English are coded as ‘other’

MLUw Coding Rules

1. Counts all the words in each utterance, add them up and divide by the total number of utterances uttered by the child
2. Do NOT include words that are repeated meaninglessly within an utterance. All words count except for animal sounds
3. Stereotypes receive 1 point
4. Route phrases such as ‘γεια σου’ ‘κι άλλο’ count as 1 word and are therefore awarded 1 point
5. The subjunctive and future participles *να* and *θα* do not count as separate words. Award points according to the verb following them and its declenation.

Appendix B

Individual Growth Trajectories

Figure 3.7.1a SSMNT Individual Growth Trajectories

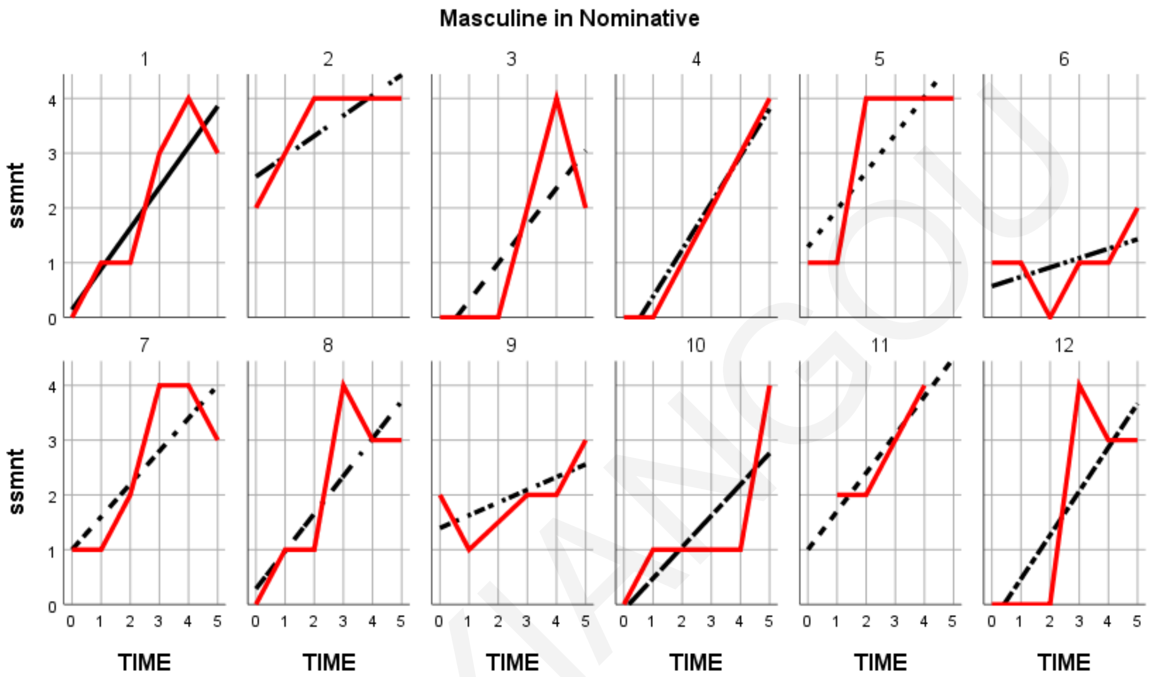


Figure 3.7.2a SSFNT Individual Growth Trajectories

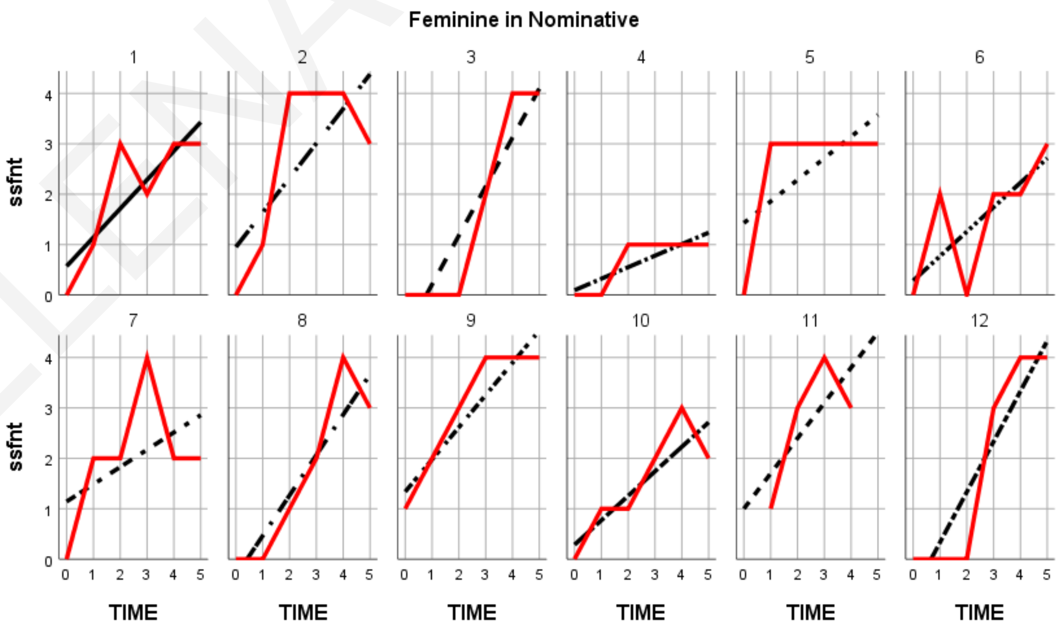


Figure 3.7.3a SSNNT Individual Growth Trajectories

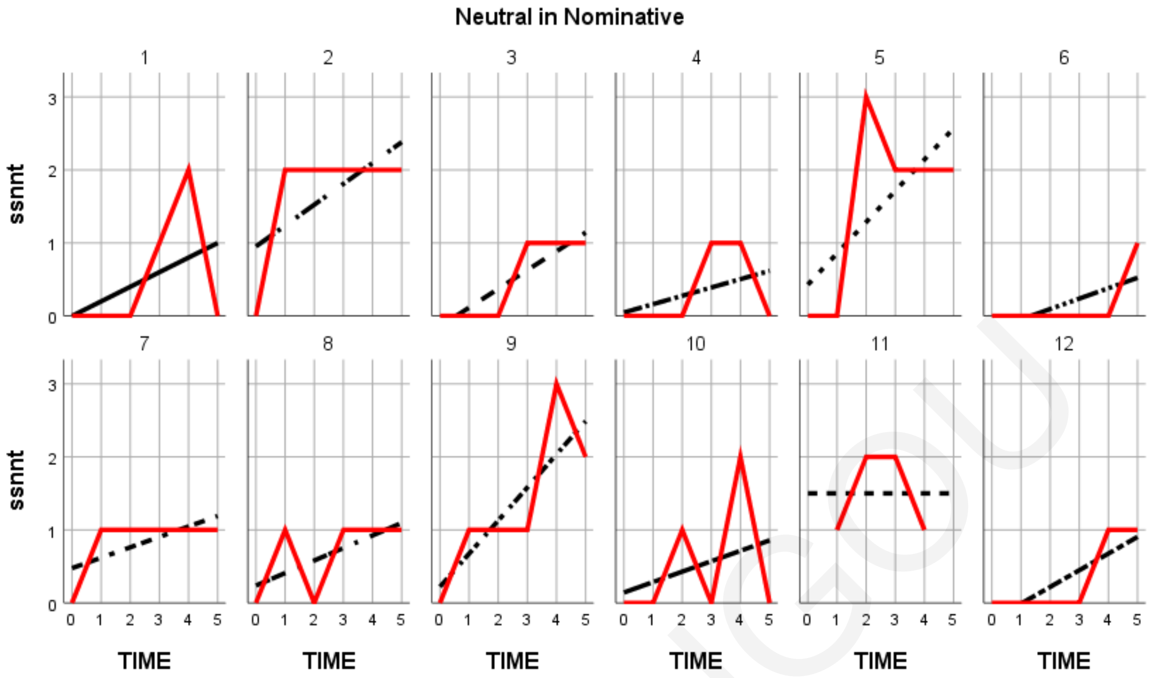


Figure 3.7.4a SSMAT Individual Growth Trajectories

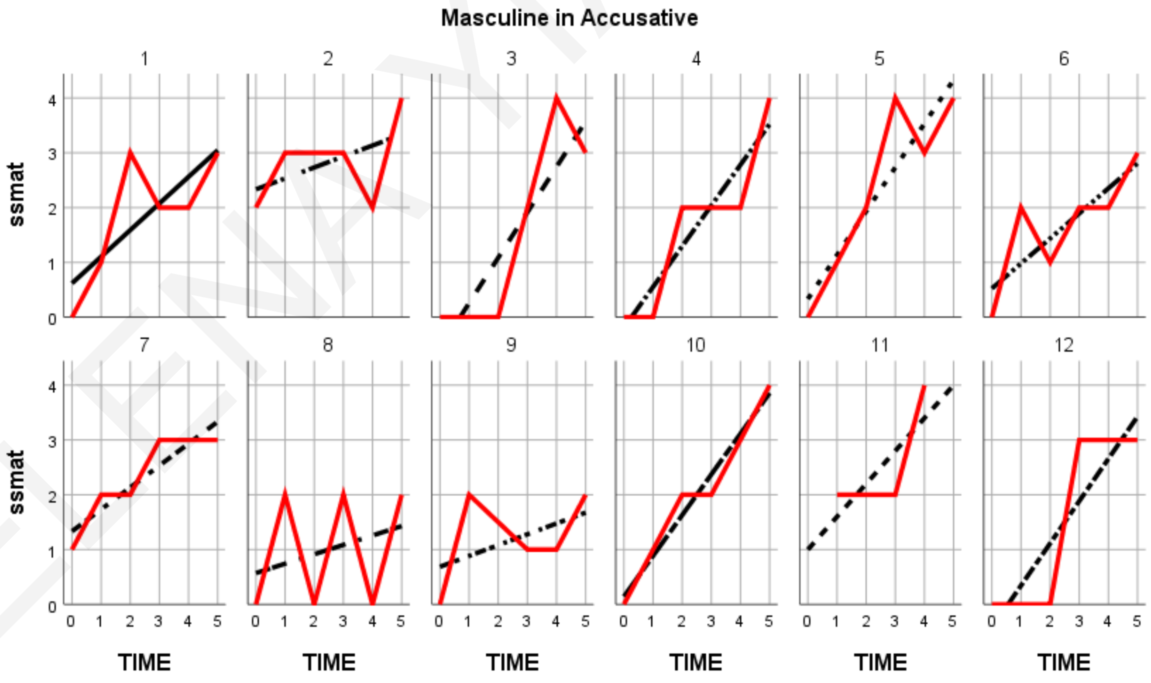


Figure 3.7.5a SSFAT Individual Growth Trajectories

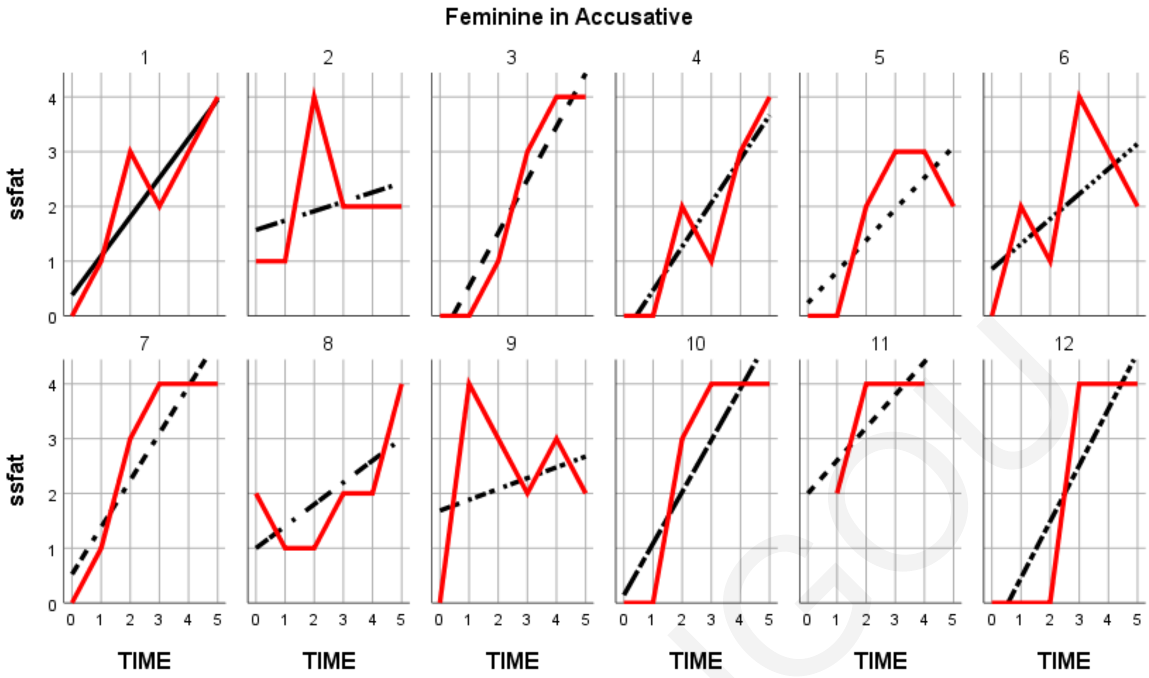


Figure 3.7.6a SSNAT Individual Growth Trajectories

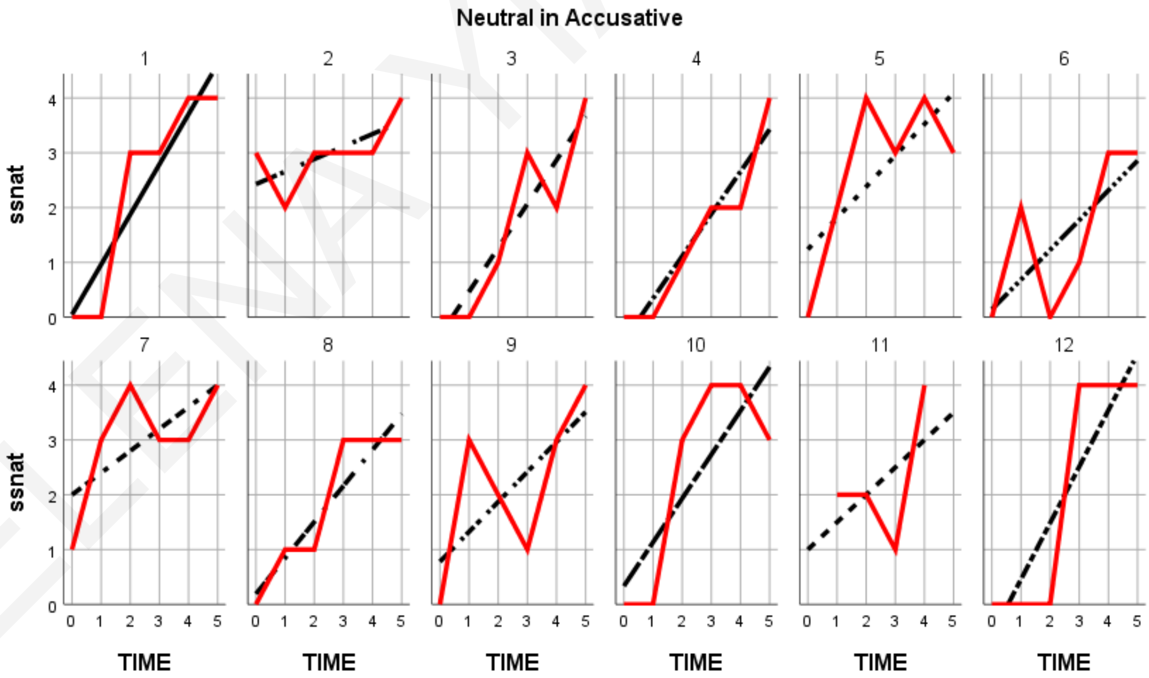


Figure 3.7.7a SSMGT Individual Growth Trajectories

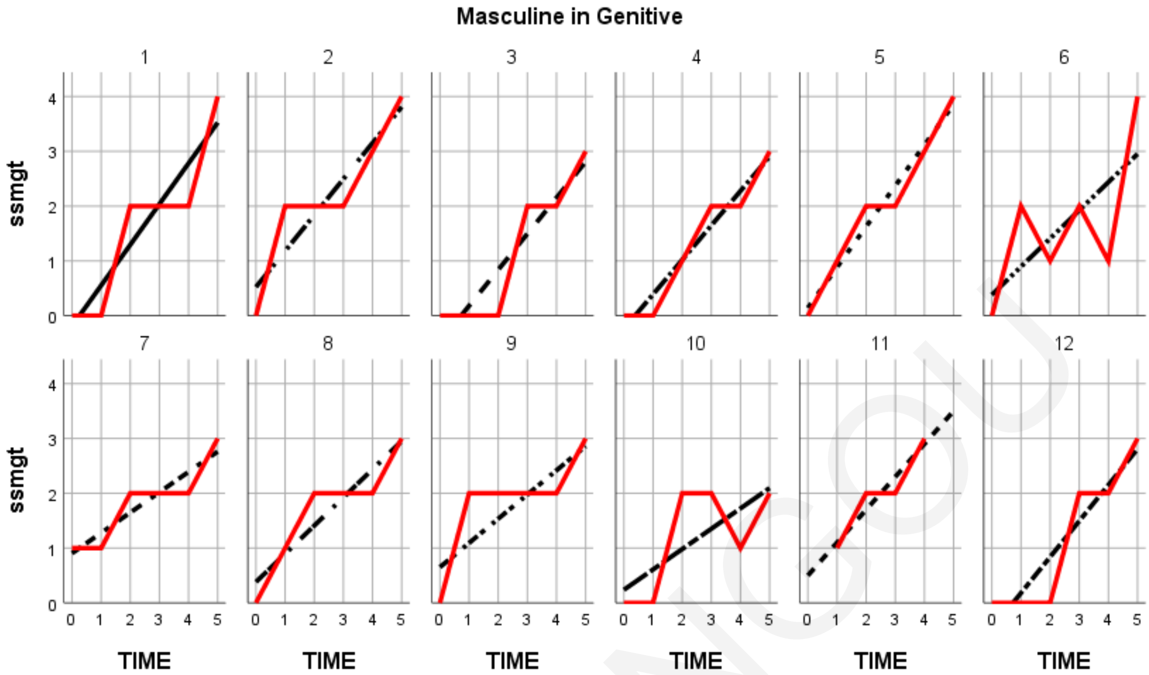


Figure 3.7.8a SSFGT Individual Growth Trajectories

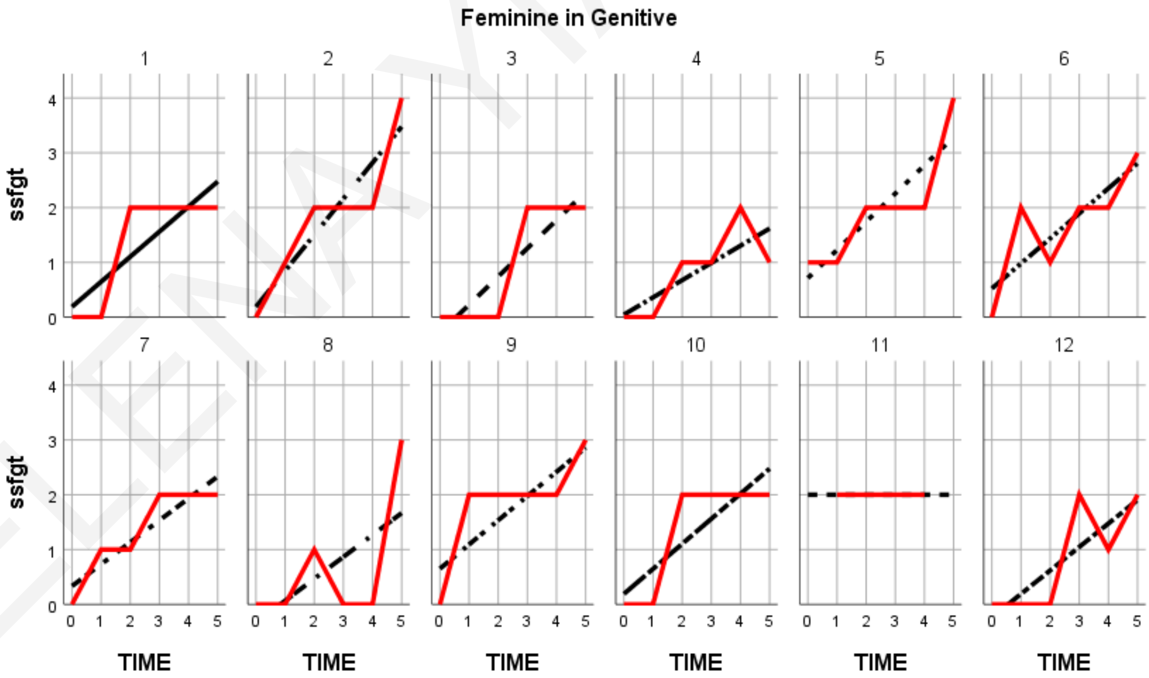


Figure 3.7.9a SSNGT Individual Growth Trajectories

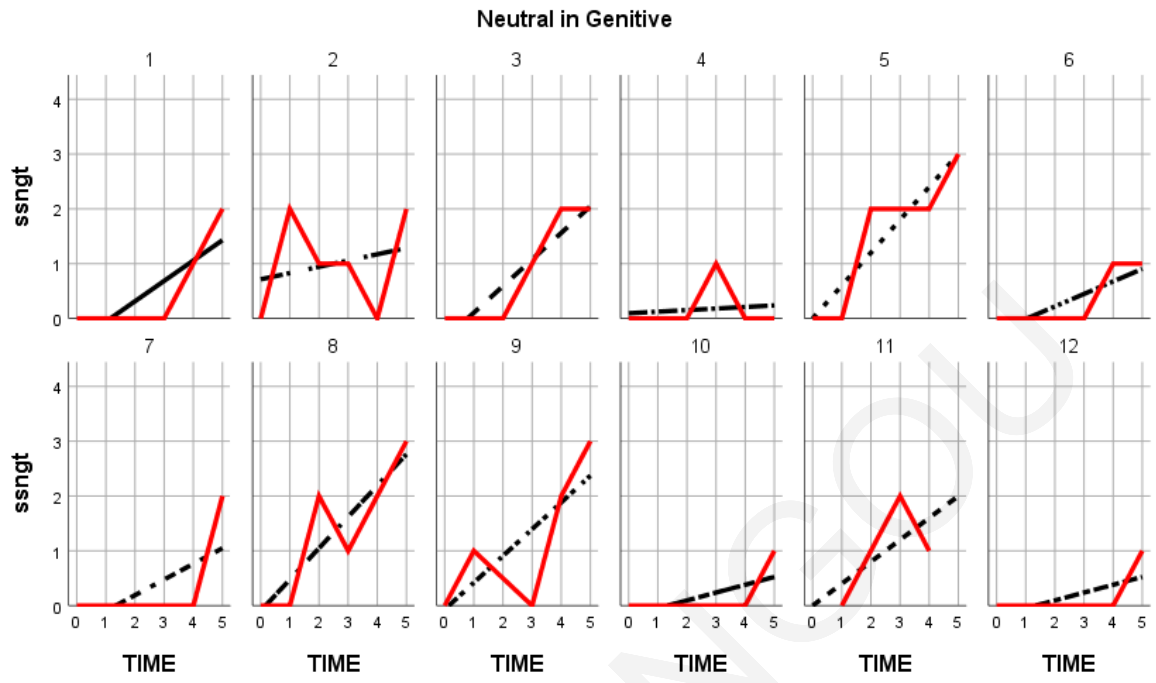


Figure 3.7.10a MLUm Individual Growth Trajectories

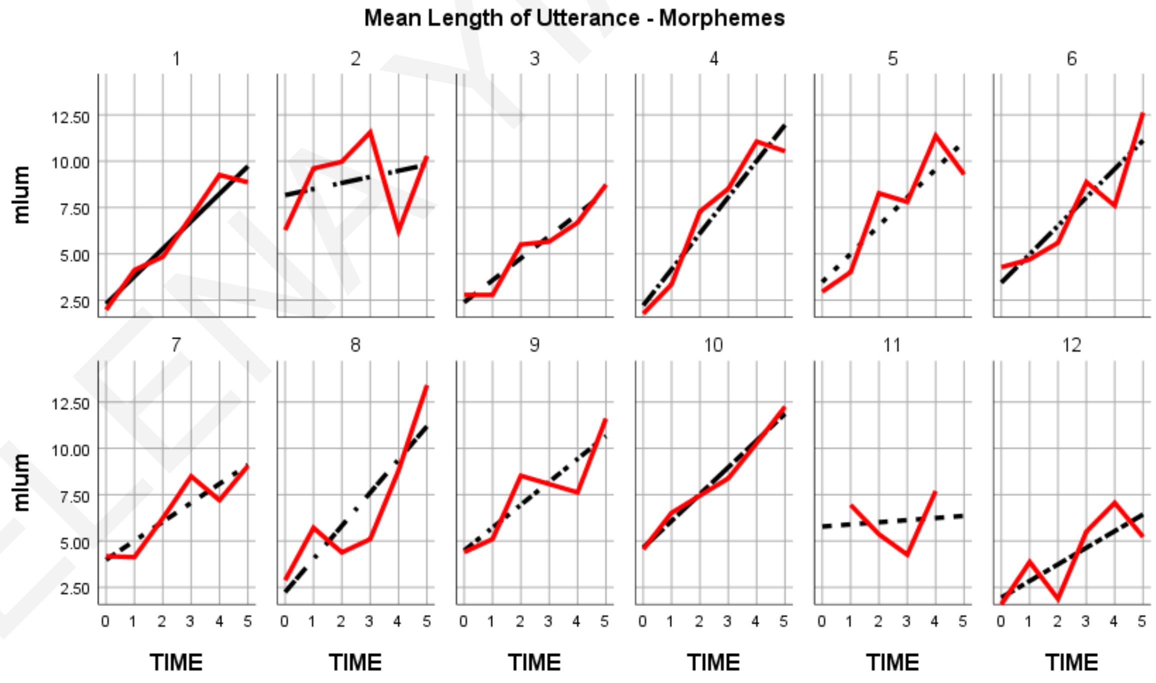


Figure 3.7.11b MLUw Individual Growth Trajectories

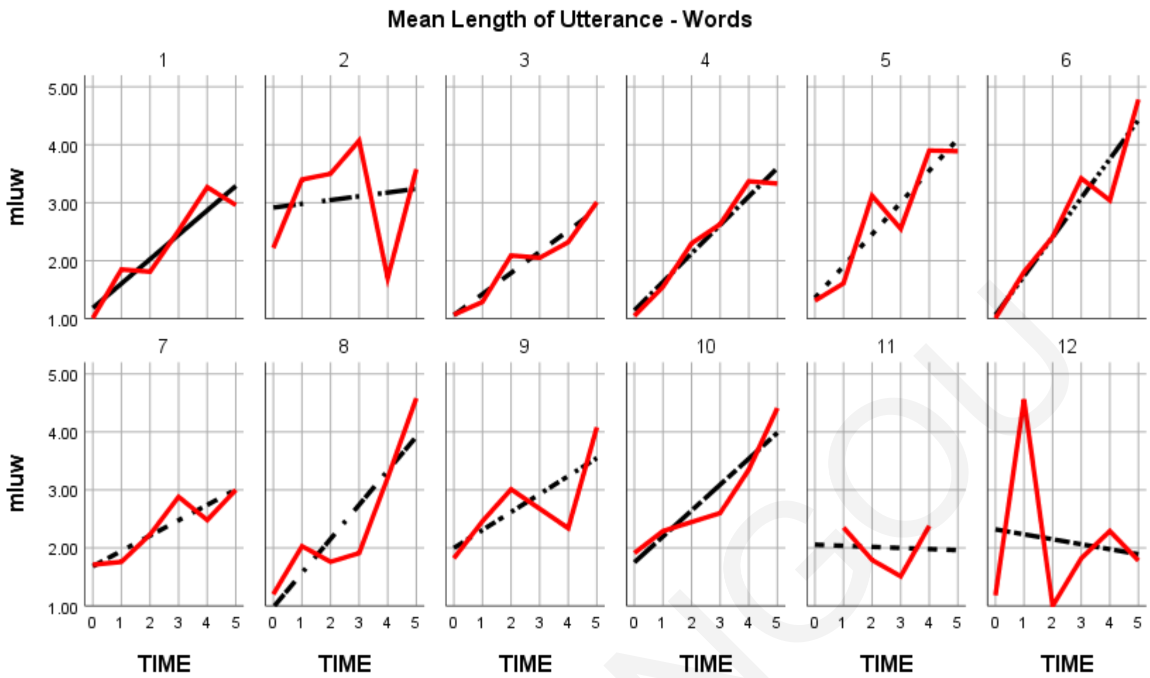
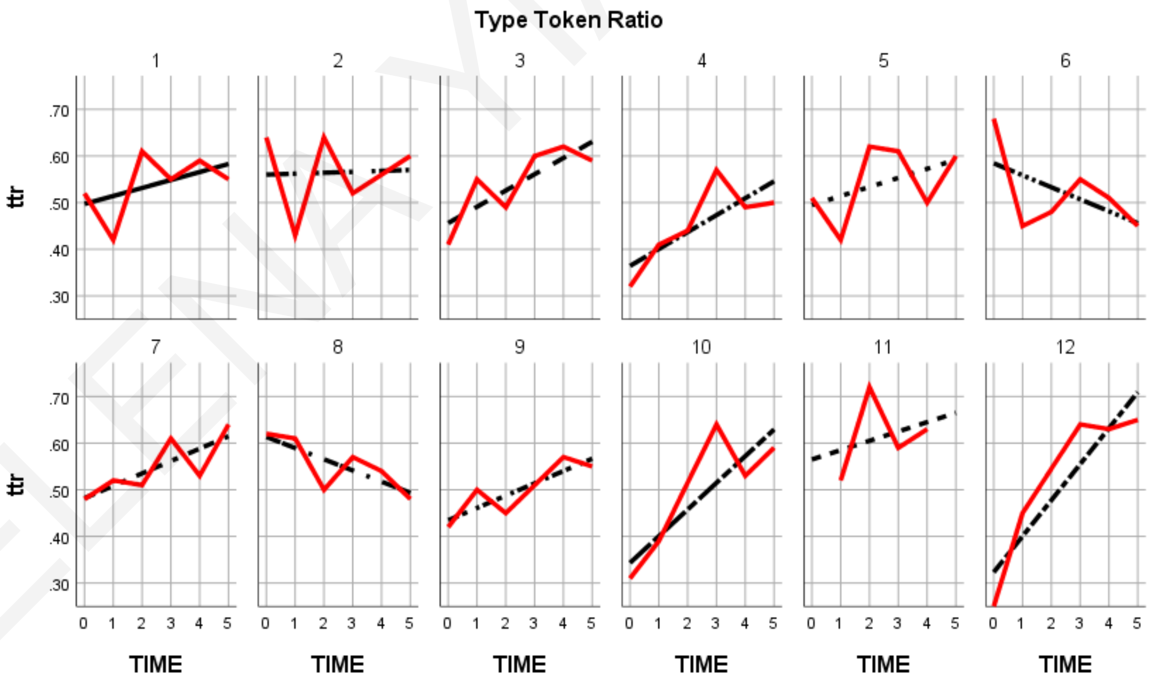


Figure 3.7.12a TTR Individual Growth Trajectories



APPENDIX C

Expressive Language Wright Maps

Wright Map 3.8.1E Age Group 1 29-34 months

```
MEASURE PERSON - MAP - ITEM
         <more>|<rare>
    3          +  NNST   e15c   e18c   e24a   e25a   e25b   e26b   e28b   e29b
                  e32a   e32b   e32c   e33b   e34a   e35a   e35b   e35c   e35d
                  e35e   e36a   e36b   e36c   e39a   e39b   e39c   e40b   e40c
                  e41c   e42a   e42b   e43c   e44d   e44e   e45a   e45c
               |
               |
               |
               |
               |  e14d   e18a   e22b   e24b   e26c   e28a   e29a   e33a   e33c
                  e34b   e34c   e38a   e40a   e40d   e41a   e41b   e42c   e43b
                  e45b
               |
               |
    2          +
              T|
               |S
               |
               |  e10a   e17a   e17b   e20c   e22c   e24c   e27b   e31a   e37d
                  e38b   e38c   e43a   e44c
               |
            X  |
               |
    1      XX  +
               |  e15b   e17c   e18b   e22a   e22e   e26a   e27a   e30a
              S|
               |
               |
               |  e21b   e22f   e22h   e23g   e37c   e44a   e44b   e9c
               |
               |
    0          +M
           XX  |  e14b   e20a   e20b   e22d   e22g   e23d   e37a   e8c    e9b
            X  |
              M|
               |  e14a   e16a   e19a   e19b   e30b   e8a    e8d
               |
           XX  |
               |
   -1       X  +  e11a   e11c   e15a   e19c   e21d   e31b
            X  |
               |
               |
              S|  e10b   e12b   e12c   e13a   e13b   e16b   e19f   e21a   e21e
                  e23a   e23c   e37b   e8b
               |
               |S
               |
   -2          +
               |
               |  e11b   e12a   e21c   e21f   e7
               |
               |
              T|
               |
               |
   -3       X  +
               |
               |  e12e   e12h   e12i   e14c   e19d   e19e   e23b   e23e   e5
                  e9a
               |
               |T
               |
               |
               |
   -4          +  e12d   e12f   e12g   e12j   e1a    e1b    e1c    e1d    e1e
                  e2     e23f   e23h   e3
         <less>|<freq>
```

Wright Map 3.8.2E Age Group 2 35-40 months

```
MEASURE PERSON - MAP - ITEM
           <more>|<rare>
    3            +  e15c    e24a    e25a    e25b    e28a    e28b    e29a    e29b    e32a
                    e32b    e32c    e33a    e33b    e35a    e35b    e35c    e35d    e35e
                    e36a    e36b    e36c    e39a    e39c    e40a    e40b    e40c    e40d
                    e41a    e42a    e42b    e42c    e44e    e45a    e45b    e45c
                 |  e39b
                 |
                 |
                 |
                 |
                 |
                 |  e14d    e26b    e27b    e33c    e38b    e41b    e41c    e43a    e43b
                    e43c    e44d
    2            +
                 |S
                 |
             X T|  e17a    e21b    e26c    e31a    e34a    e44c
                 |
                 |
                 |  e22a    e24b    e34b    e37c    e38a    e38c
                 |
    1            +
            XX   |  e18c    e22c    e24c    e44a
                S|
                 |  e10a    e17c    e20b    e26a    e30a    e30b    e37d    e44b
            XX   |
                 |  e18a    e22g    e37a    e9c
             X   |
                 |
    0        X   +M e15b    e18b    e20c    e22b    e22e    e22f    e23d    e27a    e34c
                    e8c
            XX   |
             X  M|  e10b    e17b    e21d    e23g
             X   |
             X   |  e11b    e14b    e20a    e21c    e22h    e37b
             X   |
                 |  e16a    e19b    e21a    e21e    e23c    e31b    e8b
             X   |
   -1        X   +  e15a    e16b    e19a    e8a     e9b
                S|
                 |
             X   |  e12a    e14a    e19d    e19f    e8d
                 |
                 |
                 |  e12c    e12e    e12h    e19c    e21f    e23a
             X   |S
   -2        X   +
                T|  e13b    e19e    e22d    e9a
                 |
                 |
                 |
                 |  e11a    e11c    e12i    e13a    e23e
                 |
                 |
   -3            +
                 |
                 |
                 |  e12b    e12d    e12g    e12j    e2      e23f    e23h    e3      e7
                 |
                 |T
                 |
                 |
   -4            +  e12f    e14c    e1a     e1b     e1c     e1d     e1e     e23b    e5
           <less>|<freq>
```

Wright Map 3.8.3E Age Group 3 41-46 months

```
MEASURE              PERSON - MAP - ITEM
                         <more>|<rare>
    4                          +  e15 e32 e44 e45 e45 e45
                               |
                               |  e25 e33 e35 e35 e35 e35 e36 e36 e40 e41 e41
                               |
                               |
                               |
    3                          +  e25 e28 e32 e39 e40 e41
                               |
                               |
                               |  e17 e32 e35 e36 e40 e42
                               |
                              T|S e26 e33 e39 e42 e43
    2                          +
                               |  e24 e34 e38 e42
                               |  e14 e22 e33 e34 e43
                          193  |  e22 e29 e38 e39 e40 e44
                               |  e24 e27 e29 e38
                      154 6    |
    1                         S+
              116 134 176 219  |  e43
                      123 173  |  e17 e18 e20 e24 e28 e37
                          171  |  e10 e17
                      153 195  |  e18 e20 e21 e22 e26 e9c
      143 147 174 198 26  90   |  e44
    0             192 20  38   +M e20 e22 e31
                      137 149  |  e22 e23 e37 e9b
                          208 M|  e14 e22 e26 e30
                               |  e15 e30 e34 e37 e44 e44
                               |  e10
                      189 51   |  e22 e23
   -1                     151  +  e18 e37
                               |  e14 e19 e21 e23 e27 e8c
                          28   |  e16 e8a e8d
                              S|  e12
                               |  e11 e16 e19 e21 e21 e22
                          211  |
   -2                          +  e12 e13 e21 e31
                      175 25   |S e11 e21 e9a
                          166  |
                               |  e12 e12 e15 e19 e23 e23
                              T|
                          49   |  e12 e12 e12 e13 e19 e19 e23 e8b
   -3                          +
                               |
                               |  e11 e19 e23 e3
                               |
                          140  |
                               |  e12 e23 e7
   -4                          +
                               |
                               |T
                               |
                               |  e14 e1e e5
                               |
   -5                     106  +  e12 e12 e2
                         <less>|<freq>
```

Wright Map 3.8.4E Age Group 4 47-52 months

```
MEASURE              PERSON - MAP - ITEM
                         <more>|<rare>
    4                          +  e3 e4 e4 e4
                               |  e3 e3 e3 e3 e3 e4 e4 e4
                               |
                               |
                               |
                               |
                               |  e1 e3 e3 e4 e4
    3                          +
                               |
                               |  e2 e3 e3 e4 e4
                               |
                               |  e2
                               |
                               |  e3 e3 e3 e3
    2                          +S
                               |  e3
                               |  e3 e3 e3 e4 e4 e4
                               |  e1
                          115 T|  e3 e4
                               |  e2 e2 e4 e4
                          42   |  e1 e1 e2 e2 e2 e3 e4
    1                     218  +  e1 e2 e3
                          44   |  e2 e3
      132 14  156 188 225 45  S|  e1 e2 e2 e4
              148 178 203 30   |  e2
              160 204 33  98   |  e1 e2 e2 e2
                          18   |  e3
                          168 M|
    0                          +M e1
                  142 170 29   |  e2 e2 e2 e3 e3
      161 199 214 23  43  91   |  e1 e2 e9
                               |  e2 e2 e2 e9
                          215 S|
                          213  |  e2 e2 e4
              135 144 145 180  |  e1 e1 e2 e3 e4
   -1                     209  +  e1
                          165  |  e1 e2 e3 e3
                              T|
                               |  e2 e4
                               |  e3
                               |  e1 e1 e1 e1 e2 e2 e8
                               |  e1 e1 e1 e2 e2 e3 e8 e8 e9
   -2                          +S
                               |  e1 e1 e1 e2 e2
                               |
                               |  e3
                               |  e1 e8
                               |
                               |  e2 e2
   -3                          +  e1 e1 e1 e1 e1 e1 e1 e2
                               |
                               |
                               |
                               |
                               |  e1 e1 e1 e1
                               |
   -4                          +  e1 e1 e1 e1 e1 e1 e1 e1 e2 e2 e2 e2 e3 e5 e7
                         <less>|<freq>
```

Wright Map 3.8.5E Age Group 5 53-58 months

```
--------------------------------------------------------------------------------
MEASURE          PERSON - MAP - ITEM
                     <more>|<rare>
    5                      +  e3
                           |
                           |
                           |
                           |
                           |  e3 e4
                           |T
    4                      +
                           |
                           |  e1 e3 e3 e3 e3 e4 e4
                           |
                           |
                           |  e3 e4 e4
    3                      +
                           |  e3 e4
                           |  e3 e3 e4
                           |
                          T|  e2 e3 e4
                           |S e1 e3 e4
    2                 130  +  e2 e2 e3 e3 e3
                      84   |  e3 e4
                      108  |  e1 e2 e2 e3 e4
                      124  |  e1 e3 e4
                      97  S|  e3
      228 229 76  83  94   |  e2 e3
    1             159 41   +  e1 e2 e2 e3 e3 e4 e4 e4
              194 53  82   |  e1 e2
      102 158 196 222 223  |
      10  17  201 226 93  M|  e1 e2 e2 e2 e2 e2 e2 e4 e4
                           |  e1 e2 e9
          103 131 52  67   |  e2 e2 e4
    0                 206  +M e3
                  13  210  |  e1
          114 141 231 66  S|  e3
                           |  e1 e2 e2
                      54   |  e1 e2 e2 e2 e3 e9
                           |  e3 e4
   -1                      +  e1 e2 e2 e3 e4
                           |  e1 e1 e3
                      212 T|
                           |  e1 e1 e1 e1 e2 e3 e4
                           |  e1 e2 e2
                           |
   -2                      +  e1 e2 e2 e2 e2 e2 e3 e8
                           |S
                           |  e1 e1 e1 e1 e2 e2 e3 e8
                           |
                           |
                      92   |  e1 e1 e1 e1 e1 e1 e2 e8 e9
   -3                      +
                           |
                           |
                           |
                           |  e1 e1 e1 e1 e1 e2 e8
                           |
   -4                      +  e1 e1 e1 e1 e1 e1 e1 e1 e2 e2 e2 e3 e5 e7
                     <less>|<freq>
```

Wright Map 3.8.6E Age Group 6 59-64 months

```
MEASURE      PERSON - MAP - ITEM
                 <more>|<rare>
    5                  +  e3 e4 e4 e4
                       |
                       |
                       |  e1 e3 e4
                       |
                       |
    4                  +T
                       |
                       |  e4 e4 e4
                       |
                       |  e3 e3 e3 e4
                       |
    3                  +  e3 e3 e3 e3
                       |
                       |  e3 e3 e3
                       |  e3
                      T|
                       |
    2                  +S e2 e3
      105 128 77  78   |  e2 e2 e4
                  99   |  e1 e1 e2 e2 e3 e4
          68  70  9   S|  e3 e3
                  109  |  e1 e2 e3 e4
              155 56   |  e1 e2 e2 e4
    1 112 117 64  88   +  e2 e2 e3 e4 e4 e4 e4
              230 86   |  e2
              107 169 M|  e3
              121 85   |  e1 e2 e3 e4
          167 201 89   |  e1 e2 e3
      152 220 34  63   |
    0             96   +M e3
              101 61  S|  e1 e1 e2 e2 e2 e2 e2 e3
                  16   |  e1 e2 e2 e4
                  138  |  e2 e2 e2 e9
                  87   |  e1 e1 e3
              187 95   |  e2 e2 e2 e3
   -1                 T+  e1 e2 e2 e3 e9
                  69   |
                       |  e1 e1 e1 e2 e3 e3 e4
                       |  e1 e2 e3 e8
                       |
                       |  e1 e1 e1 e1 e4 e4 e8 e8
   -2                  +S
                       |  e1 e1 e1 e2 e2 e2 e3 e9
                       |
                       |  e1 e1 e1 e1 e1 e1 e1 e2 e2
                       |
                       |
   -3                  +
                       |
                       |  e1 e1 e1 e1 e1 e8
                       |
                       |
                       |
   -4                  +T e1 e1 e1 e1 e1 e1 e1 e2 e2 e2 e2 e2 e3 e5 e7
                 <less>|<freq>
```

Wright Map 3.5.7E Age Group 7 65-70 months

```
MEASURE  PERSON - MAP - ITEM
             <more>|<rare>
    5              +  e35 e35 e44 e45
                   |
                   |
                   |
                   |T e35 e35 e36 e45 e45
                   |
    4              +
                   |
                  T|
                   |  e15 e32 e41 e41
                   |
                   |
    3              +  e25 e32 e35 e38 e39
                   |
                   |  e25 e27 e33 e36 e41
                   |
              55   |  e18 e22 e22 e32 e40
                   |S
    2         72  S+  e34 e40
      110 227 73   |  e17 e36 e39 e43 e43
                   |  e14 e24 e28 e33 e43
          111 59   |
          5   80   |  e10 e17 e24 e26
              79   |  e26 e29 e34 e39 e40 e42
    1         81   +  e22 e38
          104 122  |  e28 e29 e38 e40
      11  120 202  |
              100 M|  e10 e20 e24 e33
      133 150 207  |  e42
                   |  e20 e21 e22 e23 e42
    0              +M
                   |  e17 e34 e44 e9b e9c
                   |  e11 e15 e18 e22
                   |
                   |  e12 e14 e30 e37 e37 e44
              190  |
   -1              +  e11 e20 e23 e23 e26 e27 e30 e31 e44 e8c
                  S|
              71   |  e11 e12 e13 e16 e16 e19 e19 e22 e8d e9a
                   |
              21   |
                   |  e12 e15 e18 e19 e21 e22 e22 e37 e37 e44 e8b
   -2              +
                   |S
                   |
                   |  e12 e13 e14 e19 e19 e19 e21 e21 e21 e21 e23 e8a
                  T|
                   |
   -3              +
                   |  e12 e12 e14 e31
                   |
                   |
                   |
              200  |
   -4         129  +
                   |
                   |T e12 e23 e23 e3  e5  e7
                   |
                   |
                   |
   -5              +  e12 e12 e12 e1a e1b e1c e1d e1e e2  e23 e23
             <less>|<freq>
```

Wright Map 3.8.8E Age Group 8 71-81 months

```
MEASURE PERSON - MAP - ITEM
            <more>|<rare>
    4            +  e44e   e45a
                 |
                 |  e36a   e45b   e45c
                 |
                 |
                 |
                 |T
    3            +  e17a
                 |
                 |
                 |  e36c   e38c
                 |
                 |
                 |  e15c   e18c   e27b
    2           T+
                 |  e36b   e41b   e41c
                 |
           X     |  e32c   e33b   e40b
                 |S
                S|  e14d   e24a   e35a   e35e   e38b   e39a   e41a
       XXXXXX    |
          XXX    |  e17c   e22a   e32b   e35c   e43a
    1            +
                 |  e22c   e25b   e32a   e33a   e35b   e38a   e39c
                M|
          XXX    |  e20b   e24b   e24c   e26b   e26c   e33c   e34a   e35d   e40a
          XXX    |
                 |  e28b   e34b
                 |
                S|  e10b   e17b   e18a   e25a   e28a   e30b   e39b   e40d   e43b
                    e9b
    0            +M
                 |  e23g   e27a   e40c   e43c
                 |
           XX    |  e10a   e22b   e42a   e44d
                T|
            X    |  e12a   e12c   e20a   e22h   e29a   e34c
                 |
                 |
   -1            +  e22e   e23c   e26a   e29b   e37c   e42b   e42c   e9c
                 |
                 |
                 |
                 |S e11a   e14a   e19b   e20c   e21b   e22g   e37a   e8c    e9a
                 |
                 |
                 |
   -2            +
                 |
                 |
                 |  e11b   e11c   e12j   e14c   e16b   e18b   e19c   e19e   e21a
                    e21f   e22f   e23h   e30a   e37d   e44a   e8a
                 |
                 |
                 |
                 |
   -3            +  e12b   e12d   e12e   e12f   e12g   e12h   e12i   e13a   e13b
                    e14b   e15a   e15b   e16a   e19a   e19d   e19f   e1a    e1b
                    e1c    e1d    e1e    e2     e21c   e21d   e21e   e22d   e23a
                    e23b   e23d   e23e   e23f   e3     e31a   e31b   e37b   e44b
                    e44c   e5     e7     e8b    e8d
            <less>|<freq>
```

Receptive Language Wright Maps

Wright Map 3.8.1R Age Group 1 29-34 months

```
MEASURE  PERSON - MAP - ITEM
             <more>|<rare>
    8              +  r1 r2 r2 r2 r3 r3 r3 r3 r3 r3 r3
                   |
                   |
    7              +
                   |
                   |
    6              +
                   |
                   |
    5              +
                   |
                   |
    4              +T
                   |
                   |
    3              +  r1 r1 r1 r1 r2 r2 r2 r2 r2 r2 r2 r2 r3 r3
                   |
                   |
    2              +S r1 r2 r2 r3 r3 r3 r3 r3 r6
                   |  r1 r1 r1 r2 r2 r2 r2 r3 r3 r3 r9
                   |
    1              +  r1 r2 r2 r2 r3 r3 r6
                   |  r1 r1 r1 r2 r2 r2 r2 r3 r3 r3 r3 r7 r9
                   |  r1 r1 r2 r2 r2 r4 r4 r7 r8
    0              +M r1 r1 r1 r1 r3 r9
                   |
                   |  r1 r1 r2 r2 r3 r8
   -1              +  r1 r1 r1 r1 r1 r1 r2 r3 r4 r9
                   |
                   |  r1 r1
   -2              +S r1 r1 r1 r1 r1 r2 r2 r2 r2 r5 r6 r6 r6 r7 r7 r8
                   |
                   |
   -3             T+
          179 24   |
          163 32  S|
   -4 126 19  39  M+T r1 r1 r1 r1 r1 r3 r4 r5 r5 r5 r5 r6
          162 62  S|
          40  50  T|
   -5              +
             <less>|<freq>
```

Wright Map 3.8.2R Age Group 2 35-40 months

```
MEASURE       PERSON - MAP - ITEM
                  <more>|<rare>
    3                   +T r3 r3
                        |  r2 r2 r3 r3 r3
                        |
                        |
                        |
                        |
                        |
                        |
                        |
                        |  r2 r3 r3 r3 r3 r3
    2                   +
                        |
                        |
                        |  r2 r2 r2 r2 r2 r3 r3 r3 r3
                        |
                        |S
                        |
                        |  r1 r2 r2 r2 r2 r2 r2 r3 r3 r3 r6
                        |
    1             125 T+  r1 r1 r1 r1 r2 r3 r4 r4
                        |
                        |
                  186   |  r2 r2 r2 r3 r3
                        |
                      S|
              185 27    |  r1 r2 r2 r2 r3 r3
                        |
     127 172 177 36     |  r1 r1 r1 r6 r7
                  22    |
    0             157 M+M r1 r2 r2 r2
                  146   |
                  47    |  r1
                  48    |  r1 r1 r1 r1 r1 r2 r2 r2 r3 r9
                  31    |
                  164   |  r1 r1 r1 r8 r9
                  184 S|
                        |  r1
                        |  r1 r1 r1 r1 r2 r2 r9
                  46    |
   -1                   +
                      T|  r1 r1 r7 r8
                  37    |
                        |  r1 r1
                        |  r1 r1 r1 r3 r4
                        |S
                        |  r1 r2
                        |  r2 r2 r4 r8 r9
                        |
                        |
   -2                   +
                        |  r2 r2
                        |  r1 r3 r3 r7
                        |
                        |
                        |
                        |
                        |
                        |
   -3                   +T r1 r1 r1 r1 r1 r1 r3 r5 r5 r5 r5 r5 r6 r6 r6 r6 r7
                  <less>|<freq>
```

Wright Map 3.8.3R Age Group3 41-46 months

```
MEASURE         PERSON - MAP - ITEM
                    <more>|<rare>
    4                     +  r35a
                          |
                          |
                          |
                          |  r31
                          |T
                          |
    3                     +  r27b r28c r39d
                          |
                          |
                          |  r23b r30  r32  r35b
                          |  r33  r39a
                          |
                          |  r16b r6d
    2                     +  r23c r35c
                          |
                         T|S r17a r37b r39c
                          |  r19b r19c r34b r34c r38b
                 134 6    |  r20c r37c
                     176  |  r20d r21c r22d r23a r28b r38a
                     38   |  r22b r28a r37a
    1        173 198 26  S+  r24b r26d r38c r39b r4b
         123 143 147 193  |  r22a r34a r6f
         116 195 20  219  |  r19a r20a r20b r23d r25a r25b r25c r27a r4c
                 153 51   |  r18a r38d
     106 137 154 171 208 M|  r16a r24a
             189 28  90   |  r10c r12b r9a
                 149 192  |  r12a r36a r7b
    0                175  +M r14d r15d r22c r36b
                     25   |  r11b r13b r17b r29
                 151 174 S|  r11c r12c r14e r15e r26b r9c  r9d
                          |  r14c r15c
                     65   |  r13d r15b r18c
                 140 166  |
                         T|  r13e r14b
   -1            211 49   +  r13c r18b r21b r7c
                          |  r11a r26a r26c r2c  r8a  r9b
                          |  r10b r21d r6b
                          |
                          |  r2a
                          |S
                          |  r13a r2b  r3c  r4d  r8c
   -2                     +
                          |  r14a r1e  r21a r3b  r6e  r7d  r8b
                          |
                          |
                          |  r10a r15a r3a  r6c  r7a
                          |
                          |
   -3                     +
                          |
                          |T
                          |  r1b  r1c  r1d  r3d  r4a  r5c
                          |
                          |
                          |
   -4                     +  r1a  r5a  r5b  r5d  r5e  r6a
                    <less>|<freq>
```

Wright Map 3.8.4R Age Group 4 47-52 months

```
MEASURE                          PERSON - MAP - ITEM
                                     <more>|<rare>
    5                                      +  r
                                           |T r r
    4                                      +
                                           |  r r r r r
    3                                      +  r r r r
                                           |  r r r r r r
    2                                      +S r r r r r r r r r
                                           |  r r r r r r r r r r r r r r r r
    1                                      +  r r r
                                           |  r r r r r r r r r r r r r r r r
    0                                      +M r r r r r r r r r r r r r r r
                                           |  r r r r r
   -1                                      +  r r r r r r r r r r r r r
                                           |  r r r
   -2                                   30 +S r r r r r
                                    11 14 T|  r r r r r r r r
   -3                   16 20 21 22 44 45 S+
                     14 16 18 20 23 33 42  |
   -4 13 13 14 15 16 17 18 19 21 29 91 98 M+  r r r r r r r r r r r
                        17 20 21 21 43 60 S|T
   -5                               16 18 T+  r r r r
                                    14 14  |
   -6                                      +
                                     <less>|<freq>
```

Wright Map 3.8.5R Age Group 5 53-58 months

```
MEASURE                          PERSON - MAP - ITEM
                                     <more>|<rare>
    6                                      +
                                           |  r
                                           |
    5                                      +
                                           |  r
                                           |  r
    4                                      +T
                                           |  r
                                           |
    3                                      +  r r r
                                           |  r r r r r r r
                                           |  r r r r
    2                                      +S r r r r r r r r r r
                                           |  r r r r r
                                           |  r r r r r
    1                                      +  r r r r r r r
                                           |  r r r r r r r r r
                                           |  r r r r r
    0                                      +M r r r r r
                                           |  r r r r r r r r
                                           |  r r r r r r
   -1                                      +  r r r r r r r r r r
                                           |  r r r
                                           |  r r r r r r r r r r
   -2                                      +S
                                          T|  r r r r r r r r r r
                          124 130 228 84   |
   -3                     108 229 76  83  S+  r r r r r r r r r r r r r r r
                  102 194 201 52  53  54   |
                  159 226 67  82  93  94  M|
   -4 10  141 158 17  196 222 231 41  97   +T
                          103 131 206 223  |
                      114 13  210 57  66  S|
   -5                                 212  +
                                          T|
                                           |
   -6                                 92   +
                                     <less>|<freq>
```

Wright Map 3.8.6R Age Group 6 59-64 months

```
MEASURE  PERSON - MAP - ITEM
             <more>|<rare>
    4              +
                   |  r3 r3
                   |
                   |  r3 r3
                   |
                   |
                   |T
                   |  r3
    3              +
                  T|
               77  |
            9  99  |  r1
                   |
               70  |  r1 r3 r3
            15 23  |
            10 88  |  r3
    2          12 S+
                   |  r3 r3 r3 r3
         10 20 68  |  r3 r6
            11 78  |S r1 r3
               16  |  r2
                   |  r2 r3 r3
            63 89 M|  r3
            10 34  |  r1 r1 r2 r3 r3 r3 r6
    1       15 64  +  r2
      11 16 56 85  |  r1 r3
         12 22 95  |  r1 r2 r4
         61 86 87  |  r2 r2 r4
                  S|  r1 r2 r2 r2 r9
               10  |  r2 r7
            13 96  |  r2 r2 r3
                   |  r1 r2
    0          16  +M r1 r2 r2
               69  |
               18  |  r1 r1 r1 r1 r2 r2 r2
                  T|  r1 r2 r2 r2 r9 r9
                   |
                   |  r1 r1 r1 r1 r3
                   |  r1 r1
                   |  r1 r1 r1 r2
   -1              +
                   |  r1 r1 r1 r1 r2 r2 r2
                   |
                   |
                   |  r1 r1 r1 r7
                   |S
                   |
                   |  r2 r2 r2 r6 r6 r9
   -2              +
                   |
                   |
                   |
                   |
                   |  r1 r1 r1 r2 r2 r4 r4 r5 r5 r6 r8 r8 r8
                   |
                   |
   -3              +  r1 r1 r1 r1 r1 r2 r2 r2 r3 r3 r3 r3 r5 r5 r5 r6 r7 r7
             <less>|<freq>
```

Wright Map 3.8.7R Age Group 7 65-70 months

```
MEASURE          PERSON - MAP - ITEM
                     <more>|<rare>
    5                      +
                           |
                           |
                           |  r3
    4                      +
                           |  r3
                           |
                           |  r3
    3                      +T
                           |  r3 r3
                           |  r1 r3 r3 r3 r3
                           |  r3 r3 r3 r3
    2                      +  r1 r3
                           |  r1 r1 r1 r2 r3 r3 r3
                           |S r2 r2 r2 r2
                           |  r2
    1                      +  r1 r2 r3 r9
                           |  r1 r2 r2 r2 r2 r2 r3 r3 r3 r3 r3 r4 r6
                           |  r1 r2 r2 r2 r2 r7
                           |  r1 r1 r1 r1 r1 r1 r1 r1 r2 r2 r4
    0                      +M r1
                           |  r1 r1 r1 r2 r2 r2 r9
                           |  r1 r1 r1 r1 r1 r2 r6 r7
                           |  r1 r1 r1 r1 r2 r2 r2 r2 r8 r8 r9
   -1                     T+
                           |  r1 r2 r2
                           |S r1 r1 r1 r2 r2 r3
                  227 59  S|  r1 r1 r1 r1 r2 r4 r4 r6 r6 r6 r7 r8 r9
   -2     110 150 55  80   +  r1 r1 r2 r2 r2 r3 r3 r3 r5 r5 r5 r5 r5 r6 r7
          122 133 72  79   |
              100 202 73   |
      104 11  111 120 207 M|
   -3             5   81   +T
                           |
                           |
                          S|
   -4                 21   +
                  190 71   |
                           |
                          T|
   -5                 200  +
                      129  |
                           |
                           |
   -6                      +
                     <less>|<freq>
```

Wright Map 3.8.8R Age Group 8 71-81 months

```
MEASURE PERSON - MAP - ITEM
         <more>|<rare>
    4          +
               |
               |
               |  r37c   r39a
               |
               |
            X  |
               |
               |  r35a   r35b
               |
    3          +T
              T|  r31
               |
               |
               |
               |
               |
            X  |
            X  |
              S|
    2          +  r17a   r32    r33    r34b   r37b   r39d
               |
               |
         XXXX  |  r19b   r34c
            X  |
            X  |S r30    r38a
              M|
               |  r39c   r6d
            X  |
          XXX  |
    1       X  +  r16b   r23b   r34a   r35c
           XX  |
               |  r16a   r26d   r39b
            X S|
               |
               |  r25c   r37a   r38b   r38c   r38d   r4b
            X  |
               |
               |  r23a   r23c   r28c
               |
    0       X  +M
              T|  r18a   r22a   r26a
               |
               |
               |  r19c   r22d   r23d   r28a   r28b   r29    r36b   r6f    r9a
               |
               |
               |  r15c
               |
               |  r11b   r14c   r18b   r19a   r20a   r22b   r27b   r2c    r36a
                  r4c
   -1          +
               |
               |
               |
               |
               |S r15b   r15d
               |  r4d
               |  r11a   r11c   r12a   r12b   r12c   r13b   r14b   r14d   r18c
                  r20c   r20d   r25b   r27a   r6e    r7b    r9b    r9c
               |
               |
   -2          +  r10a   r10b   r10c   r13a   r13c   r13d   r13e   r14a   r14e
                  r15a   r15e   r17b   r1a    r1b    r1c    r1d    r1e    r20b
                  r21a   r21b   r21c   r21d   r22c   r24a   r24b   r25a   r26b
                  r26c   r2a    r2b    r3a    r3b    r3c    r3d    r4a    r5a
                  r5b    r5c    r5d    r5e    r6a    r6b    r6c    r7a    r7c
                  r7d    r8a    r8b    r8c    r9d
         <less>|<freq>
```