Phonological Development in Typically Developing Najdi Arabic-Speaking Children Aged 1-4 years

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Abstract

This study explored patterns of Najdi-Arabic phonological acquisition in typically developing Saudi children aged 1;10-4;02 years. Sixty children were recruited in five age groups with 6-month intervals. The main goals were to explore the effects of Speech-Task (Picture-Naming vs. Spontaneous speech), Syllable/Word Position, Age, and Gender on: Percent Consonants Correct, consonant acquisition, and the occurrence of phonological processes. The picture naming task aimed to elicit each consonant in four positions and twelve consonant clusters at word boundaries. Recordings were transcribed using narrow phonetic transcription and analysed using PHON. In contrast with previous studies the children in this study had higher PCC scores, made fewer phonological errors, outgrew phonological process sooner, and had an earlier mastery and customary production of consonants in the SPON rather than the PN sample. The only exception was Cluster-Reduction, which occurred more frequently in the SPON sample. Syllable/word position had a statistically significant effect on PCC, age of acquisition of consonants, and on the occurrence of 10/14 phonological processes. In general, consonants in medial-coda position were least accurate. The token frequency of consonants in the SPON sample best matched the frequency of Arabic consonants in the adult form as reported in (Amayreh et al., 1999). Females generally acquired a greater number of consonants or an earlier age of acquisition than their male peers. The findings will inform development of the first standardized articulation/phonological assessment in Arabic. Specifically, the results repeatedly demonstrate that clinical assessments should not be based on PN tasks alone, and that distinguishing between onset and coda in medial position is informative. Furthermore, the patterns found speak to explanatory theories of phonological acquisition. Patterns align, to a degree, with accounts emphasising the significance of token frequency in determining consonant acquisition whilst challenging the applicability of the sonority index to consonant acquisition in Arabic.

Keywords: Najdi Arabic, Arabic consonant acquisition, Arabic phonological development

Dedication

To you mother, I owe my success.

إليك يا أمي أهدي نجاحاتي

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List of Abbreviations

Arabic Dialects

EA	Egyptian Arabic
ESA	Educated Standard Arabic
JA	Jordanian Arabic
KA	Kuwaiti Arabic
MSA	Modern Standard Arabic
NA	Najdi Arabic
SA	Standard Arabic

Syllable and word positions

PoV	Post-Vocalic
PrV	Pre-Vocalic
SIWI	Syllable-Initial Word-Initial
SIWW	Syllable-Initial Within-Word
SFWW	Syllable-Final Within-Word
SFWF	Syllable-Initial Word-Final
WI or I	Word Initial
WM or M	Word Medial
WF or F	Word Final

Stimulus

PN	Picture Naming (in the current study)
SPON	Spontaneous Sample (in the current study)
SSS	Spontaneous Speech Sample (SPON studies in the literature)
SWA	Single-Word Assessment (PN studies in the literature)

Other abbreviations

CE	Cluster Epenthesis
CR	Cluster Reduction
PCC	Percent Consonants Correct
SCD	Singleton-Consonant Deletion
WSD	Weak-Syllable Deletion

Chapter 1. Introduction

1.1. Introduction

Speech Sound Disorders (SSD), a term that combines what previously known as articulation and phonological disorders, can be defined as the difficulties in the perception, motor production, or phonological representation of speech sounds or segments which can be idiopathic or result from an organic deficit (e.g. cleft-lip and palate, hearing loss, cerebral palsy… etc.). The prevalence of SSD has been reported as high as 3.4% in 4 year-old children (Eadie et al., 2015) and as high as 6.4% in children between 4-8 years (Burgoyne et al., 2019). SSD were also found to have over 40% comorbidity with language disorders and over 20% comorbidity with poor pre-literacy skills (Eadie et al., 2015). Children with SSD have been reportedly to be at more risk of bullying, below average peer relationships, and reduced quality of life resulting from reduced verbal conversation skills, low self-esteem, and frustration (McLeod, 2006). Although the majority of children are likely to receive therapy, the demand on Speech and Language Therapy services is much higher than what is available. For example, McLeod and Harrison (2006) reported that Speech and Language Therapy services were not accessible for 2.2% of 4-5 year old Australian children with communication difficulties. Furthermore, phonological disorders at in early childhood years appear to have adverse effect that persist into adulthood affecting both education and vocation (Lewis and Freebairn, 1992).

In the last century, results from studies that focused on the acquisition of speech sounds and the occurrence of phonological process have provided an essential source of information for assessing children with SSDs. In particular, normative studies have provided a substantial amount of information on the age and order of speech sound acquisition and age-appropriate phonological processes. The data obtained from typically developing children have formed a reference enabling clinicians to create protocols/tools for comprehensive assessment. Normative data has also formed the foundation for Speech-Language-Therapists (SLTs) in the differential diagnosis of atypical versus delayed development, in determining if treatment is warranted and in the choice of treatment goals.

The earliest normative studies were conducted on the English language and concentrated on the age of acquisition of speech sounds in various word positions (e.g. Wellman et al. (1931), Poole (1934), Templin (1957), Olmsted (1971), (1975), Smit (1986)). In the earliest studies, errors in the production of speech sounds were classified as substitutions, omissions, or distortions remaining at a surface level description of errors made, perhaps with an implicit assumption that these were driven by a child's developmental progression in motor and structural domains. Since the 1950's, the focus shifted towards a more phonological approach (Ingram, 1974b). In this approach studies explored children's speech sound inventory and their use of the rules which govern the system of speech sound contrasts affecting meaning in their language and the rules for combining of speech sounds in syllables, words, and sentences. The phonological approach assumed that the child's errors were a result of their failure to apply this system and rules and so resulted in the occurrence of phonological errors or patterns across a group of sounds. This approach to describing patterns of errors across groups of sounds (or processes) became the dominant approach to describing children's speech sound development. For example, *cat, bat, sat* could all be pronounced as [tat] by a young child. When applying a phonological approach to child speech development each production of /tat/ would result from the failure to apply different phonological rule: velar-fronting, assimilation and fricative-stopping respectively. The specificity of such errors provided an insight to the role played by other factors affecting the accurate production of speech sounds such as markedness, articulation complexity, sonority and phonologic saliency, functional load and frequency of input (discussed in more detail in chapter 2).

The phonological approach as opposed to the earlier 'surface descriptive approach' that focused on the age of speech sound acquisition has proven more valuable in the description of the systematic patterns and processes used by typically developing children in their language acquisition journey (Roberts et al., 1990). Moreover, the phonological approach has also been proven very useful in clinical applications in particular informing the design of effective interventions. For example, Weiner (1981) found that the use of meaningful minimal contrast was successful in the reduction of final consonant deletion, fricative-stopping and velar-fronting errors. It is undeniable that studies implementing either the surface descriptive or phonological approach have contributed immensely in the knowledge we have available today about typical phonological development in children and consequently in the therapeutic approaches utilized in the clinic (Wren et al., 2018).

Although most studies aim to answer similar research questions, normative phonological studies have used a range of different methods in collecting their data. The two most common methods are Single-Word-Assessment (SWA) and Spontaneous Speech Sampling (SSS). Most normative studies used SWA in the form of picture naming as the method for collecting their data (e.g. Templin (1957), Prather et al. (1975)). In contrast, others used SSS as their preferred method justified this as a more naturalistic approach that is more representative of the child's actual use of language (e.g. Olmsted (1971)). However, SWA allow the manipulation of the targets to collect the desired data in a short amount of time and with comprehensive coverage of target phonemes. On the other hand, they rarely provide opportunities for the production of the target sounds in more than a single occasion. Consequently, this method does not account for the possibility that a child may produce the misarticulated sound correctly in other words. It also does not allow for the possibility of inaccurate production of a target speech sound in connected speech which has been produced correctly as a single word. Nonetheless, SWA remains the preferred method of assessment in a clinical setting due to its time-saving advantages and the structured and standardised design that permits straightforward and reliable comparisons pre- and post-therapy.

Smit (1986) compared the age of acquisition of speech sounds in studies implementing SWA versus SSS and concluded that SSS provides more accurate information about children's phonological status, i.e. provide additional important information that compliments the data from SWA. Moreover, she argued that the difficulty of using data from SSS studies is in the reporting of the results which lacks the incorporation of normative data that is clinically applicable. McLeod and Crowe (2018) conducted a review of 64 normative studies in 27 languages and reported that only 10% of the studies (i.e. seven studies) collected data from connected speech as well as single words. However, none of the studies in McLeod and Crowe's review investigated nor reported the effect of the elicitation method on their results. In the literature, very few studies have compared the outcomes of the two elicitation methods within the same participants for an unbiased comparison. Most of these studies targeted children known to have some degree of speech/phonological difficulties (Wolk and Meisler, 1998, Morrison and Shriberg, 1992, Healy and Madison, 1987, Johnson et al., 1980, Faircloth and Faircloth, 1970, Andrews and Fey, 1986, DuBois and Bernthal, 1978, Kenney et al., 1984, Masterson et al., 2005) and rarely in typically developing children (Kenney et al., 1984). In chapter 2, the findings on these studies are discussed in more detail. The ongoing debate on which method is the most accurate in representing the child's true phonological proficiency is one of the main motivations behind this study.

1.2. Motivation and importance

Normative studies on the phonological development of the Arabic language is scarce and non-existent on the Najdi dialect (Abou-Elsaad et al., 2019, Ammar and Morsi, 2006, Khattab, 2007, Amayreh et al., 1999, Amayreh, 2003, Dyson and Amayreh, 2000, Amayreh and Dyson, 1998). Also, of the few which do exist many were completed in a partial fulfilment of a post-graduate degree and so may have limited access and are rarely published in peer reviewed journals (e.g. (Bahakeem, 2016, Al-Buainain et al., 2012, Alqattan, 2014, Ayyad et al., 2016, Owaida, 2015, Saleh et al., 2007). As a result, SLTs in Saudi Arabia have tended to construct their assessment procedures and clinical judgement based on normative data from other languages (mainly English) which is neither appropriate nor adequate. Understandably, studies based on English do not provide any information on the expected acquisition age of velar and pharyngeal fricatives or emphatic consonants nor offer any therapeutic approaches/techniques to remedy errors in their production. Similarly, the acquisition age of the rhotic 'r' in English cannot be compared to the 'r' in Arabic which is realized as either a tap or a trill.

For those reasons, the primary goal was to provide substantial normative data which can be used to facilitate clinical practice and aid in future creation of a phonological assessment tool that is designed for the Arabic language and based on Arabic normative data. The goal was to do so via exploring the particulars of the typical phonological development of Saudi children speaking the Najdi dialect in relation to their age and gender whilst adopting a statistical analysis approach to report most of the findings. Similar findings have been predominantly reported descriptively in the literature.

The aim was to collect and compare data from two speech samples: Picture-Naming (PN) and a semi-structured Spontaneous-Speech-Sample (SPON) in an attempt to explore the effects of the elicitation method on speech performance; an area that is deficient in the literature of typically developing children. Studies that compared SWA and SSS[1] elicitation methods mostly recruited children with known phonological impairment/delays. However, in typically developing children, studies that compared the two elicitation methods are very rare: one on English (Kenney et al., 1984) and one on Arabic (Bahakeem, 2016).

Although language specific phonotactic rules dictate what syllable/word position can be occupied by a consonant, the earliest normative studies focused on the accurate production of consonants only at word boundaries even when medial consonants were permissible (detailed review of normative studies included in chapter 3 section 3.5). More recent studies included word-medial (WM) consonants in their analysis. However, the majority of the normative studies that included WM consonants do not attend to onset and coda differences within WM position (except for: (Alqattan, 2014) and (Amayreh and Dyson, 2000)). Consequently, this study aims to investigate the effect of syllable/word positions following Amayreh and Dyson's and Alqattan's footsteps in the attempt to fill-in the gap in the literature in differentiating onset and coda consonants within WM position. As a result, consonants were targeted and analysed in the current study in four positions: Syllable-Initial Word-Initial (SIWI), Syllable-Initial Within-Word (SIWW), Syllable-Final Within-Word (SFWW), and Syllable-Final Word-Final (SFWF).

1.3. Structure of the thesis

Following the first chapter of introduction, chapters 2 and 3 present available findings in the literature. Chapter 2 aim to uncover the complexity involved in learning to speak

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[1] SWA vs. PN and SSS vs. SPON essentially have the same meaning and have been used interchangeably in this thesis, however PN and SPON are specifically used when referring to the stimulus in the current study.

an ambient language in light of some of theoretical influences on the study of phonological development, the factors influencing phonological development, and the effect of elicitation method on speech performance.

Next, chapter 3 focuses on the literature review of normative phonological studies. However, before that, the context that is most relevant to the current study is presented: the Arabic language, the Najdi dialect, and Saudi Arabia. Also, an elaborative insight to the difference between phonological processes in adults versus phonological errors in children is presented. As a result, the context and the detailed rationale for the focus, research questions, and approach of the study is provided.

The aims and research questions followed by the study design and the procedures followed in data collection, data preparation, transcription, and analysis implemented to investigate and report the specific findings of the current study are all presented in the Methodology chapter (chapter 4).

Then the findings of the current study are reported in chapters 5 and 6. The bulk of chapter 5 was dedicated to report on the frequency analysis of consonants, percent of consonants correct, and the acquisition of Najdi Arabic consonants. However, the chapter started with descriptive statistics of the participants' demographic data followed by some general statistics describing the collected speech samples. At the end of the chapter, some correlation and associations found between some of the variables are presented.

In chapter 6, the detailed the results of the phonological processes analysis in the current study are reported whilst continuing to investigate age-group and gender differences and the effect of speech-task and syllable/word position.

Finally, in chapter 7, all findings are discussed and compared to other dialects of Arabic and cross-linguistically to other languages. The end of this chapter includes a summary and conclusion, contribution of the current study and clinical implications, and limitations and suggestions for future research.

Chapter 2. The Complexity of Phonological Acquisition

This chapter presents a general understanding of the literature. In section 2.1., a demonstration of the complex levels of difficulty involved when learning to speak an ambient language is presented. Then, in section 2.2., a brief overview of the theoretical influences on the study of phonological development is provided followed by a discussion of the key factors affecting phonological development in section 2.3. And finally, section 2.4. provides a review of the literature for studies that explored and compared speech elicitation method in addition to other methodological considerations that may have effects on speech performance and hence the validity of findings.

2.1. The complexity of phonological acquisition

One of the first signs of a speech problem observed by parents is at the sound level. Often parents say: my child cannot pronounce specific sound or says them wrong in words. In a phonological assessment, SLTs typically start by assessing the accurate production of the speech sounds: i.e. phonemes. But what is a phoneme?

The phoneme is a term that has been used for centuries by linguists to refer to units of sounds (Rogers, 2014). Broadly, the phoneme is defined as the smallest unit of contrast within a language which, if changed alters the meaning of a word. As such, *phoneme* is a label used to identify a set or a family of sounds. Those individual sounds are the allophones of that phoneme. The allophones can be defined as the positional or contextual variants of that phoneme. Together, the entire set of allophones make up the phoneme. To better understand the difference between phonemes and allophones, one must explore the differences between types of sound distributions a child has to learn implicitly.

- *Contrastive distribution*: Two sounds are judged to be in contrastive distribution if replacing one sound by the other leads to a change of meaning in the same phonological environment. In the example below, /d/ and /b/ are in contrastive distribution and, therefore, represent different phonemes. When the phonological environment is compared, [-ɪg] has remained constant. Yet the insertion of /d/ and /b/ in the onset position yields two very different word meanings. Words that only

- differ in a single sound in the same position are termed minimal pairs. Therefore, in the example below, *big* and *dig* are minimal pairs.

Same phonological environment

/d/		[dɪg]
	[-ɪg]	
/b/		[bɪg]

- *Complimentary distribution*: two sounds, often phonetically similar, are in complementary distribution when they are found in mutually exclusive contexts. For example, [p] and [p^h] are in complementary distribution because they never occur in the same phonological environment. For example, [p^h] occurs in the syllable onset position, as in the word *peel*, but never in syllable onset within a consonant cluster, as in the word *spin*, where [p] naturally occurs.
- *Free variation:* In free variation, two sounds occur interchangeably in the same phonological environment without any changes to the meaning of the word. Free variation refers to the unpredictability in the distribution of those two sounds. In other words, there are no rules governing the appearance of one sound or the other. For example, /t/ in the word *water* can be in free variation with different sounds that one would think belong to a different phoneme. Free variation is language and dialect-specific and is often the result of normal phonological processing in adult speech. In the example below, /t/ and /ɾ/ are in free variation in American English but not in the British English accent, and vice-versa /t/ and /ʔ/ are in free variation in British English.

'water'	/t/ →	[ɾ]	[wɔɾɚ]	East American English
	↘	[ʔ]	[wɔʔə]	North-eastern British English

- *Positional neutralisation*: In positional neutralisation, two sounds can be contrastive in one phonological environment but not in another. Meaning, /d/ and /t/ belong to different phonemes because minimal paired words exist in that language (/d/ in *dime* and *ride* vs. /t/ in *time* and *write*), yet this contrast is neutralised in certain positions. For example, in American English, /t/ and /d/ both are realized as the tap /ɾ/ in the condition where it is positioned between two vowels, the second of which

- is unstressed, as in the words *city* and *lady*, which are pronounced [sɪɾi] and [leɪɾi], respectively.

In addition to the complexity of learning about phonological contrast in individual phonemes described above, the child also needs to be able to combine phonemes into syllables, syllables into words, and words into sentences. To illustrate the complex levels of unconscious processing which are hypothesized to be required to use spoken language, figure 2.1. describes how non-linear phonological theory would explain the production of a single lexical item: [ˈta:.kɪl] ‘she eats’.

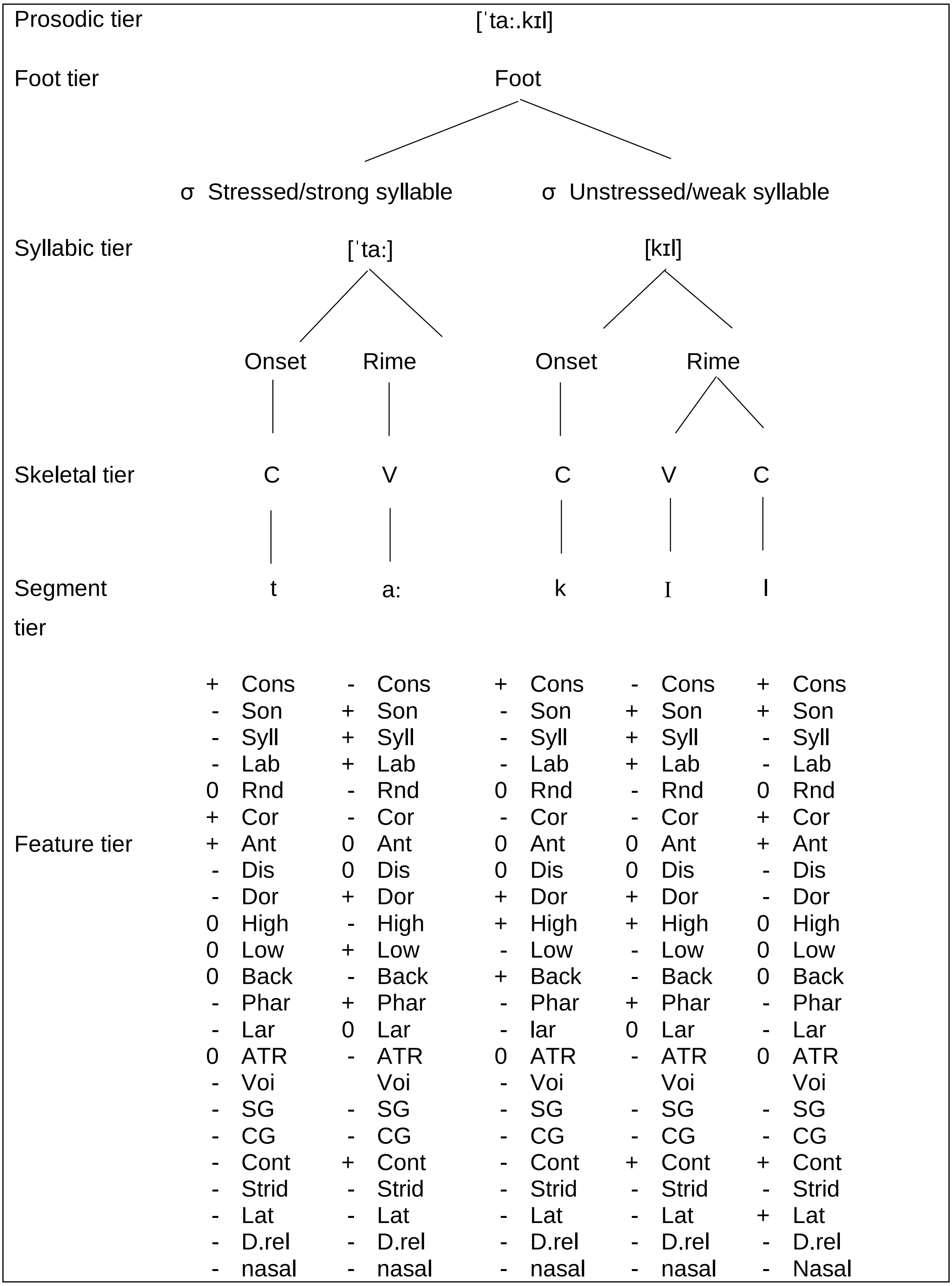

Figure 2.1. Hierarchy of planes that are encompassed within the surface form *she eats* in Arabic.
Key: C= Consonant, V= Vowel, Cons: consonantal, Son: sonorant, Syll: syllabic, lab: labial, Rnd: round, Cor: coronal, Ant: anterior, Dis: disturbed, Dor: dorsal, Phar: pharyngeal, ATR: advanced tongue root, Voi: voice, SG: spread glottis, CG: constricted glottis, Cont: continuous, Strid: strident, Lat: lateral, D.rel: delayed release.

Jakobson analysed what was previously thought to be the smallest unit in the phonological system (the sound) to even smaller units or features (Jakobson, 1968). So, the features combine to build segments, and the segments build a syllable, which consist of an onset and a rime. Syllable onset is always a consonant followed by a rime which comprises a nucleus (mostly a vowel) and is optionally followed by a postvocalic consonant. Typically, the postvocalic consonants are labelled as a coda. A universal phonological rule is that all syllables in all languages must encompass a nucleus but can do without an onset or a coda (Archibald, 2014).

The time tier is a relatively new concept in non-linear phonology. The significance of time tier can be explained using the mora, a term used to determine syllable weight. The mora is considered the building block of the syllable. The mora is often used in linguistic studies of languages where change of stress results in change of meaning. Time tier is also an important tool when the vowels in the nucleus can be contrastively extra-short or extra-long, affecting meaning. In Arabic, words like /fŭlː/ (jasmine) and /fuːl/ (cooked brown beans) differ in the time tier (i.e., vowel length). Moreover, whether the presence of an onset or a coda is compulsory in the syllable structure of a specific language is highly dependent on its phonotactic rules. Some languages only allow CV (where C represents *consonant* and V represents *vowel*) syllables, as in Japanese, whilst in Standard Arabic, CVC along with CV syllables are the most common (Beckman et al., Ryding, 2005). Furthermore, the weight of the onset, coda and even nucleus can be expressed by the number of segments in them. For example, *stop* and *strain* are two English single-syllable words that allow two and three segments in the onset (CCVC and CCCVC, respectively). As the number of segments increase, the syllable weight increases and attracts more stress. In Standard Arabic (SA from here after), CVCC is permissible but CCVC is not. However, in some Arabic dialects, CVCC and CCVC are both permissible often because of weak vowel deletion. Some examples in Najdi Arabic (NA) are shown in Table 2.1 below.

Table 2.1:

Examples of Najdi Arabic words with WI consonant cluster

Najdi Arabic	Standard Arabic	Meaning
[nɾuːħ]	/na.ˈɾuːħ/	We go
[tmuːt]	/ta.ˈmuːt/	She is dying
[ħsˤɑːn]	/ħɪ.ˈsˤɑːn/	Horse

The above examples highlight an additional level of complexity: Phonotactic constraints. These are the rules that enable one to determine what sounds can neighbour each other as well as which sound sequences are permitted in a language and which are not. While phonotactic constraints vary between languages, the rules governing them are not random. Their distribution is hypothesized to be based on the syllabic structure of the language with many authors explaining this by invoking theories of ‘markedness’ (e.g. Cairns (1986), Cairns (1988), Demuth (1995)) where unmarked sequences are hypothesized to be ‘easier’ – although as will be explained later in section 2.3.1., the definition of markedness is not without its difficulties.

As a child spends many years expanding their lexicon, s/he also learns to combine individual lexical items into phrases and phrases into sentences in a complex linguistic system that involve rules of morphology, syntax, semantics, and pragmatics, all of which are beyond the scope of this thesis which only focuses on the phonetic and phonological aspects of language learning.

2.2. Theoretical influences on the study of phonological development

The field of phonological development has undoubtedly been influenced by advances in phonological theory, but some theories have had more influence than others and have played a role in shaping assessment and therapeutic procedures in clinical practice. Below, the insights and notions from phonological theories which have been adopted in developmental clinical phonology are revisited.

For decades, child phonology experts have aimed to uncover how the child comes to acquire the sound system of their language and how they build mental representations for the phonological units that underpin this system. The earliest phonological theories looked at biological and behavioural explanations. For example, in the physiological approach, it was hypothesized that the phonological development depended on the number of nerves, muscles and the amount of energy exerted by the articulatory system in the process of sound production. In other words, it was believed that sounds requiring the least amount of energy are produced early whilst sounds that required greater effort appeared later (Mowrer, 1980). On the other hand, the behaviourist approach suggested that language learning is centred on a reinforcement system provided by caregivers. As the child attempts to imitate adult productions, correct productions are positively reinforced and incorrect ones are not. This continuous reward system was thought to eventually lead to the maintenance of the correct productions and the elimination of incorrect ones (Skinner, 1986).

Both approaches were widely criticised and have very little application in the present day. The physiological approach dismissed the role of sensory input (auditory and visual) as well as neurological development and environmental factors. Further, it did not account for the production of complex speech sounds (e.g. fricatives) at the babbling stage. Similarly, the behaviourist approach was critiqued for its inability to account for the incorrect production of some speech sounds for months or even years in spite of the presence of an adult model alongside continuous positive/negative reinforcement. Additionally, Wahler (1969) challenged the role of this reward system when mothers were observed to provide equal attention to their infants' vocalizations regardless of their resemblance to the adult form.

More modern theories consider more abstract linguistic learning and representation and fall on a continuum in terms of innateness/top-down or cognitive/bottom-up learning. Nonetheless, the theories that support the notion of an innate component differ in the definition of the nature of this innate knowledge. For example, Chomsky and Halle (1968), in their theory of generative phonology, hypothesized that children are equipped with the inborn ability to deduct and generate phonological rules from the adult surface forms of the spoken language. On the other hand, Stampe (1969), in his theory of natural phonology, suggested that children are born with a complete phonological system enabling them to learn any language. Overtime, the children learn to suppress some of this innate knowledge that is not relevant to their ambient language and consequently grasp and only retain the same set of phonological rules that govern the adults' speech production of their mother tongue.

To discuss current phonological research requires an understanding of Jakobson's distinctive features theory, Universal Grammar (UG), Optimality Theory (OT), and Emergent accounts. In the next paragraphs, each is discussed in more detail.

Jakobson (1968) believed that the biological predisposition to learn language only plays a partial role in the acquisition of speech sounds and acknowledged the role of the environment. In his Distinctive Features Theory, Jakobson relied on two main principles: (1) a linear and continuous analysis of words until their underlying smallest components have been reached, i.e. 'the features' which were then considered the smallest phonological units and the building blocks of the whole phonological system and (2) a small number of those building blocks should be able to account for any sound in all natural languages of the world (Anderson, 1985). According to Jakobson, there are two distinctive periods of vocal productions: (1) The babbling phase, and (2) The meaningful speech phase; Jakobson posits that (1) the babbling phase is not a true reflection of the acquisition of phonology as infant vocalizations have no intended meaning, have no clear sequence of sound acquisition, and do not carry a sustained effect on the later phase when children appear to have to relearn the production of speech sounds. Phase (2) of meaningful speech relates to when a child learns the phonology of their ambient language via an innate capability following a universal hierarchical order. Although Jakobson's views initially faced a lot of opposition, his *'Distinctive features theory'* is now considered to be one of the most influential phonological theories. One major shortcoming of his views is his disregard of the importance of the pre-linguistic utterances in the babbling phase. Moreover, his theory falls short of explaining individual and language-specific variations that do not follow his presumed predictable order of development. Nonetheless, anecdotal evidence shows that the principles of Jakobson's 'Laws of implication' are repeatedly implemented by Arab SLTs in their therapeutic approaches of SSD[2]. In his Laws of Implication Jakobson states that:

- Every language that had back consonants also had front consonants, but the opposite is not always true. Therefore, front to back order of acquisition was considered as natural process. He also applies the same front-to-back principle to vowels of the same height.
- All languages have stops, but not all have fricatives. Thus, language that have fricatives must also have stops and consequently the manner of articulation also played a role in the acquisition of speech sounds where the acquisition of stops proceeded fricatives.
- Affricates only existed in languages that had both stops and fricatives. Also, the number of fricatives always exceeds the number of affricates in any language. Consequently, affricates are last to be acquired after stops and fricatives.

Furthermore, Jakobson managed to set the building blocks for UG in his publication on *'Child Language, Aphasia and Phonological Universals'* (Jakobson and MacMahon, 1969, Jakobson, 1968). Following his footsteps, Chomsky believed that humans have a genetic predisposition to language learning. Words and their meaning, however, are not innate and must be learned in addition to other language specific parameters like word order within a sentence (Chomsky, 1981, Kager et al., 2004, White, 1989, Meisel, 1991). The basic premise of UG hinges on the concept that a child's phonological acquisition is directed and moulded by a set of innate principles and shapes (Archibald, 2014). Ingram (1989) suggested that utilizing the innate tools of UG becomes necessary after the child's vocabulary inventory becomes too large (exceeding the 50-word mark) to be managed without some sort of an underlying

[2] For example: therapeutic SSD goals often targeted stops before fricatives and affricates (following the universal pattern of acquisition). Similarly, treatment often commenced with front consonants which are considered as an easier than back consonants where visual feedback could be utilized. Affricated were only targeted in SLT session when the child could correctly produce both elements: stop and fricative separately.

organizational system. He proposed that the first 50 words are learned as one single unit; therefore, once UG is utilized, quantitative and qualitative differences are observed between utterances acquired during those two periods (Ingram, 1989, Ingram, 1986). First words were learned as single unit and were used in an overextended manner as a single utterance where meaning was generalized to include similar semantic concepts with the propensity of it being a noun. In contrast, words that are acquired after the 50-word mark had more specific meaning and were more versatile, i.e. inclusive of action words and nouns.

Supporting Ingram's views, Hollich and Houston (2007) believed that infants are only able to segment the speech signal into smaller units, e.g. syllables, sounds and features… etc., after their first birthday. All of which is in agreement the notion of segmental phonology and more specifically the phoneme theory. In the phoneme theory, the phoneme was regarded as the smallest unit of sound that can convey meaning in any given language (Kaan and Yoo, 2014). The influence of theories adopting the segmental phonological approach is frequently observed in the clinical work.

On the other hand, work within the Optimality theory framework suggests that that phonology is acquired via existence of universal constraints that are applicable to all natural languages (Smolensky and Prince, 1993). Smolensky and Prince suggested two basic types of constraints that are applicable to all natural languages: (1) markedness constraints, which predict the early emergence of unmarked/easy structures and the later development of marked/difficult ones, and (2) faithfulness constraints, which primarily mean that production/output must bear the closest possible resemblance to target/input (Hayes, 1996, McCarthy, 2008, Dekkers et al., 2000).

In the input-based approach, Bruner (1975) believed that language learning occurs in contexts involving information exchange between individuals who share the same interest. This learning process begins even before the production of meaningful utterances via the establishment of non-verbal communication skills: eye-contact, joint-attention, and turn-taking. Similarly, Vihman (2014) also supports Bruner's notion of the role the in joint attention and turn-taking in infants before any vocal communication is established. With respect to phonological development, recent empirical evidence suggests that input frequency of specific phonemes in child-directed speech and their phonotactic patterns do indeed influence the age at which children acquire speech sounds (e.g. Zamuner (2004), Tsurutani (2007)).

While each of the theoretical approaches above focusses on one aspect of development, the emergence approach espouses a comprehensive account of development incipient from the interaction between the physical, cognitive, and social systems as an essential component in building the child's phonological knowledge and complex coding capabilities for the ambient language. Most importantly, none of these systems are solely responsible for the phonological component of language. It is only through the integrative view based on the principles of the this approach that one can attempt to comprehensively understand child language and phonological acquisition (Davis and Bedore, 2013).

To summarize, in phonological theories and approaches different units have been considered to describe the acquisition of speech sounds whilst accounting for an innate component or a biological predisposition facilitating the process of learning to speak an ambient language. Although most of these approaches/theories provided a different explanation to the process of phonological acquisition, none draws a complete picture, and none is universally accepted. However, the clinical world has mainly adopted an approach that utilized features and segments. For ten years working as a paediatric Speech-Language-Therapist in Saudi Arabia, I repeatedly observed that children referred for speech and language assessment almost always had a history of delays in their physical, cognitive, or their social skills. Therefore, it is my conclusion to support the emergentist approach and the notion that phonological acquisition requires skills beyond the obvious verbal capabilities to include physical, cognitive, and social skills.

2.3. Factors influencing phonological development

In the previous section, phonological theories debated whether language is learned from a bottom-up direction (features to words, e.g. distinctive features theory) or a top-down (words to features, e.g. generative phonology) (Bergmann et al., 2017). Another key field of enquiry are the factors which have the greatest impact on phonological development. Although some theories concentrate on finding a single factor that best explains the processes of phonological development (e.g. physiological approach focus on articulation complexity, input based approach focus on the input frequency etc.), others implement a multi-factorial approach (e.g. the emergence approach). In the next few sections some key constructs posited as affecting acquisition across a number of theoretical approaches are discussed in detail: markedness, sonority and phonological saliency, articulation complexity, input frequency, functional load, and universal grammar.

2.3.1. Markedness

The term *markedness* surfaced following the concept of feature opposition in phonological theories first introduced by Trubetzkoy (1939/1969) and refined by Jakobson. Jakobson assigned markedness values based on adult speech and used it to predict developmental patterns in child phonology (Jakobson, 1968). He emphasized that unmarked segments should be acquired earlier, often substituting marked segments and encompassing greater assimilation power (i.e. marked segments will be assimilated to match the unmarked ones). The definition of markedness has evolved as it has been broadened by phonologists in the past decade to denote easier, less complex, more natural and more frequent segments while, traditionally, marked segments are thought to be more unnatural, difficult, complex and less frequent or absent in some languages.

In generative phonology, three main characteristics are used to define markedness of speech segments: frequency in adult speech across all natural languages (increased frequency leads to decreased markedness), diachronic changes (phonemes or segments that experience less variation over time are hypothesized to be stable and marked) and developmental acquisition patterns (unmarked phonemes/segments are expected to be acquired at younger age than marked ones) (Bernhardt and Stoel-Gammon, 1994). This view implies a general order of acquisition across all natural languages where the mastery of stops precedes fricatives, stops and fricatives precede affricates of same place of articulation, the acquisition of front-rounded vowels precede back-unrounded ones and voiceless obstruents precede their voiced counterparts (Bernhardt and Stemberger, 1998). However, normative studies do not always support the markedness principle. For example, in typically developing children, clicks and ejectives (typically classified as marked) in South African isiXhosa language have a greater assimilation power[3] (characteristically a property of unmarked sounds) (Stemberger, 1991). Studies which have attempted to test the proposed hierarchy empirically show mixed and contradicting results. Although the majority of children followed the expected path of favouring markedness constraints, findings are not sufficiently consistent to apply across children or across languages (Beers, 1995, Bernhardt, 1990). In Arabic, markedness constraints are often highlighted in the epenthesis of word-final clusters and violated by the creation of word-initial clusters via syncope in various Arabic dialects (Btoosh, 2006).

In the last decade, recent phonological theories linked the principle of markedness to the notion of universal grammar (UG), extending markedness to incorporate aspects of grammar. For example, in the Optimality Theory, unmarked components of the linguistic system are innate and do not need to be learned. In syllable shapes, for example, CV is recognized to be the preferred syllable structure in all languages and, thus, is considered to be unmarked. In contrast, CVC syllables or syllables with clusters are more complex and consequently considered to be marked (Bernhardt and Stoel-Gammon, 1994).

In an attempt to understand the underlying process of cluster reduction, Gnanadesikan discovered a link between sonority and markedness in a single-participant longitudinal study of her own daughter's speech over a period of seven months. Referring to markedness and UG, with syllable onsets comprising a single segment considered as unmarked and onsets with multiple segments (clusters) marked, Gnanadesikan looked for factors dictating the child's choice of retained segment in the output.

[3] Assimilation power refers to the ability/power of a consonant to trigger adjacent consonants to incur complete or partial assimilation.

Consistently, clusters were reduced to a single segment, of which the least sonorous segment was retained as the most sonorous one was deleted. Consequently, she concluded that sonority in relation to markedness of syllable structure was the determiner of which segment is retained in the output (Gnanadesikan, 2004). Thus, markedness may be the most influential factor in phonological acquisition, yet it can also be influenced by additional phonetic factors (discussed in the following sections).

2.3.2. Sonority and phonological saliency

In the Oxford English Dictionary, the English word *sonority* comes from either the French *sonorité* or the Latin *sonōritas* (Simpson and Weiner, 1989). In 1963, it was used to indicate the meaning of *shrillness* and *loudness*. The dictionary also defines the word *sonorous* as “giving out, or capable of giving out, a sound, especially of a deep or ringing character”.

Sonority, a word often used to explain phonological saliency, has never been adequately defined, especially not in its physical terms (Parker, 2002). Some linguists recognise its importance yet cannot define or quantify it (Clements, 1990, Kenstowicz, 1994, Dogil, 1992). Others associate it with a phenomenon of *strength* (Kawasaki-Fukumori, 1992), and on the other extreme, a few reject it as a useful construct, finding it confusing, ambiguous, and a ‘meaningless label’ (Ohala, 1974). However, the definition of *sonority* in linguistics (phonetics or phonology) has always been a heated topic of discussion. For decades, linguists have been interested in sonority of speech sounds and have attempted to investigate how it affected various linguistic elements, including syllables, phonotactic rules, prosodic features, cross-linguistic variations and diachronic sound changes. As a result, numerous sonority scales have been proposed. All scales appear to agree on obstruents being at the bottom of the scale as the least sonorous and vowels at the top of the scale as being most sonorous. Most of the disagreement occurs in the order of the sonorant consonants in between (Yavaş and Marecka, 2014).

For example, in 2002, Parker constructed a much more detailed sonority scale when compared to the universal sonority hierarchy (Figure 2.2). Parker classified low vowels as being the most sonorous, followed by mid-vowels and high vowels, then glides, rhotics, laterals, nasals, fricatives and finally plosives[4] as least sonorous (Figure 2.3). He also identified voiced fricatives and plosives as more sonorous than their voiceless counterparts. For example, /b/ and /v/ are more sonorous than their voiceless counterparts /p/ and /f/ respectively. Moreover, he gave a precise and reliable method of quantifying sonority through (1) intensity (acoustic property) and (2) intraoral pressure (aerodynamic property). Nevertheless, he acknowledged that sonority can be language-sensitive with some room for variability and that his scale may be accurately applied only to the English language (Parker, 2002).

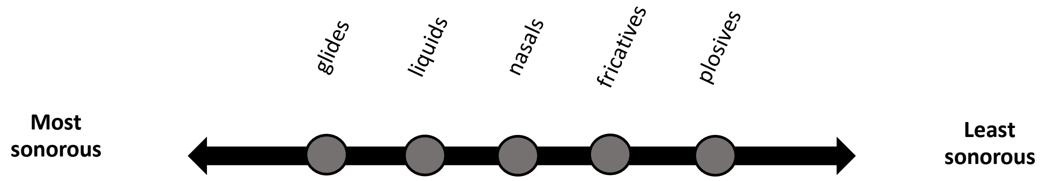

Figure 2.2. Universal sonority hierarchy.

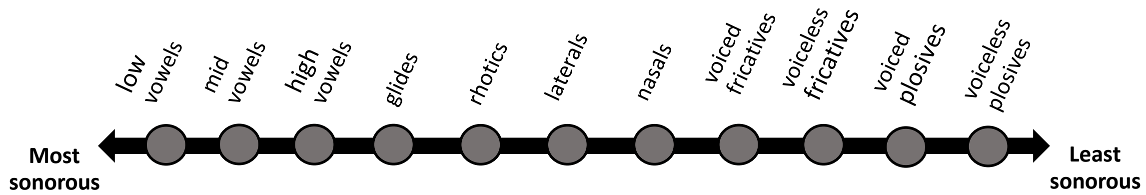

Figure 2.3. Sonority scale as proposed by Parker (2002).

In any syllable, according to the Sonority Sequencing Principle (SSP from hereafter), the nucleus comprises the highest sonority value. The sequence of segments preceding and following the vowel decline in sonority in either direction away from the nucleus. In essence, the sonority value of any syllable should look like a curve with the nucleus/vowel as its peak point (Yavaş and Marecka, 2014). The onset or coda of the syllable can either be simple with a single consonant or more complex with two or

[4] The term plosives is used interchangeably with Stops in this section to follow the terminology used by Parker (2002) in his proposed sonority scale in figure 2.3. above.

more consonants in a cluster, all depending on the phonotactics of the language. For example, in the English word *strand* ($C_1C_2C_3VC_1C_2$ structure), C_2 in the onset has a higher sonority value when compared to C_1, as does C_3 when compared to C_2, whilst the opposite is true in the coda ($C_1>C_2$). In other words, whichever consonants are closer to the nucleus will have higher sonority than the consonants further away.

In clinical practice, SLTs know babies start their vocal play with vowels followed by glides and nasals, which are the most sonorous in all sonority scales. However, normative phonological studies conducted on various languages find very little influence of sonority on the acquisition of singleton consonants. For example, there is a general agreement on acquisition order where front stops (bilabials and alveolars), although are the least sonorous, are mastered at a very early age before fricatives sharing the same place of articulation (Smit et al., 1990, Jimenez, 1987, Kilminster and Laird, 1978, Goldman and Fristoe, 1986, Fudala, 2000, Amayreh and Dyson, 2000).

Nevertheless, the sonority scale has proven to be much more useful in the acquisition of consonant clusters. Sonority difference between segments of a cluster is known to translate to their relative complexity (Yavaş and Marecka, 2014). The greater difference in sonority between segments, as in *tr*- in [tru: ħ] (she leaves), the easier the cluster, and therefore, it is classified as unmarked. On the contrary, clusters with smaller sonority difference, as in *ts*- in [tsa:fɪr] (she travels), are acquired later and are more marked. A few studies investigated the effects of sonority on consonant cluster acquisition (e.g. Davis and Bedore (2013), Alqattan (2014), Hua and Dodd (2000), Ingram and List (1987)). Although clusters that do not follow the SSP principle are rare, they do exist, therefore SSP must be considered as a general tendency rather than a fixed law (Yavaş and Marecka, 2014).

Additionally, the sonority index has been successfully used to predict the deleted elements in clusters when the cluster-reduction process is implemented by typically developing children during their early years. Typically, the least sonorous element in the cluster is preserved to maintain the maximum possible sonority difference with the nucleus (Yavaş and Marecka, 2014). For example, words like *black* and *broom* and often reduced to [bak] and [bum], where the plosive is retained, and the second consonant is omitted. One of the most investigated clusters in the literature is the /s/-cluster due to the overall greater number of combinations, as it forms two and three-element consonant clusters in many languages. In /s/-stop clusters, the /s/ is retained, which violates the SSP principle (Yavaş and Marecka, 2014); however, /s/-sonorant consonant clusters like *sm-, sn-, sl-* and *sw-* have conflicting results reported in the literature. Smith (1973) reported the retention of /s/ in such clusters, also violating SSP, whereas other studies reported the retention of the sonorous consonant and deletion of the /s/ (Gnanadesikan, 2004, Ohala, 1974).

Several studies have used the sonority index as a guide to phonological saliency to explore the chronological order of phonological acquisition within a given language and to compare and explore the rate of acquisition across languages (Alqattan, 2014). For example, Studdert-Kennedy et al. (1986) proposed that linguistic segments with higher phonologic saliency are perceived with more ease and, thus, are more likely to be imitated. However, perception of saliency has be hypothesized to vary from one child to the other, and that variability is based on the knowledge of their own vocal and motor systems (Vihman, 1993). This aligns with MacLeod's concept of cognitive saliency, which suggests that a stimulus standing out from the rest becomes more memorable (MacLeod, 2015). Yavaş (1998) also stated that phonological saliency is cognitive in nature and defines it as a skill that enables the child to classify linguistic segments based on their notability.

The term *phonological saliency* was of great interest following the OT's focus on perceptual constraints (Hua and Dodd, 2006, Dodd, 2000, Prince and Smolensky, 2008). MacLeod defined phonological saliency as the quality of a linguistic segment that holds a notion of awareness or prominence (MacLeod, 2015). As clear as MacLeod's definition first appears it has been difficult to reach consensus amongst linguists on its definition or method of quantification (Hickey, 2000, Hua and Dodd, 2006). However, some linguists have come to a partial agreement in their definitions of saliency in that it must include a perceptual prominence of a linguistic segment that makes it more perceptually notable (Kerswill and Williams, 2002, Siegel, 2010, Hickey, 2000). The main difference between phonological saliency and sonority is that sonority, in its index, accounts for both perceptual and articulatory parameters, whereas saliency accounts only for the former and not the latter (Yavaş and Marecka, 2014). Phonological saliency has often been conflated with markedness because of its similar effect on phonological acquisition.

Zhu (2000) suggested that, although phonological saliency of speech segments has general tendencies, it involves cross-linguistic variation, which results from the role of that particular segment within that phonological system of the language to which it belongs. Phonological saliency expressed in the sonority value of four syllables in Putonghua-speaking children corresponded to the order of their acquisition (Hua and Dodd, 2000). Additionally, the affricate [t͡ʃ] was found to be acquired sooner by Quiché-speaking children when compared to English-speaking children (Ingram and List, 1987). This difference was hypothesized to be due to greater saliency of [t͡ʃ] as opposed to [t] in Quiché than in English.

2.3.2.1. ***Sonority and phonological saliency influences in Arabic***

Phonological studies on the acquisition of the Arabic language seem to oppose the presumed order of voiced versus voiceless plosives acquisition that is based on Parker's sonority index scale. The principles of phonological saliency predict that voiced plosives are more salient and are expected to appear before their voiceless counterparts. However, in several dialects of Arabic, opposing findings were reported. For example, Ammar and Morsi (2006) found that voiceless Stops appear in the phonological inventory of typically developing Egyptian children before their voiced counterparts. Similar findings has been reported in Jordanian Arabic (Amayreh and Dyson, 2000). Additionally, in Kuwaiti Arabic, the same pattern was observed in voiced fricatives and affricated (Ayyad, 2011, Alqattan, 2014). These studies show a general tendency not to follow the developmental pattern suggested by phonological saliency, at least when it comes to order of acquisition based on voicing. It has also been observed that Arabic dialects generally tend to have more voiceless Stops and fricatives than voiced ones (see Table 2.3 for more details). Alqattan (2014) hypothesized that the advanced acquisition of the voiceless Arabic stops may be due to the fact that all voiced stops are pre-voiced and thus harder to produce.

Table 2.2.

Voiced and Voiceless Stops and Fricatives in Arabic Dialects

	Stops	**Fricatives**
voiced	[b], [d], [dˤ], and [g]	[ð], [ðˤ], [z], [zˤ], [ʒ][5], [ɣ], and [ʕ]
voiceless	[t], [tˤ], [k], [q], and [ʔ]	[f], [θ], [s], [sˤ], [ʃ], [x], [ħ], and [h]

2.3.3. Articulation complexity

In the majority of phonological theories, it has been assumed that ease of articulation plays a role in the order of sound acquisition. There is also an assumption that what is easy should be easy for everyone and in all natural languages. Still, there has been debate as to what defines *easy* (Bernhardt and Stemberger, 1998). These theories do not account for individual variation and practice in their definition of ease-of-articulation. Many studies have aimed to find a universal pattern in phonological acquisition (Goldman and Fristoe, 1986, Fudala, 2000, Shriberg, 1993, Smit et al., 1990, Jimenez, 1987, Kilminster and Laird, 1978, Hedrick et al., 1975, Sander, 1972, Templin, 1957, Amayreh and Dyson, 1998, Hua and Dodd, 2000). Within the acquisition of singleton segments, one must acknowledge there is a universal tendency in the order of acquisition, as first proposed by Jakobson (1968), suggesting that: stops are acquired first, followed by fricatives then affricates, front labials and alveolars are acquired before back velars and pharyngeal, and voiceless consonants are acquired before their voiced counterparts. In contrast, McLeod and Crowe (2018) in a systemic review of consonant acquisition studies of 27 languages including Arabic and English reported that in general consonants requiring an anterior tongue placement (dental, alveolar, post-alveolar, and retroflex) were acquired after consonants that required a posterior tongue placement (palatal, velar, and uvular).

As one would expect, articulation complexity of a segment is linked to its markedness and sonority levels too. Earlier, in sections 2.3.1 and 2.3.2, it has been noted that unmarked and more sonorous sounds are universally considered easier and are expected to be the first to be acquired. Yet, articulation complexity, according to the

[5] The affricate /d͡ʒ/ can also be realized as the fricative [ʒ] in some Levantine and North African Arabic dialects.

OT, travels beyond the physical and motor complexity of the segment itself into the syllable structure and word shape (Prince and Smolensky, 2008). For example, onsets, nuclei, and codas can incorporate more than a single element in the form of clusters and diphthongs, increasing their complexity.

In recent years, OT has introduced a modern instantiation of articulation complexity (Hayes, 1996). It posits that ease of articulation could vary amongst individuals and that this variability depends on experience and chance factors (Bernhardt and Stemberger, 1998). For unknown reasons, some tasks are easy to some individuals, while the same task can be more difficult for others. The OT attempts to explain this phenomenon by suggesting that the baseline ranking of constraints differs between individuals. Furthermore, it proposes that practice makes difficult elements easier, and easy but less-practiced items can remain difficult. It also suggests that practice with different elements, element combinations and sequences during the language learning process plays a significant role in the re-ranking of constraints. As languages normally differ in some of their elements, element combinations, and sequences, OT uses that fact to account for easy versus difficult variability amongst languages.

2.3.4. *Exposure and input frequency*

Typically, new-borns and babies spend the majority of their first two years of life with a small group of primary caregivers, it is through listening and exposure that those children learn their native language. The majority of more current theories of phonological development assume that the nature of exposure the child is subjected to may very well influence their speech and language development. Although the exact nature of influence of exposure varies between theories of speech and language acquisition.

Many studies aimed to define the nature, frequency and type of exposure that actually influences child language learning. Most studies in the literature focus on the relationship between input frequency of lexical items and vocabulary acquisition (e.g. Goodman et al. (2008), Schwartz and Terrell (1983), Cruttenden (1997), Ferguson and Farwell (1975), French and Local (1983), Grimshaw (1990)); however, the next paragraphs provide a summary of studies which focus on the acquisition of phonetic and phonological elements (Kirk and Demuth, 2003, Kuhl et al., 1997, Werker et al., 2012).

A study by Kirk and Demuth in 2003 revealed that children's acquisition pattern of English consonant clusters highly correlated with the consonant cluster distribution within the language. Since coda clusters are more frequent in English than onset clusters, many would assume coda clusters will also have a higher input frequency than onset clusters. Indeed, children were reported to have a tendency to acquire coda clusters before onset clusters (Kirk and Demuth, 2003). Also, they found that the first cluster to be acquired was the same type as the most frequent cluster in English (i.e., stop followed by s/z). Children's phonological processes have shown a generalised preference to the production of high-frequency type of clusters (stop + s/z) when compared to the opposite sequence (s/z + stop). As a result, they metathesized (stop + s/z) clusters into (s/z + stop) (Kirk and Demuth, 2003).

Frequency effects have also been documented cross-linguistically. For example, Roark and Demuth (2000) presented results demonstrating that children's early acquisition of phonological elements and syllable structure in both Spanish and English is associated with their frequency within that language. They also concluded that children acquired high-frequency syllable shapes sooner than lower-frequency syllable shapes. Levelt et al. (2000) had similar findings for Dutch-speaking children. They reported individual variations when the frequency of two comparable syllable structures was the same; however, higher-frequency syllables are also the least marked structures, thus their results did not account for markedness effect in the acquisition process. Kirk and Demuth (2003) hypothesized that learning may be particularly facilitated when frequency and markedness coincide.

A small number of small-scale studies have focused on the frequency of phonetic and phonologic elements measured from corpora of child-directed speech (CDS) and its relationship with acquisition order. For example, Tsurutani (2007) examined the frequency of /ʃ/, /t͡ʃ/, and /s/ in the CDS of six Japanese mothers and compared it to the order of acquisition of the same elements by their children. In the findings, Tsurutani reported that [s] was the least frequent and [ʃ] and [t͡ʃ] were the most frequent. The frequency of these three elements in CDS was reflected on the order of acquisition of the same elements by their children: [t͡ʃ] was acquired first and [ʃ] and [s] were the last to be acquired (Tsurutani, 2007). Tsurutani's results contradict the OT in that markedness constraints do not always outrank faithful constraints (i.e. that the child's production must resemble the input as closely as possible) (Prince and Smolensky, 2008, Tsurutani, 2007). Input frequency played a key role in empowering faithfulness constraints to out-rank markedness constraints, enabling the child to produce an affricate sooner than sister fricatives, irrespective of other factors like articulation complexity. Another small-scale study yielded opposing findings. Levelt and Van Oostendorp (2007) found that the distribution of word-initial consonants in Dutch-speaking mothers' CDS did not predict the order in which those elements were acquired. Finally, a third small-scale, yet longitudinal, study on two English-speaking participants, one male and one female toddlers, revealed that the female participant acquired unmarked but frequent codas (stops) sooner than marked ones, reliably corresponding to the frequency of coda-consonant in CDS. On the other hand, the male participant showed a different pattern of acquisition where marked but less frequent codas (nasals and fricatives) were acquired first. The studies above were conducted on a very small scale (six, six, and two participants, respectively) and were also conducted in different languages, thus the contradicting findings may be attributed to other contributing factors like articulation complexity, functional load and the phonotactic constraints of those languages or can simply result from learning style or individual differences (Alqattan, 2014, Stites et al., 2004).

Frequency in the literature often refers to how frequent a specific element occurs in the general population. Frequency measures had two categories: type frequency and token frequency. Token frequency refers to the total number of exposures to the same phonological element regardless of its phonological environment including repeated words. On the other hand, type frequency excludes repeated lexical items from the total count and only accounts for the number of exposures to the same phonologic element in different lexical items within the sample. In the literature, there has been a disagreement on which type of frequency has a greater effect on phonological acquisition. Although some studies found that child-directed type frequency is the most revealing measure predicting developmental speech patterns in children (Tissier, 2015), other studies suggested that token frequencies have more effect (Plunkett and

Marchman, 1989). In Arabic, Alqattan (2014) reported conflicting evidence to the role of type and token frequency in consonant acquisition that cannot be generalized across all consonants. Some consonants that are frequent in type were acquired later than those less frequent in type. Also, consonants with high token frequency, e.g. /ð/ were acquired very late.

2.3.5. Functional load

Functional load (FL) is a term that has been used by linguists for nearly 90 years, yet there is no clear, up-to-date definition for it nor an agreed method of quantifying it. It has been agreed that the FL of a phoneme is related to its worth/weight within a specific phonological system or language (Hua and Dodd, 2006). Nearly all previous research on FL focused on phoneme contrasts in minimal pairs as it was easier to define oppositions in a language via the absence of phoneme contrasts than its presence (Surendran and Niyogi, 2003). For example, the presence of contrastive phonemes in minimally paired words, e.g.: *van vs fan* has been thought to increase the FL of the phonemes involved. In 1995, Hockett proposed a mathematical equation that allows the computation of the functional load of opposition between two phonemes. His formula was based on the principle of information loss when the opposition between those phonemes is lost. In English, for example, minimal pairs like bat/cat, ball/call and bar/car would all sound the same if the contrast between [b] and [k] was lost. As the number of minimal pairs with such contrast increases, the amount of information decreases, which leads to higher functional load of those phonemes within that language.

It has been hypothesized that greater functional load is associated with earlier acquisition of contrastive phonemes. Several studies provide supporting evidence in favour of this hypothesis (Davis and Bedore, 2013, Howard, 2013, To et al., 2013, Amayreh and Dyson, 2000, Cataño et al., 2009, Ingram and List, 1987, So and Dodd, 1995). In Cantonese-speaking children, for example, the heavy functional load of /l/ in the onset position accounted for a much earlier age of acquisition (four years old) when compared to English-speaking children, whose earliest acquisition of the same phoneme is one year later (Smit et al., 1990, Davis and Bedore, 2013, Howard, 2013, To et al., 2013). Conversely, low functional load, also in Cantonese, has been associated with a slower rate of acquisition of most velars. Nevertheless, it is important to note that, in Cantonese, velars also have a low frequency of occurrence, which may have been a contributing factor. Ingram and List (1987) acknowledged that phonemes with a high occurrence do not necessarily carry more weight within the ambient language and gave the example of the English language where no significant effect on meaning occur when the interdental voiced fricative is substituted by the alveolar voiced plosive in words like this, that, those and them.

Other studies with contradicting or inconclusive results suggested that order of acquisition may result from more than a single factor. Taken together, a number of contributing factors such as input frequency, frequency of occurrence and articulation complexity together with FL can predict the order of acquisition, whilst if measured independently from one another they cannot (Amayreh, 2003, Stokes and Surendran, 2005).

2.3.6. Grammar

When grammar constraints in terms of phonological acquisition are discussed, the notion of universal grammar (UG) surely arises. UG makes specific predications about the path of phonological acquisition. A great deal of phonological research agrees that CV is the universal syllable shape, which can only consist of a simple onset and simple vowel. Some linguists even suggest that UG also provides children with the basics of building their first words by providing them with the minimal word shape CVCV (Fee, 1992, McCarthy and Prince, 1986). This theory could explain why the majority of children's first words are bi-syllabic (Archibald, 2014). This also suggests that coda consonants, consonant clusters in onset, or coda and complex nuclei (as in long vowels or diphthongs) will appear later in acquisition. Similarly, irrespective of the language, words containing more than two syllables are expected to be acquired at later stages. These suggested patterns of phonological acquisition governed by UG are well supported by several normative phonological studies (e.g. Fikkert (1994) Alqattan (2014)); although, one must admit that the full view of UG is incomplete without other contributing factors discussed above.

Now that the factors known to have an effect on the phonological development have been extensively explored, the next section focuses on investigating the effects of elicitation method as a factor that could possibly affect speech performance in children. The majority of normative phonological studies collected data using one of two elicitation methods: Single Word Assessment[6] (SWA from here after) or Spontaneous Speech Sampling[7] (SSS). Fewer studies chose different methods: non-words, delayed imitation, and story re-telling. The next section presents in detail the findings of studies that compared the effect of the two elicitation methods: SWA versus SSS. It is vital to note that the majority of these studies were conducted on English-speaking children with known speech/phonological difficulties thus their results may not be comparable to those of typically developing children.

[6] Also referred to as single word utterances/response/assessment, citing, labelling, or sound in words in the other studies.

[7] Equivalent to connected speech, conversational speech, talking, storytelling, picture description, or sound in sentence.

2.4. The effect of elicitation methods on speech performance

In 1970, two researchers were the first to compare errors in SWA vs. SSS in a single case study on an 11 year old child with severe articulation errors (Faircloth and Faircloth, 1970). The authors randomly selected 25 misarticulated words in the child's SSS and then asked to repeat those words in a carrier phrase. Only nine words were chosen for analysis: two mono-syllabic, five bi-syllabic, one tri-syllabic, and one quadri-syllabic. The child performed significantly better in SWA task and subsequently the authors concluded that SSS is their preferred method of assessment because it was more sensitive to detecting the child's speech errors.

A few years later, DuBois and Bernthal conducted another study that compared the performance of 18 children (12 males and six females) between the ages of 4;03 and 6;02 years in three different elicitation methods: SWA, SSS, and modelled spontaneous sample in a story re-telling task (DuBois and Bernthal, 1978). The authors limited their investigation to 10 speech sounds: /s/, /z/, /l/, /r/, /θ/, /f/, /v/, /ʃ/, /t͡ʃ/, and /t/ in 20 words. All participants were known to have some degree of disordered speech. The authors reported that their participants had more errors in the SSS task, fewer errors in the modelled speech task, and least amount of errors in SWA. They also concluded that errors in the SWA are an excellent indicator of errors in the SSS however SWA correct productions poorly predicted correct productions in the SSS task suggesting that SWA under-estimates a child's difficulties.

In a slightly larger study, Johnson et al. (1980) also compared SWA and SSS in 35 children (25 males and 10 females) with some degree of phonological impairment. The authors calculated the raw scores of three types of errors in both samples: omissions, substitutions, and distortion and reported the occurrence of higher number of errors in the SSS. However no statistical comparisons were made. The difference between the number of substitution and distortion errors in both samples are very close: (442) and (22) in SWA vs. (486) and (32) in SSS respectively. In contrast, the number of omission errors in the SSS (527) were much more frequent than in the SWA (323). However, they mainly relied on their conclusion that SSS is more sensitive at picking errors than SWA on the principle of error migration; i.e. 46% of SSS errors were produced correctly (35%) or as a different error type (11%) in SWA. As a result, the authors recommended the use of SWA for screening and SSS for assessment.

Moreover, Andrews and Fey (1986) compared the two elicitation methods on 14 children (12 males and 2 females) with moderate-to-severe phonological impairment testing word initial (WI) and word-final (WF) positions only. The SWA targets were elicited using 55 common household objects. The same targets were also elicited in a sentence for the SSS. None of the children named all 55 targets and the number of words successfully included in the analysis ranged between 25 and 52 words. In the results, the authors reported that 10 of the 14 children produced more errors in the SSS however with a small margin of difference. They also reported that some phonological errors only emerged in the SSS. As a result, the authors concluded that SWA are not sufficient for assessing phonological impairment.

Similar to Johnson et al. (1980), Healy and Madison (1987) also compared the occurrence of omission, substitution, and distortion errors in two elicitation methods: SWA vs. SSS. Although there was limited information about the SWA design and how the SSS elicited the same targets, the authors incorporated the word-medial (WM) position in addition to WI and WF positions in their analysis and reported the errors in a proportional percentage rather than in raw numbers. The authors also adopted the migration of errors method in their analysis where 20% of SSS errors were produced correctly in the SWA and 15% were produced as a different error type. Comparable to previous studies, their participants were mostly males (18) with only two female participants. At the end, the authors concluded that SSS had more errors than SWA especially in omissions and distortions however the percentages were marginally different which raises the concern if they were significantly different at all.

Two more recent studies by Morrison and Shriberg (1992) and Wolk and Meisler (1998) also comparing SWA and SSS expanded the types of phonological errors investigated beyond omissions, substitutions and distortions. Similar to previous studies, their participants were known to have speech/phonologic difficulties. The methodology used by Wolk and Meisler (1998) raise some concerns especially in the collection of the SSS. The authors recorded sessions were 1.5-2 hours long including a 20-30 minutes dedicated for the SSS. However, the authors only chose 162 words from the SSS for the analysis excluding short words; i.e. prepositions and conjunctions. Nonetheless, in both studies the children had higher Percent-Consonants-Correct (PCC) in the SSS when compared to SWA. Also in both studies, Cluster-Reduction (CR), consonant deletion, and syllable deletion were more common in connected speech. Also, Wolk and Meisler (1998) reported that stopping and assimilation occurred more in the SSS. In their findings, Morrison and Shriberg (1992) concluded that established sounds were more accurate in the SSS and emerging sounds were more accurate in the SWA task. Also, nasals, glides, and stops were more accurate in both samples when compared to liquids, fricatives, and affricates. Both studies concluded that SSS is most representative of the complexity of the language and that SWA do not provide either typical or optimal measure of speech performance. Likewise, Masterson et al. (2005) found that their 20 participants, who are phonologically impaired with a majority of males, also had higher PCC in the SSS. However, these results could have been affected by the fact that their SWA were specifically tailored for each child.

On the other hand, only two studies compared the performance of typically developing children in different elicitation methods. Kenney et al. (1984) compared three elicitation methods: SWA, story re-telling, and non-sense words in 30 typically developing children (15 males; 15 females). Although the authors found no significant difference between all conditions for the type and number of errors yet they reported that females were more likely to produce omission errors whilst males had more substitution errors. On the negative side, Kenney et al. (1984) had a rather narrow age range and targeted relatively older children; i.e. 4;04-4;08 years. They also limited their investigation to the accurate production to eight speech sounds: /t/, /k/, /l/, /s/, /f/, /r/, /ʃ/, and /t͡ʃ/. These limitations, in addition to the small sample size, prevent the generalization of their findings. Finally, in a more recent study on typically developing Saudi children aged 3;06-4;11, it was found that older children were more accurate in the SSS. Moreover, the study also incorporated a single case study of phonologically impaired child for comparison. This child performed better in SWA than in connected speech although very little difference was reported between her and her typically developing peers in terms of consonant acquisition (Bahakeem, 2016).

In conclusion, current evidence would suggest that phonologically impaired children tend to perform better in SWA and have more errors in connected speech. On the other hand, the effect of elicitation method on the speech performance of typically developing children may not be significant (Kenney et al., 1984) or even reversed (Bahakeem, 2016). These findings must be considered with caution however due to a number of methodological inconsistencies and weaknesses.

All of the above-mentioned studies were conducted on a small number of children: less than 35 participants except for Morrison and Shriberg who recruited 61 participants. Moreover, all participants were not typically developing and groups were not gender balanced, thus the results could have reflected gender-related differences too. Additionally, the SWA used varied significantly from a standardized articulation test to a task that is especially tailored to the participants and included a wide range of targets: between 9 and 162 words. Similarly, some studies focused on WI and WF positions, others included medial consonants in the analysis whilst other were restricted to specific speech sounds. This variation in the methodological approaches in the study of phonology is neither new nor surprising, yet it makes the generalization of the results much more difficult. Even so, based on the results of the studies reviewed in section 2.4 above, traditionally SLTs start therapy with short (as in number of syllables) and single (as in number of words) training targets and gradually increase the difficulty by increasing the number of syllables or words in the target (Hegarty et al., 2018).This is done because longer words and complex sentences resembling those of a SSS are known to be the most challenging to children with SSD.

Chapter 3. Phonological Processes in Adults and Children: a closer look into normative studies

As an introduction to the main aim of this chapter, the current study is contextualised through a description of the Arabic language and the Najdi dialect spoken in Saudi Arabia. Then, phonological processes naturally occuring in the connected speech of adults and phonological errors produced by children as they learn to match their productions to the adult form in their ambient language are explored with specific reference to Arabic. However, the bulk of this chapter was dedicated to reviewing the literature for normative studies in Arabic, English and other languages.

3.1. Arabic, Najdi Arabic, and Saudi Arabia

Arabic is one of six official languages of the united Nations and has been repeatedly ranked one of top 10 languages most spoken in the world with more than 230 million native speakers with an approximation of an additional 100 million speakers world-wide who speak some form of Arabic (Campbell and King, 2013, Katzner, 2002). Arabic is the primary language in more than 26 countries in the Middle-East and North Africa (Al-Buainain et al., 2012). Although Standard Arabic (SA), or in other terms "Classical Arabic" is one of the official languages in most of those countries, it is no one's native language (Khattab and McLeod, 2007). However, Modern Standard Arabic (MSA), a more modern version of SA that is syntactically, morphologically, and phonologically derived from SA , is what researchers presently consider as the only acceptable form of Arabic for all native speakers (Abushariah et al., 2016). Additionally, each Arabic speaking country has its regional colloquial/dialectal version of Arabic. Larger countries, such as Saudi Arabia and Iraq, even have multiple dialects that can be considerably different from each other at phonologic, morphologic, syntactic and lexical levels (Watson and Scukanec, 1997). Unlike North-African Arabic dialects, Gulf Arabic dialects including the Najdi dialect are considered the most conservative of all Arabic dialects in that it remains faithful to most of the grammatical and lexical features of standard Arabic (Campbell and King, 2013). Because MSA is restricted to formal communications, education, media, and religious events and purposes, children are not typically exposed to it in their early years. Normally, their first encounter with MSA is at school or through children's television shows. Moreover, Muslim citizens of some none-Arab Islamic countries in Asia (e.g. Malaysia, Indonesia, and Pakistan) are encouraged to have some basic SA language skills for religious purposes. Although most Asian Muslims do not speak Arabic fluently, they are often taught to read it at a young age to be able to access the holy book of Qur'an.

Qaseemi, Haili, and Riyadhi are the major three sub-dialects of Najdi Arabic (NA) spoken in the central region of Saudi Arabia. Those sub-dialects have always been in close contact with each other for obvious geographical reasons (see Figure 3.1 below). Furthermore, rapid urbanisation of Saudi Arabia, a country that is less than 100 years old, many non-Arabs and non-Najdi Saudies relocated to the Capital city of Riyadh 'The Heart of Najd' for higher education, work, business, or even seeking medical treatment in the major hospitals.

Figure 3.1: Saudi Arabia's political map defining all 13 Provinces

Furthermore, foreign language learning 'English' has been strongly enforced by the Saudi government and was mandatory in the national curriculum starting at year 10, then at year 7, and most recently at year 4. Just like in most Arab countries, Saudies associate the learning/the use of a foreign language as a sign of upper-class labelling that is sought by most especially as it has been linked to better educational and employment prospects. For those reasons and for the past 30 years, private schools competed by offering foreign language curriculums in English, French and Spanish for children as young as three years old. Over the years, cross-dialect and even cross-language influences lead to various alterations in speech sounds and loan words in the presently spoken Najdi dialect. All of those factors played a dynamic role in the creation of a modified version of the Najdi dialect emerging gradually over the past few decades. For the purpose of this study, the primary focus will be on the phonological acquisition of the Najdi dialect as a whole whilst acknowledging that sub-dialects exist, these differences are not the key objectives of the study.

3.2. Najdi Arabic phonology

Arabic phonology may appear complex for a non-native speaker as it contains speech sounds that are unique to Arabic. These sounds are often characterised by an increased articulatory complexity, especially in pharyngeal fricatives and emphatics. Although SA has a 28-consonants in its alphabet, phonologically NA has 35 consonantal phonemes. Table 3.1 below presents the phonemic inventory of the Najdi dialect using the International Phonetic Alphabet (IPA) (Ingham, 1994, Alqattan, 2014, Al-Buainain et al., 2012, Ayyad et al., 2016).

Table 3.1.

Najdi Arabic Phonemic Inventory

Manner of Articulation	Bilabial	Labiodental	Interdental	Alveolar	Post-	Palatal	Velar	Uvular	Pharyngeal	Glottal
	Place of Articulation									
Stops:										
Voiceless				t			k	q		ʔ
Voiced	b			d			g			
Voiceless Emphatic				tˤ						
Voiced Emphatic				dˤ						
Nasals	m			n			ŋ			
Trill				r						
Tap or flap				ɾ						
Fricatives:										
Voiceless		f	θ	s	ʃ		x		ħ	h
Voiced			ð	z			ɣ		ʕ	
Voiceless Emphatic				sˤ						
Voiced Emphatic			ðˤ							
Affricates:										
Voiceless				t͡s	t͡ʃ					
Voiced					d͡ʒ					
Approximant	w			ɹ		j				
Lateral Approximant										
Voiced				l						
Voiced Emphatic				lˤ						

/ dˤ/ is not typically found in the Najdi dialect, however it is used when reading or speaking in formal setting.

Dialects, for many different reasons, may slightly differ and have increased or reduced number of phonemes in their inventories. Reason for this deviation include accounting for the emphatics in that dialect, or redistribution or neutralization of contrasts (Badawi et al., 2013, Khattab and McLeod, 2007). For example, /zˤ/ is heavily present in both Lebanese and Egyptian Arabic but does not exist in the Najdi dialect. Additionally, /dˤ/ is almost always realised as [ðˤ] and although [q] and [g] are allophones of /q/ in Najdi Arabic, they are governed by sociolinguistic and lexical variation which determines their occurrence. Contrastively, /q/ has different allophones in other Arabic dialects: voiced-velar-fricative, [ɣ], in Eastern Saudi, Kuwaiti, and Bahraini dialects and voiceless-glottal-plosive [ʔ] in Egyptian and Lebanese dialects (Feghali, 2004).

In addition, as SA does not allow onset clusters and has very limited coda clusters that are exclusively found in monosyllabic words e.g.: /kalb/ ‘dog’ and /xubz/ ‘bread’, various Saudi dialects use suffix coda clusters that are distinct from one another as dialectal markers distinguishing Eastern, Southern, and Central region dialects. For example, saying [ʃaʕrɪt͡s] vs [ʃaʕrɪt͡ʃ] “your hair-feminine” can easily enable your listener identify your dialect. While /-t͡ʃ / is widely used in the Saudi Eastern dialects, /-t͡s/ is restricted to the Qasimi Dialect. Moreover, Syncope: a phonological process of vowel omission, often allows the creation of onset clusters in Saudi dialects, e.g.: [tħalɪb] ‘to milk a mammal’ and [ʕju:n] ‘eyes’ as opposed to non-permissible onset clusters in SA: /ˈtaħ.lɪb/ and /ʕu.ˈju:n/. Although this study is not directly investigating vowels in Najdi Arabic, the lack of empirical studies available on the vowels of Saudi Arabic or more precisely the Najdi dialect is hard to miss. Available literature focuses on SA having short and long versions of three vowels: /a/, /i/ and /u/ with short vowels expressed in writing only as diacritics (Salameh and Abu-Melhim, 2014). What we know for sure is that dialects of Arabic realise more than just those three vowels (Khattab and McLeod, 2007, Shahin, 1996).

3.3. Phonological process versus phonological development

Before phonological development and errors in child language are discussed, it is essential to explore the naturally existing phonological processes in adult speech in order to distinguish between developmental patterns and errors from those which are acceptable. The implications of connected speech on speech sound production have been under scientific investigation for decades (Dell, 1990, MacKay and James, 2004, Poulisse, 1999, Farnetani and Recasens, 1997). In the following section, the phonological rules and operations of continuous speech in adult speech are described whilst giving examples in various languages while exploring whether the same operations exist in Arabic dialects. In section 3.3.1. the most common phonological processes in adult speech are discussed followed by what the researcher, as a native speaker, considers as processes that are unique to Arabic in section 3.3.2.

3.3.1. Continuous speech processes in adult speech

- *Assimilation*: this process typically refers to the transfer of features between adjacent sounds. The logic behind this process states that: the less distinct the adjacent sounds are, the easier their production would be (Davenport et al., 2010). A few types of assimilation can be identified in adult speech, yet the most common types are nasal and place assimilation. Many assimilation processes are subtle and would rarely affect how an average listener perceives the uttered word, i.e.: place assimilation of /n/ in the English word: ‘include’ [ɪŋkluːd] and in the Arabic word: ‘revolution’ [ɪŋqɪlaːb]. Additionally, some assimilation processes in Arabic are compulsory and taught. For example, Iqlab is a term used in tajweed: the rules of reading the Holy Book of Qur’an. In Arabic, Iglab refers to the change of status or transformation. Iqlab can be considered one form of place assimilation that is limited to the phoneme [n] and has very stringent rules. What this states is that /n/ is realized as [m] every time it is followed by [b] in the following contexts:
    - [n] and [b] are in a SFWF cluster (example-1)
    - [n] in SFWF followed by [b] at SIWI (example-2)
    - [n] in SFWW followed by [b] at SIWW (example-3)

Table 3.2.

Examples of place assimilation of /n/ in Arabic

No.	Target	Realization	Meaning	Source
1	/d͡ʒanb/	[d͡ʒamb]	Beside/next to	Najdi Arabic
2	/mɪn baʕd/	[mɪmbaʕd]	Then after	Qur'an
3	/ʔan.ba:ʔ/	[ʔʌmba:ʔ]	News	Standard Arabic

- *Deletion or Omission*: Deletion describes the process when a sound or an element in the target word is missing in the output. Alterations, (e.g. assimilation), are preferred over omissions in adult speech. Omissions occur most frequently in word-final consonant clusters amongst English speakers (Davenport et al., 2010). Another type of deletion that occurs in a word-initial position in Arabic is Syncope: a process that results in the creation of word-initial clusters via the omission of the vowel of the first syllable. Consequently, a single syllable word is created. This type of process appears in several languages and frequently violates the permissible phonotactic possibilities where it leads to the formation of consonant combinations that are typically not allowed (Ibrahim, 2016). Table 3.3 below lists a few examples of deletion in English and various Arabic dialects.

Table 3.3.

Deletion/omission Examples in Adult Speech

Target Word	Realization	Meaning	Language/dialect
/d͡ʒʌmpt/	[d͡ʒʌmt]	Jumped	English
/kɪta:b/	[kta:b]	Book	Jordanian Arabic
/ħɪ.sˤa:n/	[ħsˤa:n]	Horse	Najdi Arabic
/xa.ɾu:f/	[xɾu:f]	Sheep	Libyan Arabic

- *Insertion:* insertion is a reverse process to deletion. When a vowel is inserted, commonly a schwa /ə/, this process is then called epenthesis. But insertion can involve any vowel e.g.: /æ/ in Persian, /u/ in Japanese, /i/ in Brazilian Portuguese, and /ɯ/ in Korean) to simplify coda clusters (Davenport et al., 2010). While the inserted segment is typically a vowel, consonants can also be inserted, see examples in Table 3.4 below for consonant and vowel insertions.

Table 3.4.

Insertion Examples in Adult Speech

Inserted segment	Target Word	Realization	Meaning	Language/dialect
Consonant	/hæmstər/	[hɛəmpstɚ]	Hamster	English
Vowel	/brādar/	[barādar]	Brother	Persian
	/kalb/	[ka.lɪb]	Dog	Lebanese Arabic
	/xubz/	[xu.buz]	Bread	Arabic: various dialects

- *Metathesis:* Although is not as common as deletion and insertion, historically it has formed many modern English words as it did in Arabic (Davenport et al., 2010, Hogg, 1977). Metathesis refers to the reversal of the order of speech sounds typically within the same word. Such metathesized utterances are considered correct and result from dialectal variation of the same expression (see Table 3.5 for examples).

Table 3.5.

Metathesis Examples in Adult Speech

Target Word	Realization	Meaning	Language/dialect
/zwa: d͡ʒ/	[d͡ʒwa:z]	Wedding	Hijazi Arabic*
/maxʃ/	[maʃx]	A scratch	Najdi-Riyadhi Arabic
/gəmbros/	[grəmbos]	Son-in-law	South Italian Greek**
/pat.təɹn/	[pat.ɹ̥ən]	Pattern	Scottish English***

*Hijazi Arabic is spoken in the western province of Saudi Arabia. **(Blevins and Garrett, 2004). *** (Davenport et al., 2010)

- *Final consonant devoicing:* In adult speech, this process involves only the voicing quality being stripped from the target consonant rather than replacing it with its voiceless counterpart. The latter being the extreme version of final consonant devoicing often considered as a substitution error in children's speech. Generally, in English, partial devoicing occurs most frequently than complete devoicing with the exception of West Yorkshire dialects and while final consonant devoicing is restricted to stops in Danish and German it is extend to fricatives in Arabic (Davenport et al., 2010).

Table 3.6.

Final Consonant Devoicing Examples in Adult Speech

Target Word	Realization	Meaning	Language/dialect
/galˤb/	[galˤb̥]	Heart	Najdi Arabic
/d͡ʒəd/	[d͡ʒəd̥]	Grandfather	Najdi Arabic
/ʔa.xað/	[ʔa.xað̥]	He took	Standard Arabic
/dɔg/	[dɔg̊]	Dog	English

3.3.2. Continuous speech processes unique to Arabic speakers

Empirical research regarding speech processes in Arabic is sparse but as a native speaker and a trained speech pathologist, the researcher is well placed to reflect on her observations to provide some insight into ‘normal’ process found in connected adult speech that is unique to the Arabic language. All examples provided are restricted to SA or its Saudi dialects. Although similar processes may exist in other languages, no claims are made that these observations can be generalised to other Arabic dialects.

Pharyngeal assimilation is a unique type of assimilation often found in adult speech of Arabic speaking individuals and is commonly known as ‘emphasis spread’ (Davis, 1995). Emphasis spread is well-defined in the literature and refers to the process by which one the neighbouring sounds, vowels or consonants, of an emphatic consonant can gain a secondary place of articulation and become emphasised (Davis, 1995, Shahin, 1996). Emphasis spread has been studied in various Arabic dialects: Jordanian, Iraqi, Palestine, Yemeni, Qatari and Saudi-Southern Abha (Davis, 1995, Jongman et al., 2011, Lehn, 1963, Watson, 1999, Younes, 1993). In the literature, there has been no consensus on the boundaries and the directionality of how the emphasis spreads but it is understood that it varies across dialects (Jongman et al., 2011). Most of these studies established that emphasis rarely spreads beyond the adjacent vowel and into the entire word (Ali and Daniloff, 1972, Younes, 1993). However, other studies concluded that emphasis can spread to the whole word and sometimes even beyond word boundaries (Bukshaisha, 1985). In Table 3.7. below, some examples are provided to show how emphasis spreads beyond the adjacent vowels and into consonants within the same the word, mostly in a leftward direction in both SA and NA.

Table 3.7.

Emphasis Spread Examples in Adult Speech

Target Word	**Realization**	**Meaning**	**Source**
/jab.sutˤ/	[jab.sˤutˤ]	Flattens	Qur'anic Arabic
/mɪs.tˤɑra/	[mɪsˤ.tˤɑra]	Ruler	Standard and Najdi Arabic
/satˤɪr/	[sˤɑtˤɪr]	Line	
/wɑsɑtˤ/	[wʌsˤtˤ]	In the middle	

Furthermore, although not evident in the literature, the researcher has noted that in some Arabic dialects pharyngealization can occur even without the presence of a neighbouring emphatic consonant. In such cases, the addition of emphasis can be considered as dialect-specific: /saj.ja:ɾa/ → [sˤaj.ja:ɾa] for 'car' and /sab.bu:ɾa/ → [sˤab.bu:ɾa] 'chalkboard' in Hejazi and Najdi dialects respectively.

Although adults simplify their production in connected speech, such simplifications are not considered as an erroneous production and make the same types of simplifications consistently. On the other hand, phonological errors in children's speech are often decreasing over-time until their speech eventually matches the adult target form during their phonological development journey. In section 3.4. below, an overview of the most common phonological processes in children is presented.

3.4. Phonological processes/errors in children

It is suggested by many researchers that there are a number of universal patterns in the manner in which, children systematically simplify adult speech to match their capabilities. Those error patterns are likely to be shared with most children irrespective of the language they speak (McIntosh and Dodd, 2008). On the other hand, inconsistencies across languages and typically developing children suggest that phonological errors can be either common across languages, language and dialect-specific, or child-specific. Ingram (1976) believed that children learned those systematic rules on their own and outgrew them gradually in specific time frames.

> *"as the child gets away from the peculiarities of his individual little language, his speech becomes more regular, and a linguist can in many cases see reasons for his distortions of normal words. When he replaces one sound by another, there is always some common element in the formation of two sounds… there is generally a certain system in the sound substitution for children, in many instances, we are justified in speaking of strictly observed sound-laws."* (Ingram, 1986, p. 223)

The systematic rules described in the earliest phonological studies in the 1970's are now known as phonological processes. In the following sections, a detailed description of each process is provided along with cross-linguistic examples.

3.4.1. Reduplication

Reduplication is one of the first documented patterns evident in child's speech especially in the first year of life that may well extend into their second year to help them form most of their first true words. Reduplication often is a method to simplify complex words into much simpler patterns that fall within child's capabilities. It is common to see reduplication mostly applied to utterances with more than one syllable as one could argue that single syllable words are simple enough to start with. Linguists and researchers have discriminated between two types of this pattern: complete and partial reduplication. Complete duplication often refers to the repetition of the initial simple CV syllable of the target utterance. On the other hand, a partial reduplication may refer to a duplication of a single sound or a whole syllable in the target utterance. For example, the name 'Noura' is often produced by very young children as /nunu/. Strikingly, reduplication occurs universally in any language whether the language itself has that feature in the structure of its words or not. Most observable examples are child production of [mama] for: mother, mum, mummy, mom or /ʔummɪ/ in Arabic and [dada] or [baba] for: dad, daddy, father or /ʔabuːj/ in Arabic. One could also argue that those early lexical forms suggest biological rather than environmental influences on the process since most duplicated syllables are primarily constructed around universally early acquired consonants.

3.4.2. Deletion

Deletion refers to the omission of single or multiple elements of a target word thought to make it simpler, shorter and easier for the child to produce. The element deleted can be a singleton consonant or a syllable. Most common type of deletion is singleton deletion which can occur in all word positions but most commonly found at word boundaries and in consonants more than vowels. Table 3.8 lists a few examples of deletion processes with subtype descriptions.

Table 3.8.

Deletion Examples in English and Najdi Arabic

Language	Target	Realization	Meaning	Deletion sub-type
English	/ʃuː/	[uː]	Shoes	Initial consonant deletion
	/bɑ.ˈnɑ.nə/	[ˈnɑ.nə]	Banana	Weak syllable deletion
	/stɔp/	[tɔp]	Stop	Initial cluster reduction
Najdi Arabic	/kalb/	[kab]	Dog	Final cluster reduction
	/tˤa˥ħ/	[tˤa˥]	Fallen	Final consonant deletion
	/ħɪ.ˈsˤɑːn/	[ˈsˤɑːn]	Horse	Weak syllable deletion

3.4.3. ***Substitution and Assimilation***

This phonological process refers to changing a single element of the target word by another. Very often substitutions are triggered by an assimilation process which is then called consonant harmony. Table 3.9 shows the different type of assimilation processes which fall into different types of harmony.

Table 3.9.

Examples of Assimilation Processes

Target	**Realization**	**Meaning**	**Assimilation**	**Type of harmony/Error**
/dɔg/	[gɔg]	Dog	/d/ → [g]	Dorsal harmony/Backing
/tʌb/	[bʌb]	Tub	/t/ → [b]	Labial harmony/Fronting
/bæt/	[dæt]	Bat	/b/ → [d]	Coronal harmony/Backing
/biːnz/	[miːnz]	Beans	/b/ → [m]	Nasal harmony
/ˈlɒːɹɪ/	[ˈlɒːlɪ]	Lorry	/ɹ/ → [l]	Lateral harmony/Lateralization

Generally, assimilation/substitution errors can be described as the change of one or more features (place, manner or voicing and in Arabic pharygealization) of an element in the target word to make production easier. Assimilation and substitution errors reflect the development of the child's phonological representations but can also be linguistically driven. The section below provides definitions and examples of all phonological errors investigated in the current study:

3.4.3.1. *Changes in voicing*

a. **Voicing** reffers to adding voicing quality to an unvoiced element in the target word. Example: /ˈsɪt.tah/ 'six' → [ˈsɪd.dah].
b. **Devoicing** errors occur when a child strips the voicing quality from a voiced element in the target word. Devoicing is typically found in word-final position and is rarely present in word-initial position. Example: /dubː/ 'bear' → [dub̥ː].

3.4.3.2. *Changes in the place of articulation*

a. **Fronting** occurs when the place of articulation of an element is fronted; i.e. place of articulation moved forward within the vocal tract. For example, palatal to alveolar or most commonly velar to alveolar. Typically fronting does not affect voicing of that element. For example, /k/ → [t] in 'kiss' or 'cat'. In Arabic, alveolars can also be slightly fronted into an interdental element as in /ruz/ → [ruð] 'rice'.

b. **Backing** occurs when a labial/coronal element is produced at a more posterior position in the vocal tract to become a dorsal element or more subtly when a labial element is transformed into its coronal counterpart. Changes in place of articulation can be obvious as in /s/ → [h] in [həʊp] for 'soap' or subtle as in /θ/ → [s] in [mu.ˈsal.las] for /mu.ˈθal.laθ/ 'triangle' in Arabic. Although the latter example can be considered typical in the Egyptian dialect, it is not so when produced by a Saudi child speaking the Najdi dialect which has a resilient presence of [θ] in its phonemic inventory and where /θ/ and /s/ are never considered as allphones.

c. **Glottalization** is an extreme form of backing and refers to the replacement of any consonant by a glottal one: /ʔ/ or /h/.

3.4.3.3. *Changes in the manner of the articulation*

a. **Fricative Stopping** involves changes to the manner of articulation of fricatives from continuous to stopped. Usually stopping is not restricted to a single position within a word or syllable and also can occur multiple times within the same word (Table 2.12).

Table 3.10.

Examples of Fricative Stopping

Type	**Target**	**Realization**	**Meaning**	**Language**
Onset Stopping	/sɔk/	[tɔk]	sock	English
Coda stopping	/fʌʃ˥/	[fʌt˥]	To deflate	Najdi Arabic
Multiple stopping	/ðɪs/	/dɪt/	This	English

b. **Deaffrication:** In this process, the child removes the stop element in an affricate sound and keeps the fricative element intacted. Two very common examples in English are: chip /t͡ʃɪpʰ/ → [ʃɪpʰ] and cheese /t͡ʃiːz/→ [ʃiːz]

c. **Liquid Gliding or Vocalization:** In this process glides: /r/, /ɹ/, or /l/ are realized as [j] or [w], or replaced by a vowel (Vihman, 1996). As gliding can be commonly found as a normal process in connected adult speech cross-linguistically, it is governed by different rules in child speech where only prevocalic liquids are glided (Johnson and Reimers, 2010).

d. **Lateralization:** This process is almost exclusively limited to the substitution of the trill /r/ or the tap /ɾ/ by the lateral /l/.

3.4.4. De-emphasis:

De-emphasis is an error type that is unique to languages with emphatic consonants where it refers the to removal of the secondary pharyngeal place of articulation to replace the emphatic consonant with its non-emphatic equivalent. Table 3.11 below lists some de-emphasis examples from the Arabic language.

Table 3.11.

Examples of De-emphasis

Target	Realization	Change	Meaning
/tˤɑːħ/	[taːh]	/tˤ/ → [t]	Fallen down
/mɑsˤː/	[mɑsː]	/sˤ/→ [s]	sucked
/ðˤɑbː/	[ðabː]	/ðˤ/→[ð]	lizard

3.4.5. Errors in the production of consonant clusters

There are two types of consonants clusters: tauto-syllabic clusters, i.e. consonant clusters with both consonants in the same syllable and hetro-syllabic clusters, i.e. two adjacent singleton consonants separated by a syllable boundary. WF tauto-syllabic clusters are the only type of clusters permissible in MSA. However, in many Arabic dialects including the Najdi Arabic, word-initial clusters are formed as a result of syncope[8]. In this study, syncope is defined as the omission of the vowel in the first CV-syllable to consequently create a WI cluster. The examples below illustrate the phonological process of syncope resulting in word-initial consonant cluster formation in Najdi Arabic.

[8] Syncope is defined as the omission or deletion of sounds or letters from within a word.

MSA	**Najdi Arabic**	**Meaning**
/ħɪˈsˤɑːn/	[ˈħsˤɑːn]	horse
/ˈrakabatʰ/	[ˈrkubatʰ]	She rode
/ʔɪʃˈtaratʰ/	[ˈʃtaratʰ]	She bought

In contrast, epenthesis is defined as the insertion of sounds or letters within a word. In the current study, epenthesis is defined as the insertion of a vowel in the syllable comprising a consonant cluster to consequently split the syllable into two syllables with a single element of the cluster in each syllable. WI clusters are purely dialectal in NA and are a result of syncope in adult speech. However, when a NA-speaking child epenthesizes a WI cluster, it is not considered as an erroneous production if the outcome is identical to the MSA form of the target word. Such cases are considered acceptable epenthesis. However, word-final clusters in NA do not differ in from their MSA form and epenthesis in these cases are considered as an error. Table 3.12 below, illustrates examples of acceptable and error type epenthesis in Najdi Arabic.

Table 3.12.

Examples of Acceptable and Error Epenthesis in Consonant Cluster Production.

Cluster Position	Target	Actual	Meaning	Verdict
Word-Initial	/ˈħma:r/	[ħɪˈma:r]	Donkey	Acceptable
		[ʔɪħˈma:r]	Donkey	Error
Word-Final	/kalb/	[kalɪb]*	Dog	Error
		[kalbɪ]**	My dog	Acceptable

*Epenthesis of this type is acceptable in other Arabic dialects: e.g. Lebanese and Iraqi.
**Epenthesis of this cluster resulted in unintended change of meaning of the target word.

The current study focuses on two types of errors in the production of consonant clusters: Cluster Reduction (CR) and Cluster Epenthesis (CE). CR in the current study refers to the omission of one of the two elements comprising Najdi Arabic clusters in either WI or WF positions. Table 3.13 lists below a few examples in Arabic and English of CR and CE errors.

Table 3.13.

Examples of Errors in the production of consonant clusters.

Target	Realization	Meaning	Language	Error type
/pleɪt/	[pʌleɪt]	plate	English	word-initial cluster epenthesis
/galb/	[galɪb]	heart	Arabic	word-final cluster epenthesis
/kalb/	[kab]	dog	Arabic	word-final cluster reduction
/stɹiːm/	[tiːm]	stream	English	word-initial cluster reduction

3.4.6. Metathesis

As explained in section 3.3.1, methathesis refers to the reversed order of two elements usually within the same word (Table 3.14). Very often metathesis can exist in adult speech and not considered as an error. However, metathesis errors are rare and evident in younger children and is one of the earliest processes to fade away.

Table 3.14.

Examples of Methathesis

Target	Realization	Meaning	Language
/ˈxub.za/	[ˈxuz.ba]	Piece of bread	Najdi Arabic
/mu.lu.ˈxɪj.ja/	[mu.xu.ˈlɪj.ja]	Egyptian food	Egyptian Arabic
/spə.ˈgɛ.tːi/	[pəs.ˈgɛ.tːi]	Spaghetti	English

3.5. The History of Studies of Child Phonological Development

The earliest documented phonological studies in the 1930's and 1960's were mainly case studies based on the analysis of parental diary records focusing on a single child's early vocal skills and words. These included German, English and Slovenian children aged 0;10-2;00 years (Leopold, 1970, Velten, 1943, Vihman, 2014). Since the 1960's, the number of studies of child phonological development quadrupled and continued to rise gradually until the 1990's. However, most studies continued to be based on single cases with a few comprised of small groups of six or eight children. Moreover, almost 60% of those studies relied on parental diaries rather than researchers' observation (Vihman, 2014). Single case and small group studies continued to be the preferred method by researchers until 2016. In table 3.15 below, which accumulates phonological development single case and small group studies since the late 1960s, it is apparent that there is a gradual increase in the number of participants and studies until 2016. While those single case studies in the 20th century focused on individual differences, larger studies in the 21th century conducted in several languages (with 10 or more participants) have provided deeper understanding of universal milestones and often posed quite a few challenges to developmental phonological theories in French, Greek, Finnish, Italian, Spanish, and several African languages (e.g. Vihman (2014), Maphalala et al. (2014), Gangji et al. (2015), May Bernhardt et al. (2015), Mahura and Pascoe (2016), Petinou and Theodorou (2016)). It is also noteworthy that the majority of researchers have focused their attention on studying phonological development in children under the age of 3;00 years (e.g. Fey and Gandour (1982), Ingram (1974a), Leonard et al. (1980), Preisser et al. (1988), Schwartz et al. (1980), Shibamoto and Olmsted (1978), Vihman and Greenlee (1987)) while fewer researchers were interested in investigating phonological development in children over 3;00 years (Haelsig and Madison, 1986, Ingram et al., 1980, Lowe et al., 1985). However, we now know that establishing a guideline for normative patterns and processes before and after the age of 3;00 is crucial and has considerable clinical implications for speech-language therapists (SLTs) in clinics and schools. Those 'normative' patterns assist clinicians to differentiate between normal, delayed, and atypical speech development and to generate an effective intervention plan tailored to the child's needs.

Table 3.15.

Accumulative count of single-case and small-group published studies in phonological development 1968-2016

Years	Duration	Studies	No. children	Languages
1968-1977	10 years	13	14	7
1978-1987	10 years	10	13	3
1988-1997	10 years	21	40	4
1998-2007	10 years	11	27	5
2008-2016	9 years	12	178	8
Total	*49 years*	*67*	*272*	*27*

Because Arabic Phonological development is the primary focus of the study in hand, the review of studies above excluded studies which inspected typical developmental milestones of Arabic speaking children and are to be examined separately in the following section.

3.5.1. Normative studies on Arabic

Although data is very limited, several studies provided some insight into the stages Arabic phonology is acquired (Abou-Elsaad et al., 2019, Owaida, 2015, Alqattan, 2014, Omar, 1973, Amayreh and Dyson, 1998, Dyson and Amayreh, 2000, Amayreh and Dyson, 2000, Ammar and Morsi, 2006, Saleh et al., 2007, Ayyad, 2011, Al-Buainain et al., 2012). The earliest studies were conducted on Egyptian and Jordanian Arabic. Later studies included dialects from the Arabian Gulf (Qatari, Kuwait, and Saudi) and Levantine (Syrian) regions. Normative studies on Arabic were often dedicated to the exploration of the phonetic inventory, acquisition age of consonants and/or phonological patterns found in a specific dialect. The earliest study, however, completed by Omar (1973) on the acquisition of Egyptian Arabic (EA) as a native language was mainly descriptive in nature and had not set a clear criteria for consonant acquisition thus was not included in this review. Table 3.16 below provides a summary of all normative phonological studies on various Arabic dialects presented in a chronological order followed by a detailed review in the paragraphs below.

Table 3.16 . *Normative Studies on Arabic*

Authors & dialect	**Year**	***N.***	**Age**	**Task**	**Position**	**Criterion**	**Major finding**
Amayreh & Dyson (Jordanian)	1998	180	2;00-6;04	SWA	I, M, F	Mastery 90% Acquisition 75% Customary 50%	Examined both SA & acceptable dialectal variation, SA results below: Early sounds: /b/, /t/, /d/, /k/,/f/, /ħ/, /m/, /n/, /l/, and /w/ Intermediate sounds: /s/, /ʃ/, /x/, /ɣ/, /h/, and /r/ Late sounds: /tˤ/, /dˤ/, /q/, /ʔ/, /θ/, /ð/,/ ðˤ/, /z/, /s/, /d͡ʒ/, and /ʕ/
Dyson & Amayreh (Jordanian)	2000	50	2;00-4;04	SWA	-	Errors over 5% of all possible chances	Examined phonological errors only: De-emphasis occurred 50%, Stridency deletion and lateralization: 25-50%, all other processes (stopping, initial voicing, final devoicing, fronting, cluster reduction, syllable reduction and final coda deletion: 1-24%
Amayreh & Dyson (Jordanian)	2000	13	1;02-2;00	SSS	SIWI, SIWW, SFWW, and SFWF	Consonants occurring in three different lexical items	phonetic inventories composed of 50% stops, 16.9% fricatives, 12.5% glides, 11.6% nasals, 7.6% liquids and 1.8% affricates Consonants accurately produced: /b/, /t/, /d/, /ʔ/, /m/, /n/, /ʃ/, /ħ/, /ʕ/, /ʧ/, /h/, /j/, /w/, and /l/. Most frequent sounds: /b, t, d, ʔ, m, j, w/. Fricatives appear in SIWW and SFWF before other positions.
Ammar & Morsi (Egyptian)	2006	36	3;00-5;00	SWA	I, M, F	Mastery 90% Customary 50-89%	Sounds acquired by the age of 4 years: /t/, /k/, /ʔ, /f/, /ʃ/, /x/, /ħ/, /h/, /m/, /n/, /w/, /j/, and /l/. Only phonological process persisting (>25%) beyond 5 years is Devoicing.
Saleh *et. Al* (Egyptian)	2007	30	1;00-2;06	SSS	I, M, F	Acquired 75% Errors produced by 2 or more children	Inventory of common consonants (produced by 50% of the group): Consonant appearing before age 2;06 years: /b/, /t/, /d/, /k/, /ʔ/, /f/, /v/, /θ/, /s/, /z/, /ʃ/, /x/, /ɣ/, /h/, /ħ/, /ʕ/, /l/, /r/, /m/, /n/, /w/, and /j/ Most frequent consonants: /b/, /t/, /d/, /ʔ/, /s/, /h/, /m/, /n/, /w/, /j/ and /l/. Consonants were most accurate in WF position Common phonological processes: Glottalization, weak syllable deletion and regressive assimilation.
Ayyad (Kuwaiti)	2011	80	3;10-5;02	SWA	I, M, F	90+% = 0-4 children with no mismatches 75-89% = 5-10 children with no mismatches	Younger group Mastered: /b/, /t/, /tːˤ/, /d/, /k/, /g/, /qː/, /ʔ/, /m/, /n/, /ðˤ/, /ħ/, /h/, /xː/, /tʃ/, /rː/, /w/, /j/ and acquired: /tˤ/, /q/, /sːˤ/, /ð/, /ʃ/, /ʁ/, /χ/, /ʕ/, and /l/. Older group: Mastered /s/, /b/, /bː/, /t/, /d/, /tˤ/, /tːˤʰ/, /k/, /g/, /q/, /qː/, /ʔ/, /m/, /n/, /f/, /ðˤ/, /ʃ/, /χ/, /ʁ/, /ħ/, /h/, /tʃ/, /rː/, /l/, /w/, /j/, and /jː/ and acquired: /θ/, /ð/, /dʒ/, /ʕ/ Also reported, whole word match, early word structures, phonological errors in the production of singleton and consonant clusters.

Table 3.16. *Normative studies on Arabic* (*continued)*

Authors & dialect	**Year**	***N.***	**Age**	**Task**	**Position**	**Criterion**	**Major finding**
Al-Buainain *et al* (Qatari)	2012	140	1;04-2;03	SSS	I, M, F	% of occurrence	Rare errors (less than 10%): Cluster reduction, De-affrication, fronting, gliding, metathesis, de-emphasis, r-deviation. Common errors (10-20%): assimilation, Coda deletion, de-gemination, devoicing, glottalization, stopping, and syllable deletion.
Qattan (Kuwaiti)	2014	70	1;04-3;07	SSS	SIWI, SIWW, SFWW, and SFWF	90% Mastery 75% Acquisition 50% Customary production	PCC, Type and token consonant frequency, Early syllable shapes and consonant acquisition. By the age of 3;07 years consonants are: Mastered: /p, b, t, d, k, g, ʔ, m, n, f, s, w, l, ɫ/ Acquired: /r, z, ʃ, x, ħ, ʕ, h, j, ʤ, ʧ, tˤ, sˤ/ Customary produced: /q, ɾ, ɣ, ðˤ/ and not acquired: /ŋ, v, θ, ð, ʒ, dˤ, zˤ/ Most frequent phonological errors are: De-emphasis, Cluster reduction, Stopping, Lateralization, coda deletion, and gliding. All errors occur less than 10% (are outgrown) by the age of 3;07 except for De-emphasis and Lateralization.
Owaida (Syrian)	2015	160	2;06-6;06	SWA	I, M, F	90% in I & F or M and F	PCC, PVC, Acquisition of consonants, Early sounds (3;11 years): /b/, /d/, /t/, /ʔ/, /f/, /s/, /z/, /h/, /ʕ/ /m/, /n/, /w/,/j/, and /l/ Intermediate sounds (4;00-4;11 years): /k/, /dˤ/, /tˤ/, and /x/ Late sounds 5;00-6;05 yrs): /r/, /sˤ/ , /ʃ/, and /ɣ/ All consonants acquired by the age 6;06 years except for /dʒ/
Abou-Elsaad *et. Al* (Egyptian)	2019	120	2;00-5;00	SWA	-	% of children producing the error at least twice in the sample	Most common processes: 51% post-vocalic devoicing, 46% total assimilation, 39% Syllable deletion, 35% fronting, 30% Cluster reduction, 29% lateralization, 27% Glottalization, 24% cluster substitution, 20% pre-vocalic devoicing, 15% Backing. Errors persisting beyond the age of 4;00 years are: Consonant assimilation, post-vocalic devoicing, Cluster substitution, and Lateralization.

Table 3.16. An overview on normative phonological studies on various Arabic dialects.
Key: *N* = Number of participants, SWA = Single-word-Assessment, SSS = Spontaneous Speech Sample, SA= Standard Arabic, PCC= Percent Consonants Correct, PVC= Percent Vowels Correct, SIWI= Syllable-initial word-initial, SIWW= Syllable-initial within-word, SFWW = Syllable-final within-word, SFWF= Syllable-final word-final, I = Word-Initial, M= Word-Medial, F= Word-Final

In 1998, Amayreh and Dyson recruited 180 Jordanian children between the ages of 2;00 and 6;04 years in nine gender balanced age groups in the largest study on Arabic phonology. The authors aimed to find the age at which Standard Arabic consonants are acquired in three word positions: WI, WM, and WF using a SWA task consisting of 58 words. Both spontaneous productions and those following a delayed imitation prompt were included in the analysis. The authors also specified three different levels of consonant acquisition: Mastery level: 90% correct production in all positions; Acquisition level: 75% correct production in all positions; Customary production level: 50% correct production in at least two word positions. In this study /b/, /t/, /d/, /k/, /ʔ/, /f/, /ħ/, /m/, /n/, /l/, and /w/ were acquired between the ages of 2;0 and 3;10; /s/, /ʃ/, /x/, /ɣ/, /h/, /r/, and /j/ between the 4;0 and 6;4; and /q/, /tˤ/, /dˤ/, /θ/, /ð/, /ðˤ/, /z/, /sˤ/, /ʕ/, and /d͡ʒ/ were not acquired by the age of 6;4. The authors reported on consonants' age of acquisition guided by the production of their acceptable dialectal variants which resulted in an earlier acquisition age for: /q/, /θ/, /ð/, /ðˤ/, /sˤ/, /d͡ʒ/, and /j/ when compared to their later acquisition age when only SA productions were considered.

Amayreh and Dyson continued to study Arabic phonology however this time on a smaller group of young children (six boys and seven girls) between the ages of 1;02 and 2;00 years (Amayreh and Dyson, 2000). The authors analysed the first 100 utterances of SSS, whether intelligible or not, to determine the positional phonetic inventories for each child in four syllable/word positions (SIWI, SIWW, SFWW, and SFWF). Each consonant had to be produced in three different lexical items to be included in the child's overall inventory and in two different lexical items to be included in that position's inventory. Three consonants occurred in all children's inventories: [b], [d],and [j], four consonants occurred in the inventories of at least ten out of the 13 children: [t], [ʔ], [m], and [w], and six consonants were present in the inventories of at least five children, [ʃ], [ʕ], [ħ], [h], [n], and [l]. Out of all positions, children produced the smallest number of consonants in the SFWW but the authors offer no further analysis whether this was due to consonant deletion or the correct but rare use of CVC syllable structure by the children. Consonants were also ranked based on the frequency of overall occurrence in each syllable/word position. Four stops: /ʔ/, /t/, /d/, and /b/ were the most frequent overall, however, in SIWI /h/ was ranked 3rd most frequent. Similarly, /l/ ranked 2nd and /m/ ranked fourth in SFWW, /l/ also ranked 2nd in SIWW, and /j/

ranked 2nd in SFWF as /ħ/ ranked fourth. In general, stops were the most frequent of all manner groups followed by fricatives, affricates, nasals, and liquids whilst glides were the least frequent.

Dyson and Amayreh (2000) again investigated the development of phonological errors in Educated Spoken Arabic, or in other words MSA, rather in the local dialect. The authors recruited 50 typically developing children between the ages of 2;00 and 4;00 and used SWA of 58 words especially designed to capture phonological error patterns and sound change. They also recruited 16 additional children aged 4;06-6;04 in four gender balanced aged groups for comparison. A 5% occurrence rate within an age group was set as the minimum rate for an error to be considered in the analysis. The most challenging consonants were mainly an emphatic consonant: /dˤ/, /tˤ/, /sˤ/, and /ðˤ/ or an interdental fricative: /θ/ and /ð/ but also included the trill /r/ and the uvular stop /q/. On the other hand, /b/, /d/, /ʔ/, /m/, /n/, /l/, /ħ/, and /x/ were the consonants that endured the least amount of errors. In general, stops and nasals were the most accurately produced whilst emphatics were consistently the least accurate. Liquids start of as challenging but become significantly easier by the age 3;00-3;04. The most frequent phonological process in the youngest age group was de-emphasis occurring at 82% followed by lateralization at 35%, stridency deletion at 27%, and cluster reduction, stopping, and final devoicing at 17-18%. All other phonological processes occurred 5-10%: Initial-voicing, fronting, syllable deletion, final-consonant deletion, and de-nasalization. All phonological processes decreased significantly with age and occurred less than 10% by the age of 6;04 except for de-emphasis and cluster reduction.

Furthermore, Ammar and Morsi (2006) also investigated speech sound acquisition in colloquial Egyptian Arabic in 36 children aged 3;00-5;00 by means of SWA. Both spontaneous and imitated productions were included in the analysis. The authors divided their participants into two groups and used 90% and 50-89% criterion for the acquisition and customary production of consonants respectively. The reported findings showed that all Egyptian Arabic consonants are acquired by the age of 5;00 and that /dˤ/, /z/, and /ɣ/ were the last to be acquired. Also, all phonological errors occurred less than 25% of the time by the age of 5;00 except for devoicing errors.

Finally, WF position was reported as the most challenging when compared to WI and WM positions.

Another study by Saleh et al. (2007) also investigated phonological development in Egyptian Arabic (Cairene dialect) however in younger children: 12-30 months. Thirty children were included in this study stratified by age into three gender balanced age-groups (5 females and 5 males each). A SSS was elicited during free play with parents via toys or pictures. In spite of the fact that most consonants were present in the phonemic inventories of the children before the age of 2;06 years: /b/, /t/, /d/, /k/, /ʔ/, /f/, /v/, /θ/, /s/, /z/, /ʃ/, /x/, /ɣ/, /h/, /ħ/, /ʕ/, /l/, /r/, /m/, /n/, /w/, and /j/, only one consonant: /d/ met the 75% acquisition criteria. Moreover, the authors reported what they considered as common consonants (used by more than 50% of the children in an age group): stops /b/, /t/, /d/, /ʔ/, nasals /m/ and /n/, glides /j/ and /w/, fricatives /h/ and /s/, and the liquid /l/. In contrast to Ammar and Morsi (2006), Saleh *et al*. found that consonants were most accurate in WF position. Phonological errors were also reported when they occurred by at least two children in an age group. Glottal replacement, weak syllable deletion and regressive assimilation were reported as the most common phonological processes use by the children.

Ayyad (2011) also studied phonological development in Arabic however in children speaking the Kuwaiti dialect. The author recruited 80 children between the ages of 3;10 and 5;02 and used SWA as means to collect her data. The author used a rather unusual definition for their criterion. For example, Mastery of consonants was based on a 90% criterion which was defined as 0-4 children with no mismatches. In other words, 100% correct production in 90% of the children in an age group. Also 75-89% criterion was used to report the acquisition of consonants which was defined as: 5-10 children with no mismatches, i.e.: at least 75% of the children had 100% accurate production. The author reported that the younger group mastered: /b/, /t/, /tːˤ/, /d/, /k/, /g/, /qː/, /ʔ/, /m/, /n/, /ðˤ/, /ħ/, /h/, /xː/, /tʃ/, /rː/, /w/, /j/ and acquired: /tˤ/, /q/, /sːˤ/, /ð/, /ʃ/, /ʁ/, /χ/, /ʕ/, and /l/. Also, the older group: mastered /s/, /b/, /bː/, /t/, /d/, /tˤ/, /tːˤʰ/, /k/, /g/, /q/, /qː/, /ʔ/, /m/, /n/, /f/, /ðˤ/, /ʃ/, /χ/, /ʁ/, /ħ/, /h/, /tʃ/, /rː/, /l/, /w/, /j/, and /jː/ and acquired: /θ/, /ð/, /dʒ/, /ʕ/. The author also reported on the occurrence of positional phonological errors in relation to mismatches to the manner, laryngeal, and place distinctive features. For example, fricative stopping occurred when [+cont] in the target fricative was produced as a stop: [-cont] in the child's production. Moreover, Ayyad reported her findings descriptively and in terms of error tokens without conducting any statistical analysis. Overall, loss of trill, stopping of /ð/ and /ʁ/ and spirantization of /q/ were the most common errors in the manner features in the younger group and erroneous production of /r/ in the older group. Similarly, devoicing (partial or full) was more common than voicing errors in the laryngeal features in the younger group whilst only partial devoicing occurred in the older group. Also, the most common place feature mismatches were reported in the production of /r/ and /χ/ whilst errors in the production of /s/, /sˤ/, and /z/ was the most common in the older group.

In 2012, Al-Buainain *et al.* published their preliminary findings of a normative phonological study on Qatari Arabic. The authors recruited 140 participants in seven age groups between the ages of 1;04 and 3;07 and used 30-minute SSS recorded during the child's interaction with their parent for the phonological error analysis. Assimilation, coda-deletion, de-gemination, devoicing, glottal replacement, stopping, syllable deletion, and de-emphasis were reported as the most common errors whilst CC simplification, de-affrication, fronting, gliding, metathesis, r-deviation and shamsiyya[9] errors were reported as least common. Although it was expected that some errors to be reported as very frequent errors due to the level of complexity involved in their production (e.g. deaffrication and cluster reduction). However, the low occurrence of these errors could have resulted from the relative young age of the participants (≤3;04 years) which may have influenced how many clusters and affricates were targeted in the first place.

Similar to Ayyad, Alqattan (2014) also studies phonological development in Kuwaiti Arabic. However, Alqattan used SSS instead of SWA in collecting their data and recruited younger children (*N* = 70) aged: 1;04-3;07. Alqattan followed Amayreh's footsteps and discriminated between consonants in onset versus coda in WM position and defined three levels of consonant acquisition: mastery, acquisition and customary production when five out of 10 children of each age group produced the consonant

[9] Al-shamsiyya error refers to errors in the production of the article /ʔal/ 'the' in Arabic, where the target /l/ is undergoes a compulsory assimilation process to fully match the adjacent consonant.

correctly with 90%, 75-89%, and 50-74% accuracy respectively. Alqattan reported that by the age of 3;07 /p/, /b/, /t/, /d/, /k/, /g/, /ʔ/, /m/, /n/, /f/, /s/, /w/, /l/, and /ɫ/ are mastered, /r/, /z/, /ʃ/, /x/, /ħ/, /ʕ/, /h/, /j/, /ʤ/, /ʧ/, /tˤ/, and /sˤ/ are acquired, /q/, /ɾ/, /ɣ/, /ðˤ/ are customary produced, and /ŋ/, /v/, /θ/, /ð/, /ʒ/, /dˤ/, /zˤ/ were not acquired. The author also reported on PCC, type and token consonant frequency, and early syllable shapes. Also, the most frequent phonological errors reportedly were: de-emphasis, cluster reduction, stopping, lateralization, coda deletion, and gliding. All errors occurred less than 10% by the age of 3;07 (i.e. are outgrown) except for de-emphasis and lateralization.

Another study explored consonant acquisition and the occurrence of phonological errors in Syrian Arabic was completed by Owaida (2015). Owaida recruited 160 participants between 2;06 and 6;06 and collected her data using SWA. Also, Owaida initially aimed to investigate three word positions: WI, WM, and WF. However, when her PCC results were insignificant between WI and WM, the author only considered consonants as acquired if they fulfilled the 90% criterion in either WI or WM in addition to WF position. In this study, all Syrian Arabic consonants were acquired by the age 6;06 years except for /dʒ/. Acquired consonants were classed as: early sounds if acquired by 3;11: /b/, /d/, /t/, /ʔ/, /f/, /s/, /z/, /h/,/ʕ/ /m/, /n/, /w/,/j/, and /l/, intermediate sounds if acquired between 4;00-4;11 years: /k/, /dˤ/, /tˤ/, and /x/, and late sounds when acquired between 5;00-6;05 yrs: /r/, /sˤ/, /ʃ/, and /ɣ/. Moreover, common phonological errors expressed in groups means and SD included: de-emphasis, dentalization, fronting, and r-deviation and rare errors included: coda-deletion, backing, stopping, and glottalization.

Finally, the most recent study on Arabic phonology was conducted on the Egyptian dialect exploring phonological error types and their occurrence (Abou-Elsaad et al., 2019). In this study, 120 children between 2;00 and 5;00 were recruited and data was collected using SWA method. A minimum of two occurrences of an error was required to meet the requirement for further analysis. The percentage of error was calculated based on the proportion of children in each age group exhibiting it. Reportedly, most common processes are: 51% post-vocalic devoicing, 46% total assimilation, 39% Syllable deletion, 35% fronting, 30% cluster reduction, 29% lateralization, 27% Glottalization, 24% cluster substitution, 20% pre-vocalic devoicing, 15% Backing.

Abou-Elsaad et al. (2019) also reported that only a few errors persist beyond the age of 4;00 years: consonant assimilation, post-vocalic devoicing, cluster substitution, and Lateralization.

From table 3.10 and the above summary, it can be appreciated that five Arabic dialects have been studied: Jordanian, Egyptian, Kuwaiti, Qatari, and Syrian. Four studies derived their results from SSS and six from SWAs. Moreover, a wide age range of participants were targeted: youngest age of 1;02 years and oldest 6;06 years. The number of participants also varied considerably with a minimum of 13 children in Amayreh and Dyson (2000) and as many as 180 children in the largest study by Amayreh and Dyson (1998). The majority of the studies implemented the analysis based on word position (i.e. initial, medial, and final) (Amayreh and Dyson, 1998, Ayyad, 2011, Ammar and Morsi, 2006, Saleh et al., 2007, Owaida, 2015, Al-Buainain et al., 2012) whilst only two studies considered position within the syllable to allow onset and coda distinction within the word-medial position (Alqattan, 2014, Amayreh and Dyson, 2000).

The criteria used in results reporting to define mastery, age of acquisition and so on varied considerably between studies. Even when the percentage criterion was the same, it was applied differently. For example, Alqattan (2014) defined their consonant mastery as 90% correct production of a consonant in 50% of the participants in an age group. Alqattan did not specify if the 90% criterion was applied in the overall occurrences or in each syllable/word position. Owaida also used the 90% criterion but made no distinction between WI and WM consonants based on non-significant differences in PCC between those two positions (Owaida, 2015). Consequently, the accurate production of consonants was only required in two word positions, i.e. WI or WM in addition to WF. Also, Owaida did not state but rather implied that 100% of the participants in each age group must fulfil this 90% criterion. Similar to Owaida, Amayreh and Dyson did not discriminate between consonants in onset and coda positions in WM position and used the same 90% criterion to report their results. However their 90% criterion was applied to all three word positions independently from one another. In other words, their consonant mastery was defined as 90% correct production in all three positions by 90% of the participants. Moreover, Ayaad *et. Al*'s 90% criterion was identical to Amayreh and Dyson's however defined differently: a consonant was reported to fulfil the 90% criterion if less than five children in any age group had any mismatches. Ayyad's age groups consisted of 40 children each, thus her criteria can be defined as 100% accurate production in 90% of the participants in any given age group.

Even more variability is found in the criterion used in reporting of phonological process. For example, Alqattan reported the percentage of errors relative to the total number of words, whilst Dyson and Amayreh reported the percentage of errors in relation to the total number of possible occurrences (Alqattan, 2014, Dyson and Amayreh, 2000). Abou-Elsaad also reported the occurrence of phonological errors but in relation to the number of children in an age group that demonstrated that error type in at least two occasions (Abou-Elsaad et al., 2019).

It is apparent that some studies used more stringent rules in the reporting of their findings of either age of acquisition of consonants (Amayreh and Dyson, 1998) or the occurrence of phonological errors (Amayreh and Dyson, 2000) whilst others used more lenient rules (Alqattan, 2014, Abou-Elsaad et al., 2019). Regardless of the differences in sample size, dialect investigated, elicitation method, or the criterion used to report the results, the review of normative studies on Arabic revealed some general tendencies. For example, coronal stops /b/, /t/, and /d/ in addition to nasals: /m/ and /n/, glides: /w/ and /j/, the lateral /l/, and fricative /ħ/ are reported as early sounds; i.e. acquired before the age of 4;00. Moreover, all remaining fricatives, emphatic consonants, and the affricate /dʒ/ were considered as the most challenging and the last to be acquired. On the other hand, there were some variability in the age of acquisition reported for a few consonants: /sˤ/, /ʃ/, /ʕ/, and /h/. For example, /ʃ/ and /ʕ/ were both reported as acquired by 4;00 and mastered by 5;00 in Kuwaiti Arabic (Ayyad, 2011) but in Syrian Arabic, /ʃ/ was mastered late (> 6;00) and /ʕ/ was mastered before 3;11 years (Owaida, 2015). Also in Kuwaiti Arabic, Alqattan (2014) reported both /ʃ/ and /ʕ/ as acquired but not mastered by 3;07 years. However, in Jordanian Arabic, /ʃ/ was mastered at 5;00 before /ʕ/ which was not mastered even by 6;04 years. This variability can possibly result from methodological differences or dialectal variation.

Additionally, the token frequency of consonants has been reported in three Arabic dialects: Jordanian, Egyptian, and Kuwaiti (Amayreh and Dyson, 2000, Alqattan, 2014, Saleh et al., 2007). All studies computed the frequencies from the spontaneous sample obtained from the participating children. Table 3.15 below presents the findings of these studies from most frequent to least frequent manner of articulation groups and the four most frequently occurring consonants.

Table 3.17.

Token Frequency of Consonantal Manner Groups in Three Arabic Dialects.

Amayreh and Dyson (2000)	**Saleh et al. (2007)**	**Alqattan (2014)**
Jordanian Arabic	*Egyptian Arabic*	*Kuwaiti Arabic*
Stops (50%):	Stops (46%)	Fricatives (31%)
Fricatives (17%)	Nasals (19%)	Stops (29%)
Approximants (13%)	Fricatives (17%)	Nasals (16%)
Nasals (12%)	Laterals (9%)	Approximants (6%)
Laterals (8%)	Approximants (9%)	Lateral (6%)
Affricates (2%)		Tap and Trill (5%)
		Emphatics (4%)
		Affricates (2%)
Most frequent consonants:		
/ʔ/, /t/, /d/, and /b/	/ʔ/*, /n/, /t/ and /b/	/h/, /n/, /b/, and /m/

*/ʔ/ token frequency in Egyptian Arabic = 20%, is the only consonant with token frequency exceeding 11% in all three dialects.

Stops were the most frequent manner group in both Jordanian and Egyptian Arabic. Similarly, the most frequent consonants in Amayreh and Dyson (2000) were all stops: /ʔ/, /t/, /d/, and /b/ however, in Saleh et al. (2007) the four most frequent consonants included three stops: /ʔ/, /t/, and /b/ and one nasal: /n/ which was the second most frequent consonant with token frequency of 11%. However, In Kuwaiti Arabic, fricatives were the most frequent and the four most frequent consonants included one stop: /b/, two nasals /n/ and /m/, and the fricative /h/. As already explored in previous paragraphs, all normative studies are in consensus that stops and nasals are typically acquired before fricatives. This fact alongside the variability of the age range of the participants targeted in each study where Alqattan recruited relatively older Kuwaiti participants (up to 3;04 years) whilst Saleh et al. recruited Egyptian children who are 1;00-2;06 years and Amayreh and Dyson recruited Jordanian children who are 1;02-2;00 years could explain why fricatives were reported as the most frequent manner group in the Kuwaiti dialect but not in Jordanian or Egyptian. Both Jordanian and Egyptian children may have produced more fricatives as they grew older (i.e. >3;00 years) similar to KA-speaking children, however this cannot be determined due to the upper age limit in the EA and JA studies (Saleh et al., 2007, Amayreh and Dyson, 2000).

Now that normative studies on Arabic have been reviewed elaboratively, the next section focuses on reviewing normative studies on English and other languages (section 3.5.2.). It is understandable that all normative studies on any language predominantly focuses on age-related differences, however the current study also aims to explore gender-related differences. As a result, section 3.5.3. of this chapter is dedicated to present a review of gender-related differences reported in developmental studies across all languages.

3.5.2. Normative studies on English and other languages

Normative studies on the English language started in the 1930's with a the aim of determining the age of acquisition of consonants (Wellman et al., 1931, Poole, 1934). Also, early studies classified articulation errors in three categories: substitution, omission, and distortion. It was not until the 1950's that a phonological approach to the analysis of error emerged. Table 3.18 presents a summary of the major findings of 12 normative studies on different dialects of English.

From table 3.18, the variation in the sample size, age range, positions targeted, and criterion used can be appreciated. This variation, especially in the criterion of choice, undoubtedly affected the reported findings. Studies that applied a stringent criterion (e.g. Poole, 1934 that used 100% criterion) reported a later acquisition age of consonants when compared to studies that implemented the 75% criterion (e.g. Wellman et al. (1931), Templin (1957)). It is worth noting that the purpose of the study typically dictates the choice of methodology. For instance, the majority of the normative studies above implemented a cross-sectional design, except for McIntosh and Dodd (2008) who also only recruited children at the age of 2;00 years in a longitudinal study for the purpose of investigating whether early phonological assessment at age 2;00 is a predictive of phonological disorder at age 3;00. Similarly, Lowe (1989) recruited over a thousand participants in the process of creating the ALPHA[10] test of phonology. It is also apparent that the early studies focused on the age of the acquisition of consonants whilst later studies focused on the phonetic inventory and phonological errors/patterns. Moreover, two studies made an extra effort to differentiate the age of acquisition of consonants based on word-position (Olmsted, 1971, Smit, 1986) and a single study reported different age of acquisition between boys and girls (Smit, 1986).

[10] ALPHA test of phonology by Robert J. Lowe is used to assess the phonological development children between 3;00 and 8;11 via a delayed imitation task of 50 words embedded in short sentences. It assesses the accurate production of consonants in I and F positions in addition to the underlying phonological processes .

Table 3.18. *Normative Studies on English*

Authors	**Year**	***N.***	**Age range**	**Task**	**Position**	**Criterion**	**Major finding**
Wellman	1931	240	2;00-6;00	SWA*	I, M, F	75%	First acquired: /m, n, b, f, w̦, h/ Last acquired: /ŋ, θ, ð, ʒ, d͡ʒ/
Poole	1934	65	2;06-8;06	SWA*	I, M, F	100%	First acquired: /m, p, b, w, h/ Last acquired: /θ, z, s, ɹ/
Templin	1957	480	3;00-8;00	SWA* or reading aloud	I, M, F	75%	First acquired: / m, n, ŋ, p̦, f, w, b/ Last acquired: / θ, z, ʒ, d͡ʒ/
Olmsted	1971	100	2;00-4;00	SSS	I, M, F	50%?	Last acquired: /ŋ, ð, ʒ, t͡ʒ, d͡ʒ/ Also, reported on different age of acquisition based on word position of: /t, θ, z, , t͡ʒ, d͡ʒ, l/
Prather *et. al*	1975	147	2;00-4;00	SWA	I, F	75%	First acquired: /m, n, ŋ, p̦, h/ Last acquired: /v, θ, z, d͡ʒ/
Stoel-Gammon	1987	33	2;00	SSS	I, F	90%	WI acquired: /b, t, d, k, g, n, m, f, s/ WF acquired: /p, t, k, n, s, ɹ/
Dyson	1988	20	1;11-3;06	SSS	I, F	Correct in 2 lexical items in 5/10 children	2;00-2;05 acquired WI:/ p. b, t, d, k, g, m, n, f, s, h, w, l, j/ and WF: /p, t, d, k, m, n, f, s, ʃ, t͡ʃ/ 2;09-3;03 acquired WI: all stops, all nasals, + /f, s, z, h, w, j, l, ɹ/ and in WF: all stops (but not /g/, all nasals + /f, v, s, z, ʃ/
Lowe	1989	1320	3;00-9;00	Delayed imitation of sentences	I, F	90% in either position	First acquired in WI /m, n, p, b, d, k, w, h/ and in WF: /m, p, t, d, k, g/ Last acquired: /r, ð, s, z/ All phonological processes disappeared by 6;06 years except for labialization.

Table 3.18. *(Continued)*

Authors	**Year**	***N.***	**Age range**	**Task**	**Position**	**Criterion**	**Major finding**
Smit	1990	997	3;00-9;00	SWA**	I, F	N/A	First acquired: /m, n, p, b, d, w/ Last acquired: / θ, ð, s, z, ʃ, t͡ʒ, d͡ʒ/ Also reported different age for I vs F positions And different age for females vs males, with females acquiring 9 consonant before their male peers: /d, g, θ, ð, ʃ, t͡ʒ, d͡ʒ, l, j/
Dodd *et al.*	2003	684	3;00-6;11	SWA*	I, M, F	90%	Acquired by 3;00-3;05: stops + nasals + /f, v, s, z, h, w, j/ and WI /l/, Last to be acquired: / θ, ð, ɹ/. Also examine phonological patterns in children aged 2;00-2;11, 90% of children had error free speech by 6. Voicing disappeared by age 3, stopping by age 3;06, WSD and fronting by 4;00 deaffrication and CR by 5;05 and liquid gliding persisted until age 6.
McIntoch & Dodd	2008	62	2;01-2;11	SWA*	I, F	90% and 75%	1;01-2;06 acquired: /m, n, p, b, t, d, k, g, s, w/ 2;07-2;11 acquired: /ŋ, z, f, l, j, h/ All children missing: /ʃ, θ, t͡ʃ, d͡ʒ, r/ and /ð, ʒ, v/ were not assessed. Phonological patterns included: cluster reduction, final consonant deletion, stopping, fronting, weak syllable, deletion, gliding and deaffrication. Qualitative analysis was more accurate in predicting phonological delays.

Table 3.18. An overview on normative phonological studies on various English dialects.
*spontaneous and imitation accepted. **spontaneous production only accepted.
Key: *N* = Number of participants, SWA = Single-word-Assessment, SSS = Spontaneous Speech Sample, I = Initial, M= Medial, F= Final ,WI = word-initial, WF = Word-final

In spite of the methodological differences, a clear pattern of consonant acquisition across all studies can be seen. It seems that there is a general consensus that all nasals and most stops are acquired early around the age of 3;00 years. Also, fricatives and affricates are acquired latest with voiced and voiceless interdental fricatives and the affricate /d͡ʒ/ identified as the most challenging and the last to be acquired.

The worldwide growing interest in phonological development in the last three decades is clearly reflected in the number of languages in which normative studies were conducted in the last three decades e.g.: Cantonese (So and Dodd, 1995), Turkish (Topbas, 1997), Modern Standard Chinese (Hua and Dodd, 2000), Zulu (Naidoo, 2003), French (MacLeod et al., 2011), Hong-Kong Cantonese (To et al., 2013), Xhosa (Maphalala et al., 2014), Swahili (Gangji et al., 2015), Hindi (Kaur and Rao, 2015), Setswana (Mahura and Pascoe, 2016), Cypriot-Greek (Petinou and Theodorou, 2016). Similar to studies on Arabic and English, normative studies in other languages also differed in the elicitation method used, the number of participants, the target age range, the positions investigated, and the criterion applied. Table 3.17 below presents the main methodological differences amongst these studies. For example, the most obvious difference can be seen in the number of participants recruited. For example, To et al. (2013) recruited over a 1000 participants but Naidoo (2003) only recruited 16. In addition to the usual 75% and 90% criterion used for consonant mastery in Arabic and English studies, other studies used 66.7% (Setswana), 80% (Cypriot-Greek), 83.3% (Zulu), and 85% (isiXhosa) criterion. Six studies used SWA which ranged between 40 and 89 words and five studies used SSS which also varied considerably in the total number of words included in the analysis ranging between 50 and 301 words. The majority of studies investigated phonological development in children above the age of 3;00, however four studies (in French, Cantonese, Modern Standard Chinese, and Turkish) recruited participants before their 2nd birthday. These methodological differences make it difficult to identify cross-linguistic trends.

Moreover, hypothetically, differences in functional load, syllabic structure, frequency of consonants, and phonotactic rules that are language-specific could be associated with differences in phonological acquisition. Results suggest these may exist but must be interpreted with caution. For example, the acquisition of /k/ in the majority of the studies reviewed in this section occurred at around 3;00-3;06 years (Gangji et al., 2015, Naidoo, 2003, So and Dodd, 1995, Maphalala et al., 2014, To et al., 2013). However, /k/ has been reportedly acquired at a younger age in several languages: before 1;06 in Turkish, at 1;06 in Modern Standard Chinese, and at 2;00 in Cypriot-Greek. Similarly, backing, as a phonological process was found to be frequent and typical of Cantonese speaking children while it was reportedly rare in English, Arabic and Turkish (Hua and Dodd, 2000, Dodd et al., 2003, Alqattan, 2014, Topbas, 1997). The cross-linguistic comparison between the findings of the English studies and some of other languages will be later compared to those of the Arabic and the current study in more detail in the discussion chapter.

Table 3.19.

Normative studies in other languages

Study	*N.*	Age	Language	Stimulus	Positions	Criterion
(So and Dodd, 1995)	268	2;00-6;00	Cantonese	SWA 57 words + SSS	SIWI, SIWW,& SFWF	75% & 90% accuracy measure (+4 participants aged 1;00-2;00)
(Topbas, 1997)	22	1;00-3;00	Turkish	SSS 90-301 words	SIWI, SIWW, SFWF, & SFWW	Phonological process in 4 different lexical items or occurred at least in 20% of targets.
(Hua and Dodd, 2000)	129	1;06-4;06	Modern Standard Chinese	SWA 44 words	Syllable-initial Syllable-final	90%of the children in an age group produced the sound at least once, irrespective of whether it was correct target or not.
(Naidoo, 2003)	16	3;00-6;00	Zulu	SSS 100 words	I, M, F	5/6 children producing the sounds correctly irrespective % correct.
(MacLeod et al., 2011)	156	1;06-4;06	French	SWA 40 words	I, M & F	75% accuracy measure Consonants and clusters
(To et al., 2013)	1726	2;04-12;04	Cantonese	SWA 51 words	I & F	90% accuracy measure
(Maphalala et al., 2014)	24	3;00-6;00	isiXhosa	SWA 48 words	Intervocalic	Correct production by 85% of the children in a group.
(Gangji et al., 2015)	24	3;00-5;11	Swahili	SWA 48 words	I & M	75% average correct production in both positions. Phonological processes included when exhibited by 50% of the children at least once.
(Kaur and Rao, 2015)	20	4;00-6;00	Hindi	SSS 30 min	I, M, F	not specified
(Mahura and Pascoe, 2016)	36	3;00-6;00	Setswana	SWA 89 words	I, M, F	Fully emerged: 66.7% 5/6 participant produce the phoneme once irrespective to target matching. All phonological processes reported regardless of the number of times they were produced.
(Petinou and Theodorou, 2016)	24*	2;00-3;00	Cypriot-Greek	SSS min 50 words	I and M	80% of the children in an age group

*. Longitudinal studies, Key: *N* = Number of participants, SWA = Single-word-Assessment, SSS = Spontaneous Speech Sample, SIWI= Syllable-initial word-initial, SIWW,= Syllable-initial within-word, SFWW = Syllable-final within-word, SFWF= Syllable-final word-final, I = Initial, M= Medial, F= Final

In general, the most problematic issue was in comparison of the findings between studies that used different criterion or used the same criterion but applied it differently. For example, Dodd et al. (2003) defined their 90% criterion as: the correct production of speech sounds spontaneously or via imitation by 90% of the children in each age group. Although the authors do not explicitly state, but rather it is implied that the correct production is required in each position investigated. In contrast, Owaida (2015) also used the 90% criterion but mandated the accurate production of the speech sounds in only two word positions: WI and WF or WM and WF in 90% of the children in an age group. Both Dodd *et al.* and Owaida do not state what percentage of correct production is required to fulfill this criterion, however because the author used SWA, it is implied that 100% accuracy is recquired as sounds are typically targetted once in the naming task. Alqattan (2014) also used the 90% criterion however, the acquisition of consonants needed to fulfill this 90% accurate production in only 50% of the participants in an age group. Moreover, Alqattan stated that a single correct production of the consonant was enough to make the judgment on its acquisition status. On the other hand, Amayreh and Dyson (2000) required the correct production of the speech sound in at least three different lexical items.

Also, in spite of all the methodological differences, a general trend is clearly evident in the order of which manner of articulation groups are acquired first. Across all Arabic and English dialects and also cross-linguistically stops and nasals were the first to be acquired. Also, in general, fricatives and affricates were agreed upon to be the most challanging and acquired last although some fricatives were reportedly acquired early in several languages: e.g. /f/, /s/, and /h/. These results are in general agreement with the notions of markedness and articulation complexity consitute some of the universal tendendies in phonological development. Nonetheless, input frequency, functional load, and grammar differe amongst languages and sometimes amongst dialects of the same language. This differences in phonological development is attested in language or dialect specific tendencies.

3.5.3. Gender-related differences in normative studies

In a systematic review, speech and language delays were found to be more common in boys than girls (Law et al., 1998) . Also, a demographic review of referrals to 11 speech and language clinic in the United Kingdom over nine years revealed that 50% more boys than girls were referred to the clinics (Petheram and Enderby, 2001). Similarly, a meta-analysis of over 170 studies by Hyde and Linn (1988) revealed that only 1% of the variance in language acquisition is accounted for by gender. In the area of speech production, females were consistently observed to perform much better than their male peers (Hyde and Linn, 1988). Many studies have shown that there are gender differences in all aspects of language learning/usage. For example, French-speaking young girls were found to have superior linguistic abilities to the boys of the same age, i.e. acquired more words, used more grammatical forms and complex syntax (Bouchard et al., 2009) . The authors even suggest that separate normative data for boys and girls maybe warranted. Similarly, stylistic gender differences in the spoken language (English) has been widely studied and documented in children as young as 3 years (McGillicuddy-De Lisi et al., 2002). However, in other normative phonological studies, the distinction between female and male performance was not investigated (e.g. Alqattan (2014), Ayyad et al. (2016), Saleh et al. (2007), (2019), Amayreh and Dyson (2000), Ammar and Morsi (2006), Al-Buainain et al. (2012)). In contrast, more studies aimed to explore and report gender-related differences (e.g. Dodd et al. (2003), Holm and Dodd (2006), Lim (2018), Fox (2006), Maphalala et al. (2014), Phoon et al. (2014), Clausen and Fox-Boyer (2017), Bauer et al. (2002), Huttenlocher et al. (1991), Owaida (2015), Amayreh (2003), Dyson and Amayreh (2000), Wellman et al. (1931), Smit et al. (1990)) however, there was a debate whether these differences were significant or not. And when they were significant, no consensus was reached with regards to the age at which gender played a vital role in the development of speech and language.

The normative studies that did not attempt to investigate gender-related differences in this review were mostly conducted on the Arabic language (Alqattan, 2014, Amayreh, 2003, Amayreh and Dyson, 2000, Ammar and Morsi, 2006, Saleh et al., 2007, Abou-Elsaad et al., 2019, Al-Buainain et al., 2012), however the methodology of these studies was rationalized by the findings of previous studies that investigated gender as an independent variable yet found it to have no significant effect on their dependant variables. These studies were either conducted on a different Arabic dialect or another language (e.g. Arabic (Owaida, 2015, Amayreh and Dyson, 1998, Dyson and Amayreh, 2000), Xhosa (Maphalala et al., 2014), German (Fox, 2006), and Danish: (Clausen and Fox-Boyer, 2017)). Some studies even found no gender-related differences in the phonological development of bilingual children speaking Cantonese and English (Holm and Dodd, 2006), and multi-lingual children speaking English, Malay, and Mandarin (Lim, 2018).

In contrast, females consistently outperformed their male peers in all studies that found a gender-related difference regardless of what aspect of language/phonological acquisition was being investigated. For example, A longitudinal study on mono-lingual English-speaking children found that girls consistently outperformed the boys on multiple age-appropriate speech and language performance measures assessing vocabulary production and comprehension, spelling, grammar, utterance length, reading comprehension, generation of synonyms, verbal analogies and verbal intelligence collected via maternal report, maternal interview, teacher questionnaire, direct assessment, and the analysis of the child's spontaneous speech (Bornstein et al., 2004). Similarly, Simonsen et al. (2014) found that Norwegian-speaking females surpassed their male peers in using more complex grammar, in the comprehension and production of vocabulary, and in a few types of imitation skills. Moreover, in a longitudinal study that focused on linguistic and intellectual development, Moore (1967) reported that the speech quotient was the only area where a significant gender-related difference in advantage to the girls was found. Also, both Winitz (1969) and Halpern (2013) concluded that girls had a more advanced functional verbal and linguistic skills than boys of the same age and McCormack and Knighton (1996) reported that girls aged 2-5 years were more accurate in their phonological output than the boys.

Occasionally, the interaction between age and gender in speech and language developmental studies have been found significant. However, to this date studies disagree at what age these differences are significant. Some studies report differences at a very young age, before the age of two years. For example, gender-related differences in the lexical development as measure by the MacArthur Communicative

Development Inventory: Words and Gestures were reportedly present from a very early age, as young as 8, 9, or 10 months through 14 months of age (Bauer et al., 2002). Huttenlocher et al. (1991) confirm the lexical advantage the girls have in acquiring new words faster than boys at the age of two years. Also, another study found gender-related differences in advantage to the girls yet in their speech measures at 18 months of age (Hyde and Linn, 1988).

Other studies claim that gender-related differences are only present in mid-childhood years (i.e. 2;00-6;00 years). For example, Wellman et al. (1931) reported that girls between 3;00-4;00 years of age outperform the boys of the same age in their accurate production of consonants, but this difference was no longer significant at 5;00 years. In other words, by the age of 5;00 years the boys appear to have caught up. Bornstein et al. (2004) reached similar conclusion, yet it was at 6;00 years that the authors reported that boys catch up with the girls in their speech and language skills. Smit et al. (1990) investigated gender-related differences in regard to the acquisition age of consonants and found that the difference between girls and boys was only significant at: 4;00, 4;06, and 6;00 years in advantage of the girls. Similarly, Weindrich et al. (1998) reported age specific effect of gender, i.e. at 2;00 years there were significantly more boys than girls with expressive disorders, and at 4;06 years significantly more boys than girls had articulation disorders. Furthermore, between the age of 3;00 and 5;00 years the boys were found to be less consistent than the girls in their speech production variability measure (Kenney and Prather, 1986).

Furthermore, a few studies reported even a later age before gender-related differences present themselves as significant (i.e. beyond the age of 5;06 or 6;00 years). In both English and Malay, girls outperformed the boys in older age groups (Phoon et al., 2014, Dodd et al., 2003). In general, older girls (above the age of 5;06 years) scored higher on all phonological consistency measures than boys of the same age (Dodd et al., 2003). Similarly, Poole (1934) set the age of 5;06 years as the age where gender-related differences rise in consonant acquisition where girls acquired some speech sounds a year ahead of the boys. Poole (1934) also claimed that between 2;06-5;06 years the phonological abilities of girls and boys develop at the same pace.

Since the current study is mostly concerned with phonological development, gender-related differences that are specific to aspects of the phonological development are explored in more detail. Only two studies reported gender-related differences in the number of consonants acquired by a certain age. Wellman et al. (1931) reported that English-speaking girls acquired 3.8 more consonants than the boys at 2 years, 10.3 more consonants at 3;00 years, 8.3 more consonants at 4;00 years, and 1.6 more consonants at 5;00 years. Similarly, Amayreh (2003) also reported that more consonants were acquired by the Arabic-speaking girls in their oldest age group (6;06-7;04 years) whilst the boys in the same age group had the narrowest range of consonants acquired. Moreover, Smit et al. (1990) reported that the English-speaking girls had an earlier mastery of nine consonants than the boys: /t/, /d/, /θ/, /ð/, /ʃ/, /ʧ/, /ʤ/, /l/ and /j/ whereas the boys only mastered /n/ six months sooner than the girls. In Smit *et al*.'s study, the greatest reported advantage the girls had was in the mastery of the voiced interdental fricative when they mastered it 2.5 years before of the boys did at age 7;00 years. Similarly, Dodd et al. (2003) found that the difference in the age of acquisition between the two genders was only significant in the acquisition of the voiced and voiceless interdental fricatives: /θ/ and /ð/ also to the advantage of the girls. Moreover, when manner of articulation groups were compared, Owaida (2015) reported that girls were more accurate than boys in the production of nasals. Finally, Dodd et al. (2003) also reported that boys had lower score than the girls of the same age in their phonological accuracy measure. Nonetheless, further analysis revealed that this difference was only significant in cluster reduction errors.

In sum, there is a general debate regarding whether gender plays a role in phonological development in children. However, there is an agreement that when these differences existed, the females consistently had the advantage over their male peers. Etchell et al. (2018) conducted a systematic review of how sex differences are presented in childhood language and brain development and determined that gender-related differences were only found in studies that implemented a tighter age-range in their methodology. The authors suggested that gender-related differences are age sensitive, i.e. the differences are only be prominent at a certain age but are negligible in other ages (Etchell et al., 2018). Several hypothesis have been suggested to why this gender difference exists (e.g. faster development of fine motor skills in females

(Dodd et al., 2003); gender-related differences in the rate of brain maturation (Hyde and Linn, 1988); speech organs maturing earlier in females (Templin, 1957, Winitz, 1969); difference in social skills (Moore, 1967)).

3.6. Conclusion

The subject of phonological acquisition in Arabic is significantly under-researched. Unfortunately, most existing studies focus on a specific Arabic dialect and/or are small-scaled most of which were completed as partial fulfillment of a research degree and have not been published in journal or book form making them very difficult to access. For example, a doctoral thesis completed in 2016 investigated phonological development in Saudi-Arabic speaking children with similar approach to the current study yet to date have limited accessibility (Bahakeem, 2016). In addition, diglossia in Arabic makes the generalization of the findings of those studies even harder. The scarcity of available data regarding Arabic phonological acquisition mean that when diagnosing and treating Arabic speaking children with phonological difficulties Speech-Language-Therapists (SLTs) draw on data from studies in the English language which is not accurate nor applicable to Arabic.

Moreover, irrespective of the investigated language or dialect, all studies used either SWA or SSS to collect their data but hardly ever compared the two. Similarly, many studies only investigated WI and WF positions (Smit et al., 1990, McIntosh and Dodd, 2008, Prather et al., 1975, Stoel-Gammon, 1987, Dyson, 1988, Lowe, 1989, Owaida, 2015), while others also included WM position in their analysis (Naidoo, 2003, MacLeod et al., 2011, Kaur and Rao, 2015, Mahura and Pascoe, 2016, Dodd et al., 2003, Wellman et al., 1931, Poole, 1934, Templin, 1957, Olmsted, 1971, Al-Buainain et al., 2012, Ayyad, 2011, Saleh et al., 2007, Ammar and Morsi, 2006, Amayreh and Dyson, 1998). Only two studies investigated WI and WM positions (Petinou and Theodorou, 2016, Gangji et al., 2015). Furthermore, two studies on Arabic and one in Turkish investigated the acquisition of consonants in four syllable/word positions: SIWI, SFWW, SIWW, and SFWF (Topbas, 1997, Alqattan, 2014, Amayreh and Dyson, 2000).

Expectedly, all developmental studies focused on researching age related milestones in phonological development. Nonetheless, gender-related differences were also explored, yet only occasionally. Iresepctive of what aspects of phonological development was investigated, there is no consensus in the literature to weather these differences are significant. However, when gender-related differences were reportedly observed, studies reported conflicting ages at which these differences are prominent. although they all agreed that the females always outperformed their male peers.

of the pariticpants as a factor. However the gender of the particpant was only occasionally explored and when it was, many discrepancies in the findings have been reported in the literature. Whilst some studied found no gender-related differences on the varibales under investigation, others did. When the differences between the two genders were noted, the females were consistently more accurate than their male peers in their speech and phonological skills yet these difference were reportedly significant at different ages in different studies.

In conclusion, the gaps in the literature in four main areas shaped the methodoligical choices of the current study (discussed in detail in the next chapter). These areas are: normative phonological studies on Saudi Arabic dialects, the comparision between SWA/PN and SSS/SPON sampling methods in typically developing children, exploring the effect of gender as an independent variable, and the distinction between onset and coda consonants in word-medial position.

Chapter 4. Methodology

4.1. Aims of the Study

The aim of this study is to describe the specifics of speech sound acquisition and phonological developmental patterns in typically developing Arabic children between the ages of 1;10 and 4;02. More specifically, it focuses on the effects of Speech-Task, Syllable/word position, and the age and gender of the participants. Speech-Task and Syllable/word position are two important factors that are typically overlooked in normative phonological studies. The Najdi dialect, that is widely spoken in the central region of Saudi Arabia is a very conservative dialect. Being very close to MSA and several other dialects spoken in the gulf region, it can be anticipated that the findings of the current study could also have some reliable application to these dialects. Ultimately, the foremost goal of this research is to facilitate the future design of a phonological assessment tool in Arabic.

4.2. Research Questions

The current study aims to gain a better understanding of the acquisition and developmental patterns of Najdi Arabic phonology in Saudi children aged 1;10-4;02 years. To that end, the following research questions are addressed:

1. How does the Speech-Task, Syllable/word position, age, and gender of the participants relate to:
    - The accuracy of speech production from 1;10 and 4;02 years
    - The composition of children's phonetic consonant inventory between 1;10 and 4;02
    - The Mastery, Acquisition, and Customary production of individual consonants
    - The occurrence of phonological error patterns and the age at which they emerge and disappear from children's speech
2. How does the frequency of sounds, markedness, sonority, articulation complexity, and functional load relate to the accurate production and age of acquisition of consonants?

3. How do the phonological developmental patterns of Arabic-speaking children compare to those typically found in children speaking other Arabic dialects or non-Semitic languages with a special focus on English.

4.3. Ethical Review and Approval

The research proposal letter addressed to school administrations, Information sheet, Consent form, and the protocol of this study were all submitted for ethical approval to the Newcastle University research ethics committee. All of these documents were first developed in Arabic then translated into English to be submitted to Newcastle University ethics committee (Appendix-A, B, C, and D).

The information sheet was used as an invitation to participate leaflet which explained in detail: the aims and of the study, participation procedure including steps to ensure confidentiality, the participant's/parents' right to withdraw from the study and ensuring the child is comfortable and willingly participating in all data collection activities. The consent form included the approval of audio and/or video recording with a short questionnaire tapping demographic data and other data about the child to determine their eligibility for the study. The explanation of this process allowed the granting of Newcastle University Ethical approval.

4.4. Study Design

This is a qualitative and quantitative study utilising a cross-sectional design collecting data from two speech samples of 60 children aged 1;10-4;02 years stratified by age into five age groups. The age groups had a range of ±2 months with a two-month gap between age groups to ensure a discrete and clear distinction between them as follows: Group-1: 1;10-2;02, Group-2: 2;04-2;08, Group-3: 2;10-3;02, Group-4: 3;04-3;08, and Group-5: 3;10-4;02. This study aimed to collect data from three types of schools (public, private-middle class and private-high class) in order to sample a range of socio-demographic groups with 1:1 ratio of male to female participants.

4.4.1. Stimulus design

The stimulus comprised of two main sections: Picture-Naming (PN from here after) and an elicited spontaneous speech sample (SPON from here after). The PN task was designed to target each Najdi-Arabic (NA from hereafter) consonant in four syllable/word positions: Syllable-Initial Word-Initial (SIWI), Syllable-InitialWithin-Word (SIWW), Syllable-Final Within-Word (SFWW), and Syllable-Final Word-Final (SFWF) in addition to six consonant clusters in Word-Initial (WI) position and eight clusters in Word-Final (WF) position (Appendix-E). Twelve multi-syllabic words in the PN task also intended to assess phonologic consistency, and therefore were targeted three times. The picture book contained 55 pages and targeted 70 words chosen from JISH Arabic Communicative Development Inventory (Dashash and Safi, 2014) to ensure younger children's familiarity with the items and also to reduce the likelihood of prompting. Forty-one pages targeted individual utterances, eight pages targeted two, two pages targeted three, and finally a single page had pictures of four different animals all of which were target utterances. All images used were professionally photographed and copyright purchased online from www.shutterstock.com (see Appendix-F for more details and copyright proof of purchase).

Figures 4.1 and 4.2 provide specifics on word-types and number of syllables of target words included in the PN stimulus. Finally, the ease of picture representation and verbal elicitation played a vital role in choosing target words. Words that were more problematic to prompt or had known colloquial equivalents were excluded.

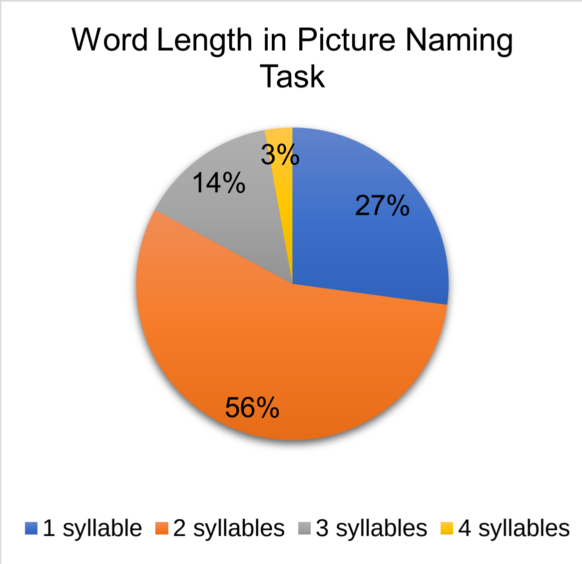

Figure 4.1. Word length in Picture Naming task

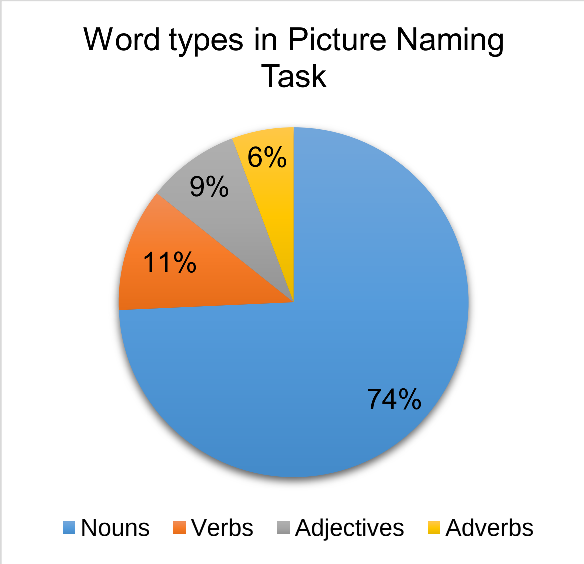

Figure 4.2. Word types in Picture Naming task

Then the SPON sample was elicited via using a story book and an age appropriate toy for at least 20 minutes. In this study, a wordless storybook (Frog, Where Are You?) By Mercer Mayer followed by a play activity with toys: Fuzzy-felt Farm Animals were used with children above three years old and LEGO DUPLO Number Train for the younger children. Also, a series of open-ended question and/or drawing activity using Crayola Beginnings First Markers (8 Pack) were often used to create additional conversational opportunities.

4.4.2. Protocol

On the day of recording, the researcher visited the participant's classroom and arranged with the teacher the best suitable time to remove the participant out of the classroom avoiding meals, nap and play times in addition to any important classes or rehearsals. On the agreed time, the child would then be escorted by the researcher to the designated area where all recording equipment had been set up and provided with a brief explanation of procedure.

In each session, the researcher usually started with a warming up picture-naming task of two very easy items: banana and a cat followed by the targets of the PN task. In each recording, the researcher aimed have the child attempt to the phonologic consistency PN sub-list three times (which analysis was deferred for future studies), name a list of 19 mono-syllabic and 39 bi-syllabic words once (Appendix-D), and elicit a minimum of 20-minute speech sample via a semi-structured speech task. Furthermore, reinforcement, e.g. praise words and stickers, were provided regularly to maintain the structure of the session and child's continuous motivation. Figure 4.4 below defines the details and sequence of the protocol as conducted. In cases where a child was reluctant to participate and all attempts to start with PN task had failed, the protocol was modified accordingly. For example, starting with the SPON recording was easier for some shy or withdrawn children as they could not resist playing with the toys which then triggered the use of verbal communication.

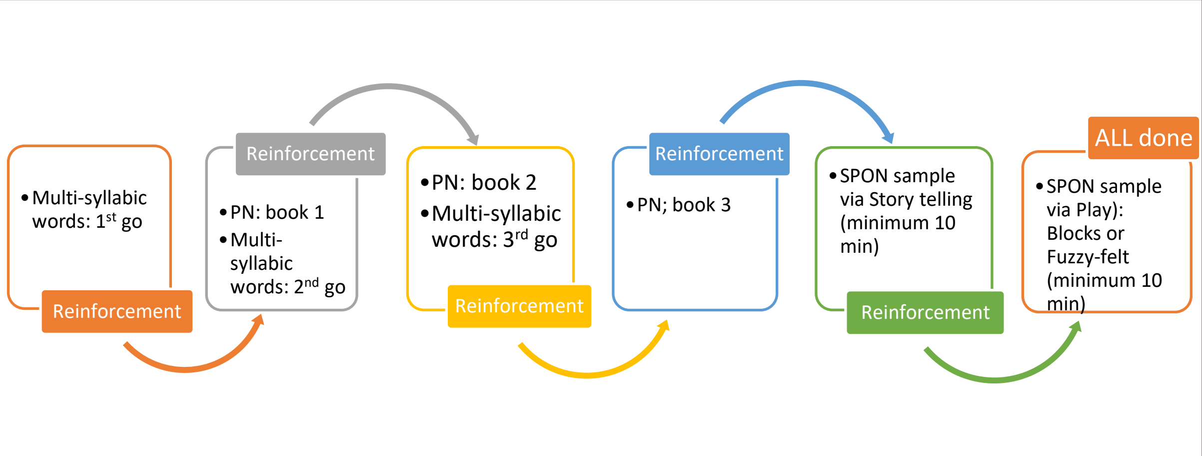

Figure 4.3. Data collection protocol

Following the successful completion of participant's recording, a "Thank you" letter/template (Appendix-G) was filled with the participant's name, date and time of recording then given to the child to provide to his parents. The letter also contained the expected date of the completion of the study and the contact information of the researcher should the parents need to discuss the child's participation.

Where a child who was reported to have age-appropriate communication abilities on the questionnaire but was later suspected otherwise by researcher and consequently excluded from the study the parents were contacted on the phone to set up a meeting on school premises to discuss their child's participation. Only when the parents refused/could not have a face-to-face meeting with the researcher, a date and time was set for a phone call to discuss the researcher's impression about their child's communication abilities. The researcher was very careful not to provide any diagnosis and only to provide an impression with strong recommendations of full assessment by a licenced SLT. After that, a sealed letter with a list of local private and governmental centres that provided speech-language therapy services was given to the parent/child. As the school system is different in Saudi Arabia to the United Kingdom, the researcher's impression about the child's communication abilities was not discussed with teachers or any school faculty. Such impression of a suspected communication difficulty by a qualified SLT, i.e. the researcher, could lead the school's administration to send in a request of a transfer of the named child to a mainstream school where a fulltime speech-language therapist works. This process was done to protect the child and maintain their privacy.

4.4.3. Elicitation procedure

It was desired that the participants would provide all PN target words spontaneously therefore a range of direct and indirect methods were employed in the elicitation process to ensure the child was entertained enough and did not lose interest. Below are some examples of techniques used, for the entire list see the examiner's protocol in Appendix-D.

- WH-questions: What is this? Where are the student and teacher?
- Listing with a raised tone followed by a pause: This is an apple, and this is a…?
- Taking turns naming body parts
- Can you name these animals for me?

Nevertheless, in cases when the child failed to name the item spontaneously, the researcher followed a five-step cuing protocol that allowed additional chances for a spontaneous production of the target word (Figure 4.4). Stages 1 and 2 below: No cues and Semantic cues respectively, were the desired spontaneous production whilst cues levels 3, 4 and 5: Phonemic cues, Forced alternatives and Imitation respectively, carry different levels of phonemic information facilitating the verbal production of the target word.

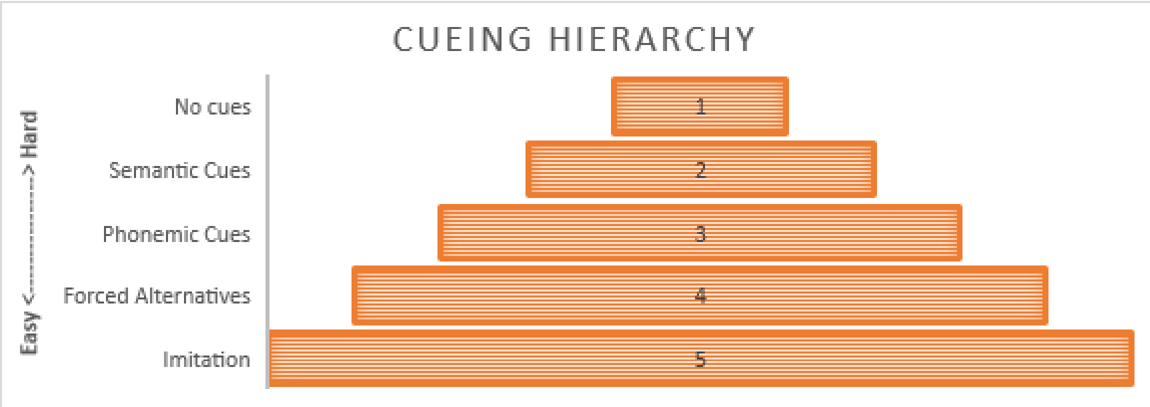

Figure 4.4. Cueing hierarchy

In semantic cuing, level-2, a description of the item or its function would be provided to the participant without providing any phonemic cues. On level-3, the first sound or syllable would be provided as a cue while in level 4 and 5, the full target word would be pronounced to the participant using either an obvious forced-alternatives technique or an imitation request. For example, the target word /kɪ.mɪθ.ra/ as in "pear" was often unrecognized by children in the younger age groups therefore the researcher elicited it by asking the child: "I know this is an apple, but can you tell me if this is a pear or a car?". This made the children laugh as the alternative choice was often a silly option which then added a few amusing moments and provided the children with a great sense of achievement. If even after that the child was unable to articulate the target word, the researcher would then ask the child to imitate her production "This is a pear. What is it?" or by a more direct approach "Can you say "pear" for me?

Once the picture naming task was completed, the story book was first presented to the child and the researcher started telling the story, describing only the events on the first page in order to give a model of what is expected from the child. The researcher used short but full sentences to describe the events in the story. Then the child was asked: "Can you tell me what happened next?". This process was repeated as needed throughout the task. Finally, the toy that best suited the child's age was presented and the researcher played alongside the participant whilst explaining what she is aiming for/doing. For example, on the Fuzzy Felt toy, the researcher explained to the child: "I will make a farm, with a barn and animals. What will you make?". Also, very often the researcher asked for the child's assistance on how to play, e.g. 'Can you tell me how to build a fence, so the cows do not escape?'. Such techniques often triggered a series of sentences that were spontaneous. Sometimes, when the SPON sample was too short or when the toys where too exciting and the participant was too involved to speak, they were removed. As an alternative, the researcher presented blank papers and colouring markers as she engaged in a social conversation with the child regarding their favourite food, toys, friends, family members or their daily routine using open ended questions.

4.5. Data Collection

Data collection for this study was conducted over a period of 16 weeks in the capital city of Riyadh-Saudi Arabia. All data was audio recorded using Edirol R-09HR Handheld SD Recorder and a Shure PG14/PG185 Lavalier wireless microphone system. The microphone was placed within 30 cm of the child's mouth on a specially designed vest or clipped to their clothing. When the child refused to wear the vest and/or have the microphone clipped to their clothing, it was either placed on the table or held in front of the child by the researcher. Additionally, all video recordings, when consented for by parents, were recorded using a Sony Handycam HDR-XR160E digital camera recorder on a tripod within 4-6 feet from the participant. Mostly the recordings took place in a waiting area that was empty during the day, the library, the pantry, a resource room or even a quiet corner in an open area. Each participant recorded was given a code number and all identification information removed from audio and video recordings. At the end of each day, all recordings were checked and downloaded on a password-protected external hard drive and then lableled using the same code number.

4.5.1. Recruitment process

Nurseries and kindergarten schools were contacted individually by the researcher to set up an official visit. During the visit, a "Purpose of the Study" letter (Appendix-A) was hand delivered to the administration explaining the nature and purpose of this study with a request to access school facilities and children for research purposes. If the headmistress agreed for the school to take part in the study, an "invitation to participate" letters attached to consent forms was then provided for school administration, teachers or distributed directly to potential participants (Appendix-B and C). The method of distribution depended highly on the school's policy.

In wave-1 of the recruitment process, three schools were approached to participate in this study. However, due to low response rate (see Figure 4.5), the researcher had to contact additional schools and nurseries to ensure the full number of participants was recruited within the timeframe of 16 weeks. Seven additional schools were approached, and five accepted to participate in the study. After the completion of wave-2 in the data collection process, still there was insufficient number of participants especially in the youngest two age groups. In Saudi Arabia, such young children are typically found at home. This is an expected outcome to the extended maternity leave system in Saudi Arabia that allows women to have up to three years of paid maternity leave during their career service irrespective of how many children they have. The researcher therefore reached out to friends and family in wave-3 to complete the recruitment of the remaining twenty participants. An introductory message was written in Arabic and sent with researcher's contact information in addition to a copy of "Invitation to Participate in a Study" information sheet and consent form via WhatsApp to friends and family who in turn have forwarded it to their friends and family. As a result, the exact number of individuals who have received this invitation is unknown. Only those who have contacted the researcher with interest to participate were counted. The researcher then went through the consent form verbally over the phone with the parent to ensure the child fulfilled the criteria of the study in hand before setting up time, date and location for their child to participate. The researcher kept track of those who did not fulfil the criteria and were excluded even though a handwritten consent form was never completed by the parents. Seventeen of the 20 friends and family recruits were recorded in their own home and three were recorded at the researcher's residence in the presence of the mother. Figure 4.5 below demonstrates the data collection process. In the same figure, notice that the number of recruits exceeds the number of the participants in the current study because the initial study design aimed to recruit 84 participants in seven age groups with a sub-group of 12 children recorded three times for the purpose of longitudinal data comparison . Finally, there were a few occasions where children have consented to participate but not recruited due to the saturation of the age-groups. These consents are not presented in the figure below.

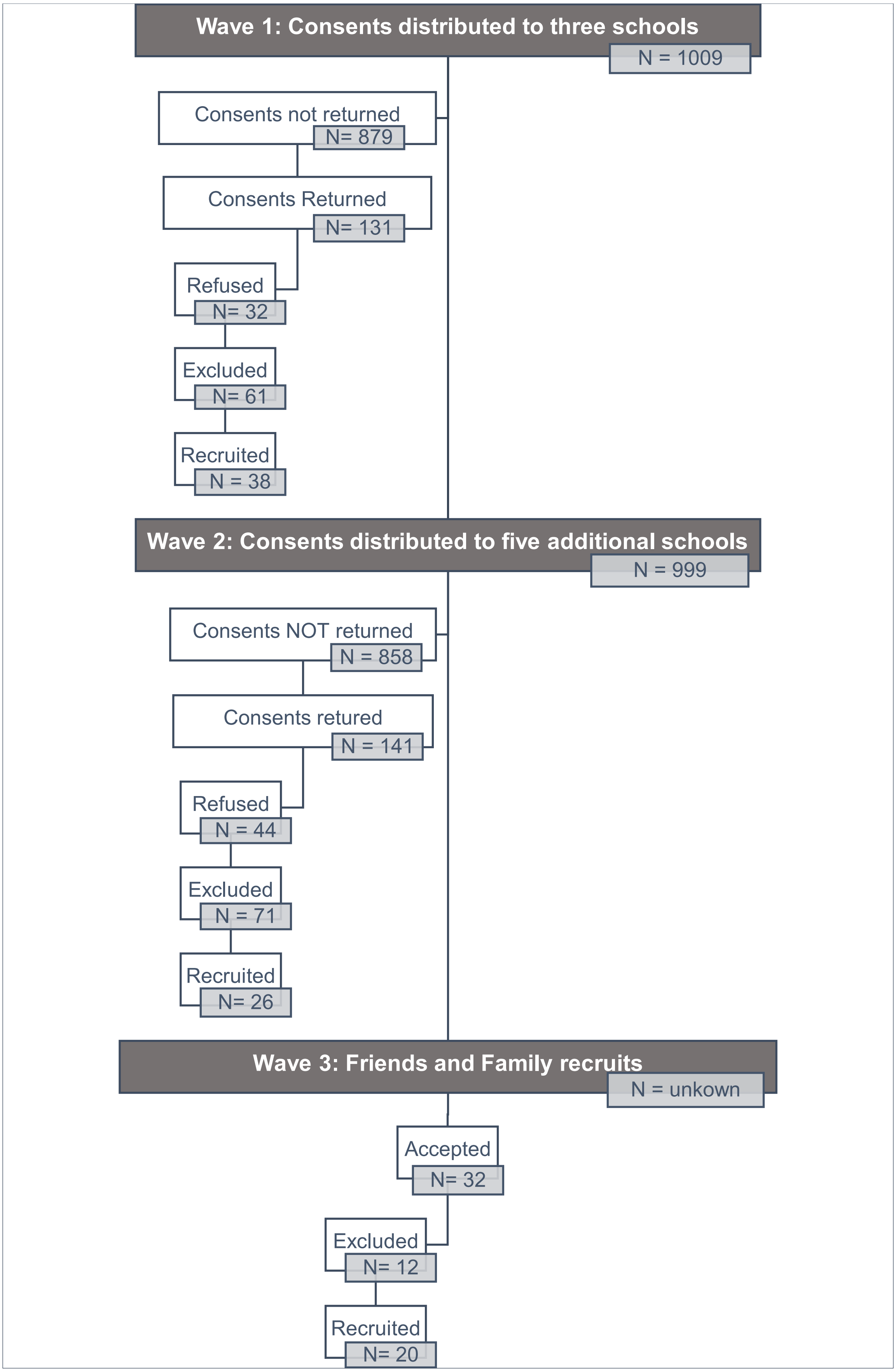

Figure 4.5. Data collection process. Key: N= Number of consent forms/Potential Participants.

4.5.2. Participants

Sixty participants aged 1;10-4;02 years were recruited and grouped based on their age in five groups. There were twelve children in each age group, and all groups were gender balanced. Age groups were stratified based on six-month intervals with an age range of ±2 months. This design allows a two-month gap between successive age groups to ensure a discrete and clear distinction between them.

Table 4.1.

Cross-sectional Groups, Age Range, Mean Age and Number of Participants

Age Groups	Age range	Average age in years	No. of participants
Group-1	1;10-2;02	2;00	12
Group-2	2;04-2;08	2;06	12
Group-3	2;10-3;02	3;00	12
Group-4	3;04-3;08	3;06	12
Group-5	3;10-4;02	4;00	12

4.5.3. Inclusions and exclusions

Riyadh is in the heart of the central region of Saudi Arabia, it is also the biggest city and the capital of the country and families from all over the country moved to the capital city of Riyadh for different reasons whilst continuing the use their own dialect to communicate. Therefore, family's origin was used as an indicator of which dialect the family spoke at home. All participants recruited fulfilled the inclusion criteria that included: age, family origin, and language related criteria of which Arabic is:

- the mother tongue of both parents
- the child's first language
- the main language spoken at home

Moreover, all participants must not have had any history of any hearing and communication difficulties or any visual impairment interfering with their ability to identify printed material.

In exclusions, more than 50% were due to the age of the child. Most children were older than the oldest age group in the study and a small number of children fell between age groups. The second most common reason for exclusion was the family's origin. Accumulatively, all other exclusions comprised of 26% of those who agreed to participate in the study.

Furthermore, three male participants who only used pointing or jargon to communicate were excluded from Group-1 even though their parents did not report any concern about communication abilities. A study conducted in the UK showed that the communication abilities of young children were often informally assessed (using pictures and play to elicit speech) and the impression given based on clinical expertise was highly associated with speech/language difficulties confirmed via formal assessments 18 months later (Emanuel et al., 2007). Similarly, in the current study, the decision to exclude low-performing male participants in Group-1 was based on the clinical expertise of the researcher with the acknowledgement that this may bias the collected data to give a slight advantage for the male over the female participants in Group-1. However, including them was more likely to cause even more bias by giving a large false advantage for the female participants in the same age group. In a large normative study, such participants would have not been excluded and would have possibly formed the lower end of the normal curve. However, including them in the current study was not possible as it would have led to the potential loss of 50% of the male participants data in Group-1 as each age-group only had 6 same-gender participants. Moreover, the decision to exclude those low-performing participants with no intelligible speech was an attempt to err on the side of caution in case they were indeed delayed.

4.5.4. Challenges in data collection

Although every effort was made to collect the data in a quiet environment away from distractions and high levels of background noise, the researcher had no choice but to accept any location she was offered on school premises to record the sessions. As a result, the presence of background noise and distractions interfered with the quality of some of the recorded session. Moreover, upon the reviewing of recordings, there were three incidents where the audio files had been completely or partially corrupted for unknown reasons. Another problem that was revealed during data preparation is that the audio recorder had run out of battery and the recording of the session was incomplete. As a result, when the audio files were compromised, the participants were re-recorded in a different location or on a later date. In total, 12 participants were rerecorded: two in groups 1 and 2, one in group-3, four in group-4, and three in group-5.

Additionally, during data collection, it was noticed that the youngest three age groups did not respond appropriately to the forced alternatives technique in the PN task. Most children consistently repeated the last option while others consistently repeated the first. This was later discussed with the supervisors and panel members and it was decided that irrespective of the prompting technique all picture naming targets in those age groups must be labeled as an imitation when they were not produced spontaneously.

Furthermore, friends and family recruits unfavourably affected the data collection process in terms of time and expenses. Those participants were recorded upon the parent's preference at either their residence or the researcher's. Almost all families chose recording times between 16:00 and 20:00, which coincided with rush-hour times in city. As a result, no more than two participants per day could have been recorded due to the small window of time chosen by the families which subsequently made the recruitment of the remaining twenty participant a lengthy process. For each participant the researcher recorded in the comfort of their home, the researcher used the family car and driver to get there. Travel time, accuracy of directions and petrol expenses were the main issues for those recruits. In the rare event of the parents choosing to have their child recorded at the researcher's home, the cost and preparation time of refreshments served to the mother and child were an additional burden but a cultural necessaity.

4.6. Data Preparation

After all participants have been recorded, a project was created using PHON, a free software program used for the analysis of large phonological data (Hedlund and Rose, 2019). In the project, individual corpus was created for each participant and labelled using the same reference code of the recordings. Individual audio files were then attached to the sessions created within the corpus and labelled with the date it was recorded on. In the event of more than one audio recording/participant, multiple sessions would be created within the same corpus and labelled accordingly. Each audio file would then be segmented into sections focusing on isolating utterances. Different utterances where then labelled according to their type:

- SPON: for connected speech produced during the semi-structured speech elicitation task or spontaneous speech interrupting the picture naming task
- PN: Picture naming: for speech produced during the picture naming task of target words
- Extended PN referrers to speech produced during the picture naming task but missed the intended target word (not included in the analysis).

The transcription of sessions mainly relied on the audio recordings. In cases of ambiguous utterances, video recordings (when available) were reviewed utilizing contextual as well as visual cues to facilitate the understanding of misarticulated and difficult to identify speech. For each utterance, the researcher filled in the following tiers in PHON: IPA target, IPA actual, English translation, Language, Utterance type, and Missed PN. The tiers English translation, IPA target and IPA are relatively self-explanatory. However, in the language tier, three different types of utterances were encountered: Arabic (Ara), English (Eng) and utterances that have an Arabic target with a clear influence of the English language or vice versa (AE). For example, a child producing the target /ˈd͡ʒazmɪˌtɪk/ as [ˈʃuːzɪk] ‘your shoe’. All intelligible Arabic entries of either speech sample were included in the analysis. On the other hand, interjections, non-Arabic, and extended PN utterances were excluded from the analysis in the current study. In the missed PN tier, it was indicated which PN target was intended but not produced. This tier was particularly created for the purpose of assessing the ease of identification of PN targets used in the current study in future research. Furthermore, in the Utterance Type tier, a numeric value ranging between 0 and 9 was entered. Each numeric value corresponded to an utterance type corresponding to the level of prompting used (Table 4.2).

Table 4.2.

Key to the Scale Used to Define Utterance Types in PHON

Type Tier code	Meaning
0	Answering questions
1	Spontaneous naming
2	Semantic cues
3	Phonemic cues
4	Forced alternatives
5	Imitation
6	Refused to name
7	No response or unintelligible (unknown IPA target)
8	Self-corrected
9	Interjections

The cross-comparison between different tier values in different speech tasks was not possible during the time of the analysis due to the limitation of the software yet they were essential for future use in later versions of the software. As a result, no comparison was carried out between spontaneous and imitated utterances in the current study.

4.7. Transcription

The researcher, who is a native speaker of NA and an experienced SLT, transcribed all the sessions phonetically using the International Phonetic Alphabet (IPA) revised 2005) and the Extended International Phonetic Alphabet (E-IPA). All the entries in Phon of both the PN and SPON samples were transcribed using narrow phonetic transcription except for interjections and unintelligible utterances and included in the analysis. Two participants from the Group-1, and one participants from Groups 2, 3, 4, and 5 (i.e. 10% of participants) were randomly chosen and sessions were transcribed by another Saudi SLT who received two training sessions on data entry in PHON. The author’s transcriptions were hidden from the SLT, but all other tiers were visible. Interrater reliability was 97% for the broad transcriptions and 86% for the narrow transcriptions of the consonants. Appendix-H lists all phonetic symbols used in the transcription process.

4.7.1. Word identification

It was anticipated that some of the intended words by the children might be difficult for the researcher to identify especially in the occurrence of multiple mispronunciations. Video recordings were then used to identify contextual cues to aid in the word identification process. Also, during the recording of the sessions, when the researcher recognized the intended target word, she immediately articulated it. This was done with the intention to warrant an easier transcription process weeks or months later. In the cases of friends and family recruits, the mother was asked to clarify when the researcher failed to identify an utterance. These techniques were very helpful in identification of mispronounced words especially in young participants in Groups 1 and 2.

4.7.2. Gemination

All geminates in the IPA target were transcribed as two identical consonants with a syllable break symbol between them; i.e.: /ˈbatˤ.tˤa/ "duck". However, geminated consonants in the IPA actual were transcribed as a long or half-long consonant, i.e.: [bː] or [bˑ] consecutively. This method of transcription aimed to differentiate a stressed or a strong articulation of a consonant from those that are half-long or geminated, i.e. long. However, during the analysis, this transcription method proved troublesome in reports of consonant omissions/deletions. Phon software failed to recognise the length marks as gemination. Geminates produced correctly and transcribed as long consonants in the IPA actual were detected as deletion of the SIWW phoneme (see figure 4.6 below). As a result, all geminated consonants were re-transcribed in the IPA actual as two identical phonemes when correct and a single phoneme when gemination was lost. Consequently, half-long consonants were rarely transcribed and only in a non-geminated context when a child produced long consonants.

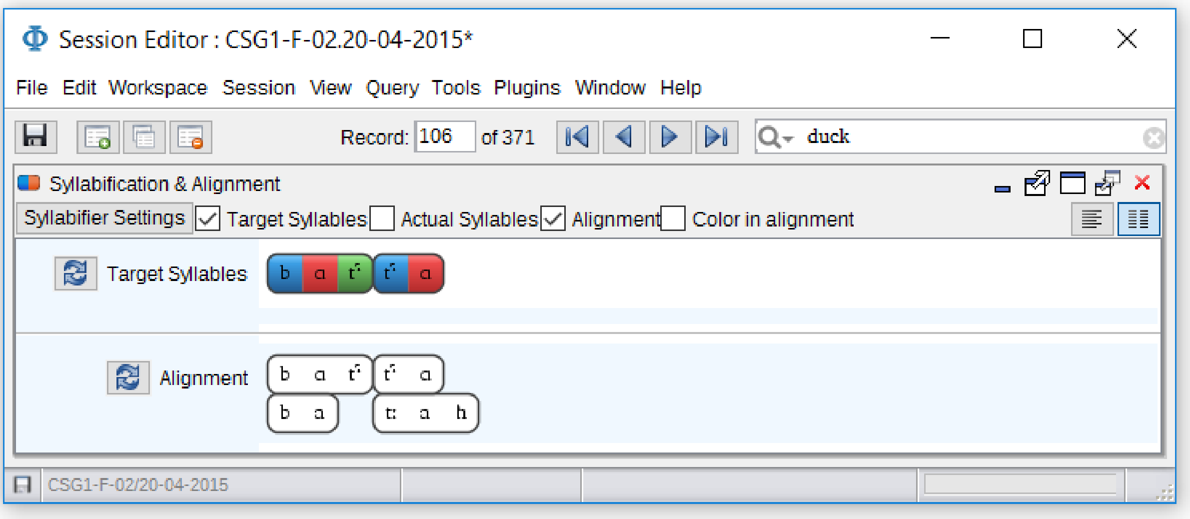

Figure 4.6. Phon IPA target and IPA actual alignment

4.7.3. Tap and trill distinction

The consonant ‘r’ is realised in Arabic as either a Tap [ɾ] or a trill [r]. The trill is often naturally realized in a geminated context or in SFWF position, e.g. [sˤur.rɑ] ‘navel’ and [mur:] ‘bitter’. In all other context, the Tap [ɾ] is realized. In data transcription, the realization of the Trill /r/ as an alveolar or a retroflex approximant [ɹ] or [ɻ] were also considered.

4.8. Analysis

In the current study, the analysis focused on three main components of the child’s phonological system: PCC, consonant acquisition, and the occurrence of phonological errors in addition to the reporting of the token frequency of consonants in the SPON sample. The following paragraphs define and briefly demonstrate how each is calculated.

The total of consonantal tokens in the IPA target of the entire SPON sample = 34076. Therefore, the token frequency of individual consonants was calculated using Phon *phone inventory* reports and calculated manually via applying the following equation:

$$Token\ frequency\ of\ the\ consonant\ X = \frac{total\ no.of\ \ consonant\ X\ occurrences}{34076} X\ 100$$

Similarly, PCC reports were created in Phon software using the *Tools* function and customized for a specific purpose; e.g. to specify a speech sample and syllable/word position (Hedlund and Rose, 2019). Results were then reported via implementing the principles of the following equation:

$$PCC = \frac{total\ no.of\ consonants\ correctly\ produced\ in\ IPA\ Actual}{total\ no.of\ consonants\ in\ IPA\ Target} X\ 100$$

Next, consonant acquisition in NA is reported in three competency levels: Mastery, Acquisition and Customary Production. For any consonant to be included in any of these groups, it must be produced correctly by 11/12 of participants in that age group, i.e. +90% of participants. Consonants that were judged as ***Mastered*** by an age group, had to be produced correctly +**90%** of time by 11/12 participants in that age group. Similarly, consonants that were produced correctly **75-89%** of the time by 11/12 participants were judged as ***Acquired***. And finally, consonants that were produced correctly **50-74%** of the time by 11/12 participants in the same age group were judged as ***Customary Produced*.** It is important to note that the group's average of correct production of the consonants was not considered in this analysis. Phon's PCC reports of individual consonants were used in the reporting of this section. Reports were then reviewed, and results computed manually using the following equation:

$$PCC\ of\ consonant\ X = \frac{total\ no.of\ consonant\ X\ correct\ productions\ in\ IPA\ Actual}{total\ no.of\ consonant\ X\ occurences\ in\ IPA\ Target} X\ 100$$

Finally, the occurrence of 14 phonological processes/errors involving singleton consonants and consonants clusters are reported, namely: Voicing, Devoicing, Velar-fronting, Coronal-backing, Glottalization, De-emphasis, Fricative-stopping, Deaffrication, Lateralization, and Liquid gliding/vocalization, singleton consonant deletion (SCD), weak-syllable deletion (WSD), Cluster Reduction (CR), and Cluster Epenthesis (CE). The definition of each error type is included in the reporting of the results in each corresponding section in chapter 6. All phonological error reports were created using *Phones query* and customized for a specific purpose, e.g. to specify a speech sample, singleton consonants vs. clusters, syllable/word position… etc. All results were reported via implementing the principles of the following equation:

$$Error\ occurrence\ = \frac{total\ no.of\ errors\ in\ the\ IPA\ Target}{total\ no.of\ possible\ error\ occurrences\ in\ the\ IPA\ Target} X\ 100$$

At the end, Phon reports were extracted in excel, reviewed and edited as required before they were imported and analysed in IBM SPSS Statistics 24 (IBM_Corp., Released 2017). It is worth noting that the founders of the Phon software provided continuous and individualized training for this project in addition to trouble-shooting support and throughout the analysis period.

Chapter 5. Results: PCC Correct and Consonant Acquisition

This chapter will present the results of the qualitative and quantitative analysis of this study in seven major sections. Section 5.1 presents the descriptive statistics of this study related to participant's demographics: family's income, parental education, maternal occupation and working hours, time spent with non-Arabic speaking carer, other languages spoken at home, and the distribution of residential of living districts of participating families. Section 5.2 present the results of IPA target and actual word count statistics, word length, type, and token frequencies. Then, section 5.3 presents the results of frequency analysis of consonants in the spontaneous speech sample in relation to positional and non-positional manner of articulation groups and individual consonant. Following, section 5.4 and 5.5 present the results of non-positional and positional PCC comparing speech-task, manner of articulation, age-group, and gender differences. Moreover, section 5.6 explores the correlation and associations between the demographic data in section 5.1 and PCC. Finally, section 5.7. presents the results of Najdi-Arabic positional and non-positional consonant acquisition while comparing the difference between speech-task, age-group, and gender.

5.1. Data Analysis Strategy

In each section of the analysis, the aim was to conduct parametric testing wherever the data allowed (i.e. ANOVAs). This was especially important to enable to author to fully explore the data and include tests of interactions. In order to determine whether parametric tests were appropriate, the following systematic approach was applied to each analysis. First, the data distribution was tested for normality for each dependent variable. Parametric test was conducted when all data was normally distributed. When this was not the case, the following decision-making sequence was applied. For data where all or the large majority of the groups had normal distribution, parametric tests were still applied as the analysis of variance is robust to some deviation from the normality assumption (Norušis, 2006). Similarly, parametric tests were also used disregarding the significant *p* value of Levene's test for equality of variance but only when the number of cases in each of the groups was identical (Norušis, 2006). In all other cases which the dependant variable did not meet these criteria, an attempt to transform the data was made. However, in cases where most of the data was not normally distributed even after using multiple data transformation measures, the analysis was conducted, and results were reported using non-parametric tests.

5.2. Participants and demographic data

In this section, the findings of participants' demographic details are presented: family income, parental education, maternal occupation and working hours, time spent with non-Arabic speaking carer, other languages spoken at home, and the distribution of residential of living districts of participating families.

5.2.1. Participant stratification

A total of 60 participants were recruited in this study and allocated to five cross-sectional age-groups with six-month intervals. Each group had 12 participants (six females and six males) and all participants spoke the Najdi dialect of Arabic. Children who predominantly spoke other dialects were excluded from the study, however, subtle influences of other dialects most likely caused by daily interaction with non-Najdi classmates, friends, or teachers cannot be ruled out. Table 5.1 below provides additional age-related details about each age groups.

Table 5.1.

Participants' Demographic Details in All Five Cross-Sectional Age-Groups

	G1[11]	G2	G3	G4	G5
Actual Group Age Range *(year; months)*	1;10-2;02	2;04-2;07	2;10-3;02	3;04-3;08	3;10-4;02
Actual Group Age Range *(months)*	22-26	28-31	34-38	40-44	46-50
No of participants	12	12	12	12	12
Gender ratio: *(Females/Males)*	6/6	6/6	6/6	6/6	6/6
Group's Mean Age (months)	24	30	36	42	48
Group SD of age	1.47	1.29	1.28	1.48	1.64

5.2.2. Family Monthly Income

[11] G = Group in all tables and figures from here after.

In the consent form, parents were asked: What is the sum of family's monthly income? Parents had to choose an answer from multiple choice options provided below:

(1) less than 10,000 SR
(2) 10,000-19,000 SR
(3) 20,000-29,000 SR
(4) 30,000-39,000 SR
(5) 40,000-49,000 SR
(6) More than 50,000 SR

Three of 60 families (i.e. 5%) did not answer this question. Figure 5.1 reveals the proportion of families falling into each family income group. From here, it can be concluded that over 61% of the families average monthly income is between 10,000 and 29,000 SR.

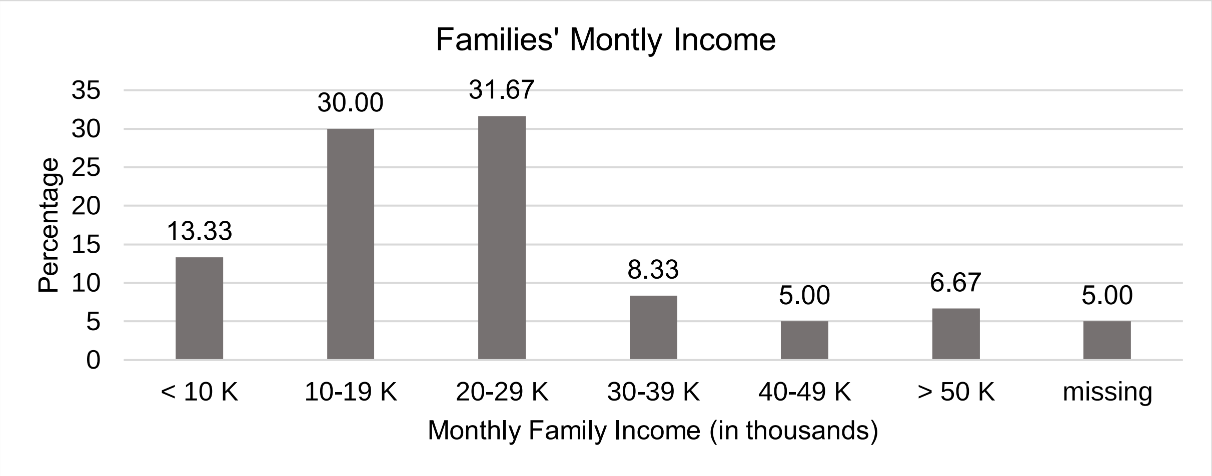

Figure 5.1. Proportion of families falling in each monthly income category. Key: K= 1000

5.2.3. Parents' Education

Also, in the consent form, the parents were asked to provide information about the last/highest maternal and paternal educational degree. Again, they were provided with multiple choice options/categories: Higher education, BSc, High-School, Less than High-school. One family did not provide information about mother's educational level i.e. 1.67% and two failed to provide information about father's education level i.e. 3.33%. Figure 5.2 below provides a comparison between the percentage of maternal and paternal educational level in each category.

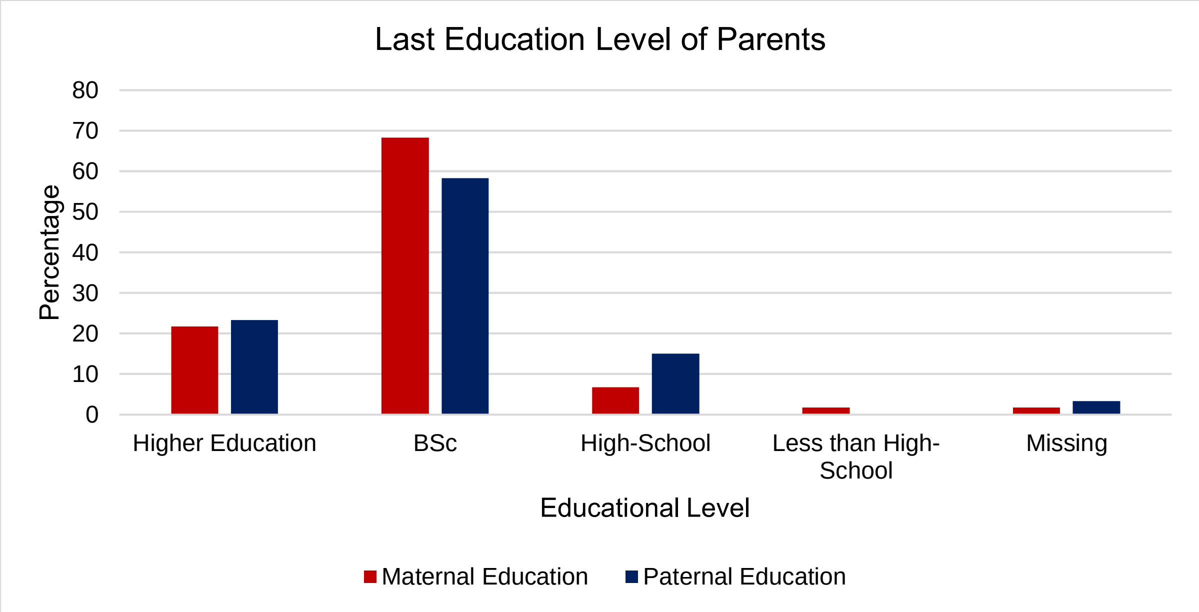

Figure 5.2. Percentage of maternal and paternal educational level in four educational categories.

From Figure 5.2 above, slightly more fathers have higher-education degrees i.e. 23.3% while only 21.7% of mothers do. On the other hand, 10% more mothers are bachelor's degree holders. Moreover, fathers were more than twice as likely to only hold a high-school degree i.e. 15% as the mothers whose last degree is high school does not exceed 7% in the sample. Lastly, none of the fathers of the participants had less than high-school education while 1.7% of the mothers did.

5.2.4. Maternal occupation and working hours

As majority of mothers in Saudi Arabia prefer full-time jobs that allowed them to be home before their children are back from school, full-time jobs were divided into two categories:

a. Full-time jobs which working hours ending at or before 14:00
b. Full-time jobs which working hours extended to at least 17:00.

The distinction between the two categories was made on the assumption that longer working hours are likely is to affects the amount of time spent with the children after school on daily basis. In figure 5.3, less than 12% of mothers are stay-at-home mothers, 6.7% work part-time and the majority of mothers are working full-time. Over 53% of mothers are working in jobs with short working-hours by nature 8:00-14:00 (i.e. 30 hrs/week). These jobs would normally be in the education system or government jobs. And finally, only 22% of mothers worked in a 45 hours/week jobs, such jobs are typically found in the medical field, banking, or in the private sector.

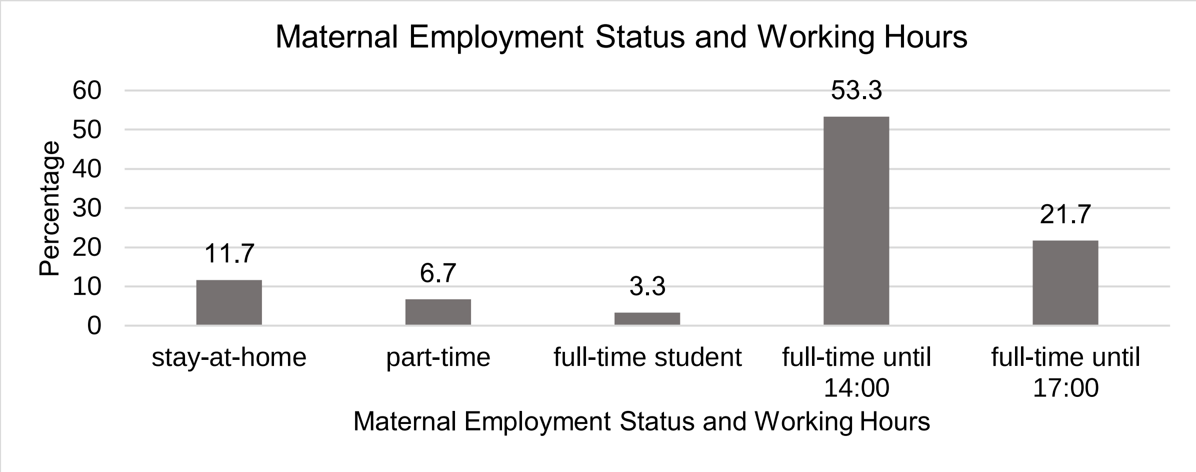

Figure 5.3. Maternal employment status and working hours

5.2.5. Time spent with a non-Arabic speaking carer

The family size in Saudi Arabia and in the Middle East in general is much larger than in western countries with an average of 3-4 children. Consequently, the hiring of a full-time nanny/domestic worker to take care of all the children is a money saving alternative for day-care/nursery costs. Most domestic workers are recruited from a non-Arabic speaking country, e.g. Philippines, Indonesia, Sri Lanka, etc. When the workers arrive in Saudi Arabia, they learn Arabic via daily interaction with the family. Occasionally, the domestic workers may speak some English which is then used as the main channel of communication with all the family members, including the children. It is suspected that the number of hours spent with a carer whose first language is not Arabic may influence the child's phonological development. Therefore, this hypothesis will be tested via exploring the association between the number of hours a participant spends with a non-Arabic speaking carer and their phonological development later in this chapter.

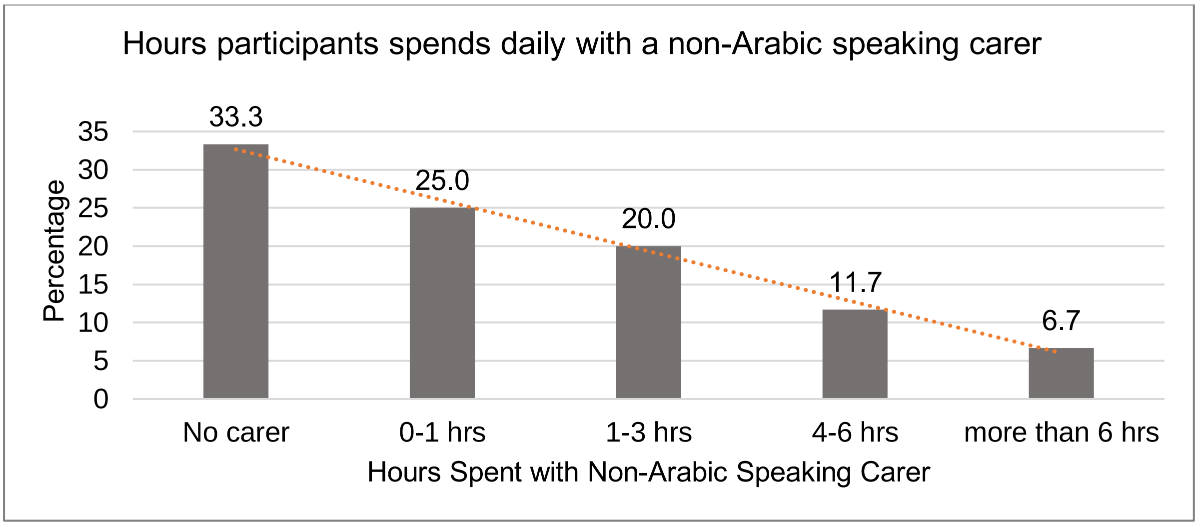

Figure 5.4. Number of hours participants spend daily with a non-Arabic speaking carer

Figure 5.4. shows that the over 58% of the participants spent 1 hour or less and only 6.7% of children spent 6 hours or more with non-Arabic speaking carer. There is a clear linear negative relationship between the proportion of children in each category and the number of hours spent with non-Arabic speaking carer.

5.2.6. Other languages spoken at home

English in the Kingdom of Saudi Arabia (KSA) is not a 'neutral' language. It is highly associated with political, religious, social, and economic implications. Today, English is the only foreign language taught at Saudi Arabian public schools. In 2003, English was approved to be taught in all primary public schools (grade 1-6). Nevertheless, English has been routinely taught at a very young age in private schools as early as 1970s. Although it is not declared as an official language in Saudi Arabia, English is the primary language used in international trading, international political communication, banking, hospitals, and very often in the private sector too.

In the last decade, at a social level, English has been associated with higher educational and socioeconomic status. As a result, it has been used often in social interactions and between family members. Consequently, the current study also aimed to explore whether the frequency of using other languages on a daily basis at home is be associated in anyway with the phonological development of the participants. Figure 5.5 presents the proportion of families that spoke other languages (mostly English) on daily basis. The majority of families rarely (41%) or never (28%) spoke in a language other than Arabic with/to their children. Please note that that two of the participating families, i.e. 3.3% failed to provide information about their language speaking habits at home.

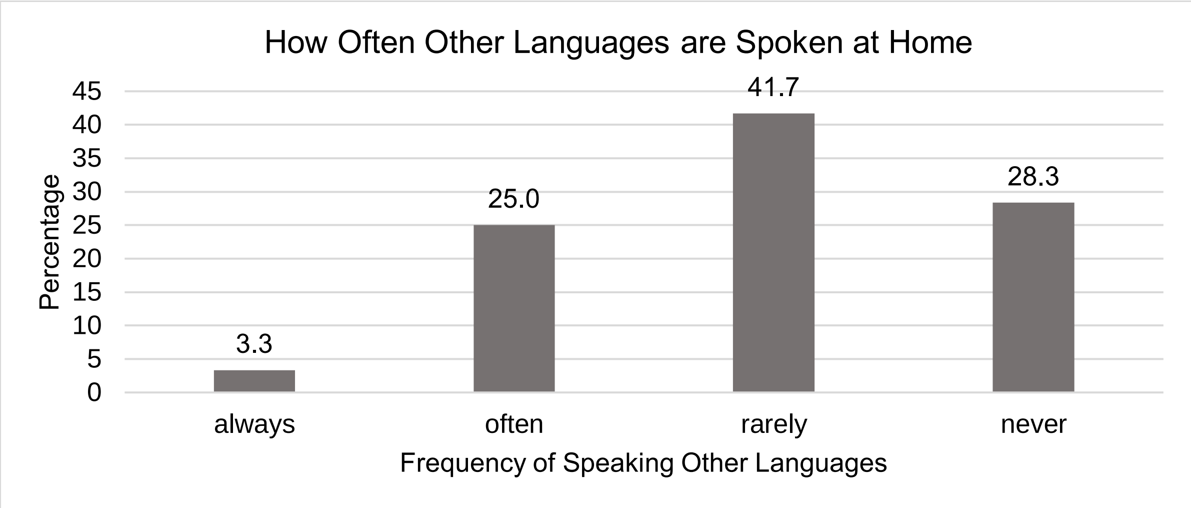

Figure 5.5. The frequency of how often other languages spoken at home.

5.2.7. Distribution of residential districts of participating families

This section explores the residential district for families in relation to the proportion of participants living in six main districts in the capital city of Riyadh: Northern, Southern, Eastern, Western, Central, and Other. Three of the participating families, i.e. 5%, failed to provide information about their residential living district. Moreover, over 73% of the participating families lived in either the Northern or Eastern regions of the capital. This does not reflect the distribution of the general population in the capital. However, it is can be explained via location of the participating schools which were mainly in the Northern and Eastern regions.

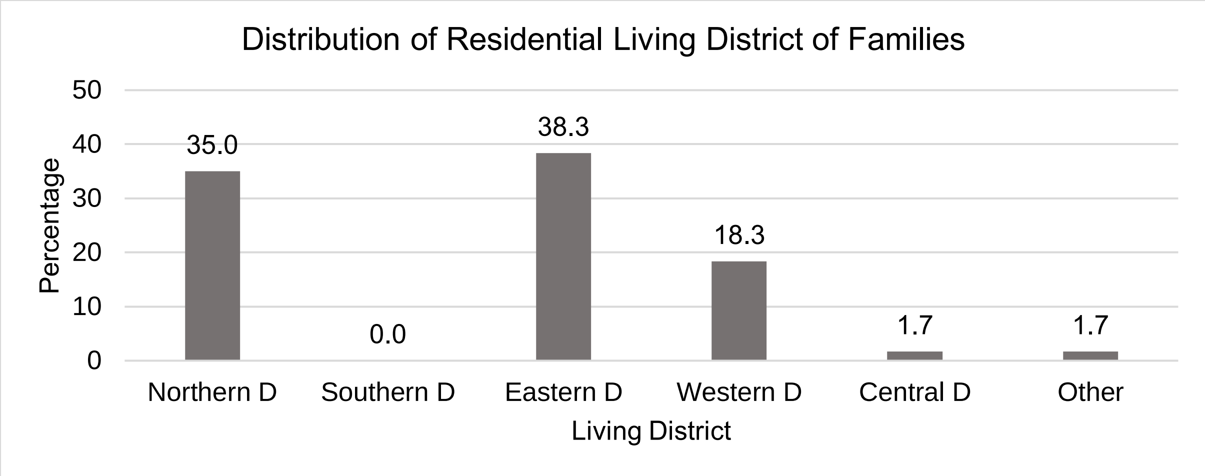

Figure 5.6. Proportion of participating families falling into each residential district of the Capital: Riyadh. Key: D= District.

5.3. General statistics

This section provides general descriptive statistics about the corpora collected including word count, languages in the sample, word length, type and token frequency of words.

5.3.1. IPA Actual word count and languages in the sample

This section presents the findings of word count and language choice by the participants in the entire corpora then differentiated by speech-task: Picture naming (PN) and the Spontaneous sample (SPON). The focus here is on ‘words’ which is identified in the current study as the orthographic words, including all affixes and morphological material. Table 5.2 presents the total number of words produced by the participants’ in each age group in both languages: Arabic and English. Arabic words consisted of a minimum of 98.67% of the sample irrespective of speech task. Additionally, a sizable increase in word count between age groups is obvious in Group-2 (average age 2;06 years) which is more evident in the PN task with a 42.6% increase (see tables 5.3. and 5.4. below) suggesting that 2;06 years is a critical age for language acquisition and vocabulary growth.

Table 5.2.

Total Words Produced by All Participants in All Speech Tasks.

All tasks	**Arabic word count**	**% Arabic words**	**English word count**	**% English words**	**Total word count**
G1	3557	98.42	57	1.58	3614
G2	5006	97.51	128	2.49	5134
G3	5975	98.26	106	1.74	6081
G4	6597	99.17	55	0.83	6652
G5	6943	99.53	33	0.47	6976
TOTAL	*28078*	*98.67*	*379*	*1.33*	*28457*

Table 5.3.

Total Words Produced by All Participants in PN Sample.

PN sample	**Arabic word count**	**% Arabic words**	**English word count**	**% English words**	**Total word count**
G1	760	99.22	6	0.78	766
G2	1325	98.29	23	1.71	1348
G3	1522	97.88	33	2.12	1555
G4	1515	99.08	14	0.92	1529
G5	1435	99.24	11	0.76	1446
TOTAL	*6557*	*98.69*	*87*	*1.31*	*6644*

Key: PN= Picture Naming.

Table 5.4.

Total Words Produced by All Participants in SPON Sample.

SPON sample	**Arabic word count**	**% Arabic words**	**English word count**	**% English words**	**Total word count**
G1	2797	98.21	51	1.79	2848
G2	3681	97.23	105	2.77	3786
G3	4453	98.39	73	1.61	4526
G4	5082	99.20	41	0.80	5123
G5	5508	99.60	22	0.40	5530
TOTAL	*21521*	*98.66*	*292*	*1.34*	*21813*

Key: PN= SPON= Spontaneous

5.3.2. *IPA Target word count*

In this study, there was a grand total of 28,609 Arabic words (14,231 words targeted by the female participants and 14,378 targeted by the male participants) that have been included in the analysis. In this section, general word count is reported followed by proportional word count in relation to the number of syllables in the words. Finally, an additional analysis of token and type word frequency and ratio between them is also reported.

Table 5.5.

IPA Target Word Count in PN and SPON Samples.

All tasks	G1	G2	G3	G4	G5	TOTAL	%
PN	776	1354	1563	1530	1460	6683	23.36
SPON	2863	3817	4560	5140	5546	21926	76.64
Total	*3639*	*5171*	*6123*	*6670*	*7006*	*28609*	*100*

Key: PN= Picture Naming, SPON= Spontaneous.

As seen in the table 5.5, 76.64% of the data comes from SPON sample. Although only comprising of 23.36% of the data, the PN sample allowed unique insight to the analysis especially evident in PCC and consonant acquisition (sections 5.5, 5.6, and 5.7 respectively) that is unlikely to be grasped via the analysis of SPON alone.

5.3.2.1. Word length

This section presents the findings of word length proportion in both speech samples. The PN task was designed to target all Arabic consonants in all syllable/word positions, consonant clusters, and a phonological consistency task. Table 5.6 shows that single and multi-syllabic words are overrepresented in the PN sample and as a result the proportions in word-length categories is expected to differ from the SPON sample.

Table 5.6.

Target Word-Length Proportion in PN Task.

PN targets by syllables	**Intended target for**	**No word types (repetitions)**	**Word tokens**	**Proportion**
Mono-syllabic	Word-initial clusters & singleton consonants in word-final position	6 (x1)	19	20.21%
	Singleton consonants in word-initial position & word-final cluster	8 (x1)		
	Singleton consonants in specific positions	5 (x1)		
Di-syllabic	Singleton consonants in specific positions	39 (x1)	39	41.48%
Tri-syllabic	Singleton consonants in specific positions & phonological consistency	10 (x3)	30	31.91%
Quadri-syllabic	Singleton consonants in specific positions & phonological consistency	2 (x3)	6	6.38%
Total		*70*	*94*	*100%*

Key: PN= Picture Naming

As expected, multi-syllabic words had a much higher proportion in the PN sample than in the SPON sample in all age groups. This is due the inclusion of a sub-list of 10 multi-syllabic words (repeated 3 times) for the purpose of assessing consistency of phonological errors. Table 5.7 below shows that the proportion of 3-syllable and 4-syllable words in PN sample is much higher across all age groups. It is also notable that disyllabic words had the highest proportion across all age groups in both speech samples. On the other hand, mono-syllabic words have the second highest proportion in the SPON sample whilst mono-syllabic and tri-syllabic words compete to hold the second highest proportion of the PN sample.

Table 5.7.

Word Length Proportion: PN and SPON Comparison.

Number of syllables	PN					SPON				
	G1	**G2**	**G3**	**G4**	**G5**	**G1**	**G2**	**G3**	**G4**	**G5**
1-syl	23.28	21.94	27.84	21.44	21.17	35.62	31.33	34.69	29.65	27.32
2-syl	53.82	45.51	44.38	42.88	42.47	53.96	56.38	52.87	54.28	56.00
3-syl	19.08	26.93	22.91	29.28	29.72	9.58	11.16	10.88	14.69	14.66
4-syl	3.82	5.62	4.87	6.41	6.65	0.81	1.07	1.49	1.21	1.97
5-syl	0.00	0.00	0.00	0.00	0.00	0.04	0.05	0.07	0.18	0.04
6-syl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02

Key: PN= Picture Naming, SPON= Spontaneous, Syl= Syllable.

In general, the average proportion of tri-syllabic words in the PN sample was more than double its proportion in the SPON sample. Also, the quadri-syllabic words were four times more frequent in PN sample than in SPON sample (Figure 5.7). Please note that 5-syllable and 6-syllable words only occurred in the SPON sample with very low rates thus are not represented in the figure below.

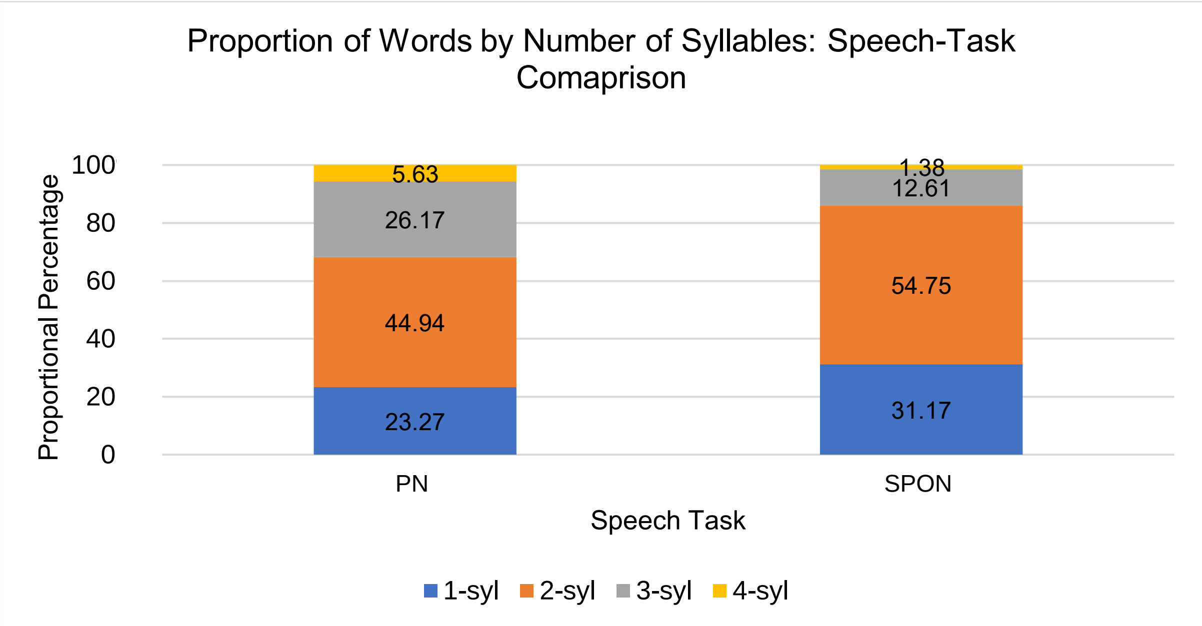

Figure 5.7. The proportion of words by number of syllables across all age groups: speech task comparison. Key: PN= Picture Naming, SPON= Spontaneous, Syl= Syllable.

5.3.2.2. Word type and token frequency

In Tables 5.8 and 5.9, the average word types in both speech tasks increase with age. However, in the PN sample, the average types appear to plateau at Group-3 (average age 3;00 years) whilst they keep on a steady increase with age in the SPON sample (Figure 5.8). This is most likely a result of near complete lexical acquisition of PN targets by the age of 3 years. Although all target words in the PN task have been carefully chosen from the JISH Arabic Communication Development Inventory which was based on the MacArthur-Bates Communicative Development Inventories (MB-CDIs), there was no guarantee that younger participants would have acquired them and/or even attempt to produce them during data collection sessions.

Table 5.8.

Word Type and Token Frequency: PN Sample.

PN	**G1**	**G2**	**G3**	**G4**	**G5**
Average tokens	63.50	110.42	126.83	126.25	119.58
SD Tokens	39.13	32.73	32.37	45.39	21.41
Average types	49.25	75.08	85.17	85.17	85.33
SD Types	27.19	20.41	12.34	12.34	12.46
Ratio Average	0.80	0.69	0.69	0.71	0.72
Max Ratio	0.95	0.80	0.85	0.80	0.78
Min Ratio	0.66	0.59	0.55	0.47	0.58

Key: PN= Picture Naming, SD = Standard Deviation, Max= Maximum, Min = Minimum

Table 5.9.

Word Type and Token Frequency: SPON Sample.

SPON	G1	G2	G3	G4	G5
Average tokens	233.25	306.75	371.17	423.50	458.08
SD Tokens	168.03	132.02	152.98	171.35	219.31
Average types	95.50	131.58	168.67	222.75	249.33
SD Types	72.64	49.37	83.40	83.40	101.27
Ratio Average	0.43	0.46	0.49	0.54	0.57
Max Ratio	0.62	0.62	0.81	0.72	0.73
Min Ratio	0.25	0.29	0.37	0.35	0.42

Key: SPON= Spontaneous, SD = Standard Deviation, , Max= Maximum, Min = Minimum

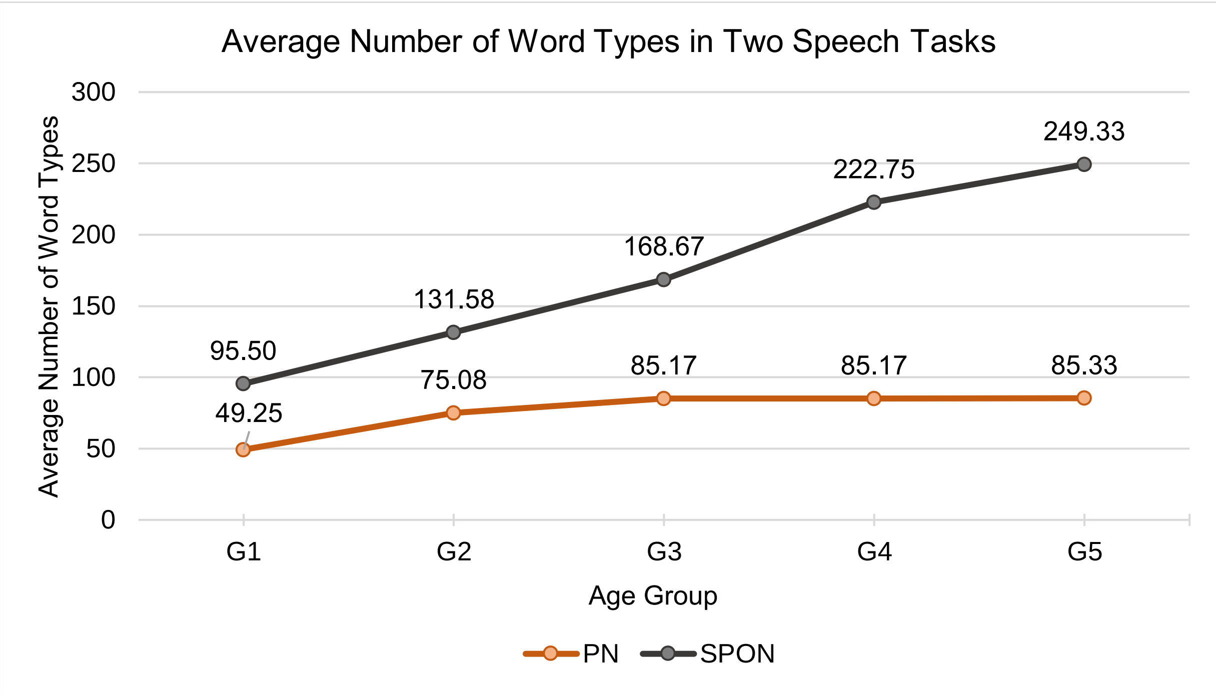

Figure 5.8. Average word types/age-group– speech task comparison. Key: PN= Picture Naming, SPON= Spontaneous

Finally, it is notable that word token/type ratio is higher in PN sample when compared in SPON sample across all age-groups. This difference was expected due to the nature of PN task which only allowed the repetition of a sub-list of tri-syllabic words when there was no control over what the participants produced repeatedly during the collection of the SPON sample. However, when word token/type ratio is compared in the SPON sample across all age groups, a gradual increase is observed from 0.43 in Group-1 to reach 0.57 in Group-5 (Table 5.9) whilst in the PN sample the token/type ratio fluctuates between age groups with a general tendency to gradually decrease with age (Table 5.8 above).

5.4. Frequency Analysis of Consonants

Consonant frequency have been argued to be an important contributing factor in the development of speech sounds by children (Demuth, 2007, Levelt et al., 2000, Levitt and Healy, 1985). The frequency of consonant occurrence is well documented in several of the world's languages however, it is not the case in Arabic. Alqattan (2014)is one of the few to report consonant occurrence frequency in Kuwaiti Arabic using spontaneous speech samples of 72 participants between the age of 1;04-3;07 years. In this section, the results of token consonant frequency are reported in the SPON sample only. Because the PN task has been designed to target all consonants in the Najdi dialect equally, the design undoubtedly interfered with both type and token consonants frequency. Consequently, the analysis of token consonant frequency in PN sample has been excluded. Section 5.4.1. below presents the general token frequency of consonants in the SPON sample corpora followed by the same calculations with syllable/word positions taken into consideration in section 5.4.2.

5.4.1. Token frequency of consonants in the SPON sample

In the current study, the token frequency of consonants was calculated from the targets of the child's own speech in the SPON sample in two contexts: in consonantal manner groups and for each consonant individually.

5.4.1.1. In relation to manner of articulation:

Figure 5.9 shows that fricatives were the most frequent (32.61%) in the sample (irrespective of word/syllable position) followed by stops and nasals: 26.71% and 13.70% respectively. On the other hand, affricates were the least frequent (1.04%).

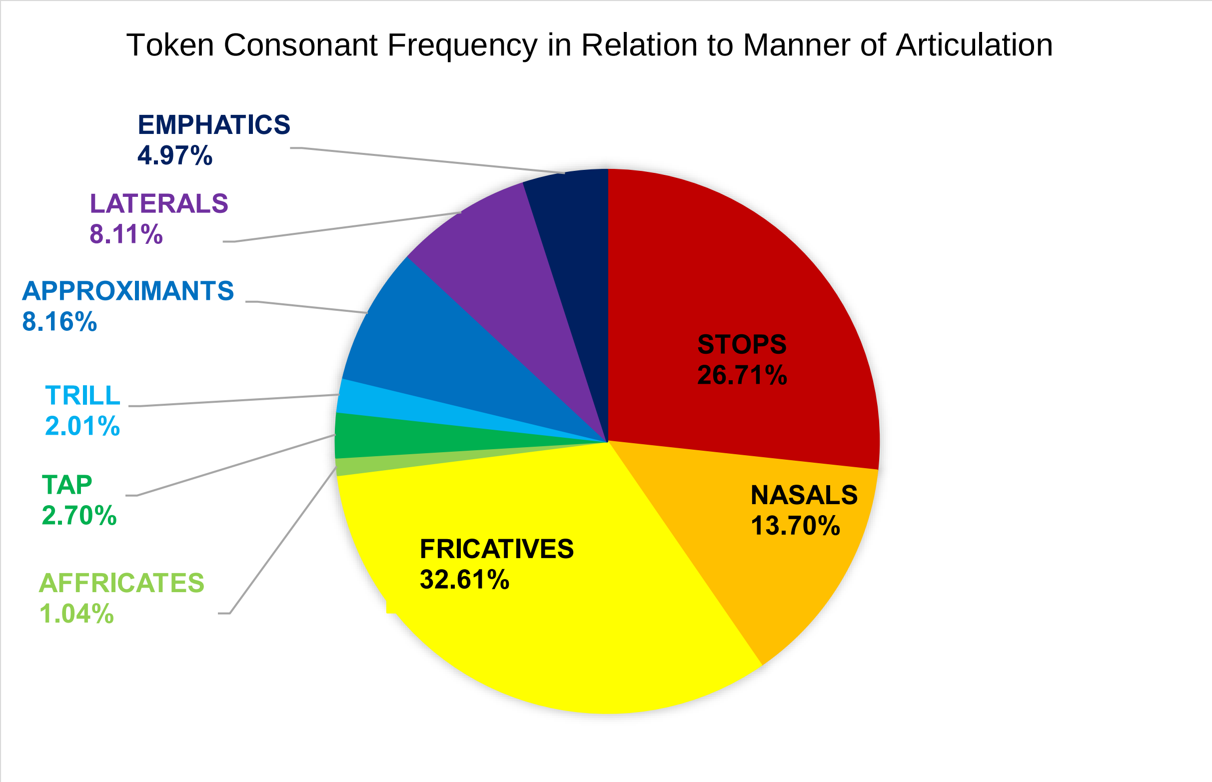

Figure 5.9. Proportional percentage of the frequency of nine manner of articulation groups in the Spontaneous sample.

5.4.1.2. Token frequency of individual consonants

In Figure 5.10, the token frequency of individual consonants in the SPON sample is reported irrespective of syllable/word position. The most frequent consonant in the sample is /n/, with frequency of 9.11% followed by two glottal consonants: the plosive /ʔ/ and the fricative /h/ (8.26% and 8.19% respectively). The consonants: /l/, /b/, and /ð/ also appear to occur frequently with token frequency value of 7.36, 6.74, and 5.33 respectively.

Moreover, the six least frequent consonants or consonant combinations are either non-Arabic /d͡z/ and /p/ that are produced in loan words i.e. /ˈbiːd͡zə/ for “pizza” and /ɑɪpad/ for “iPad” or a cluster created via truncated syllables: [st] as in /ˈstannɪ/ “wait for me” and [ɾt] in /ˈɾtaːħ/ “he is rested” or vowel syncope: [bʃ] as in /ˈbʃaʕɾɪ/ “in my hair” and [tʃ] in /ˈtʃiːl/ “she carries”.

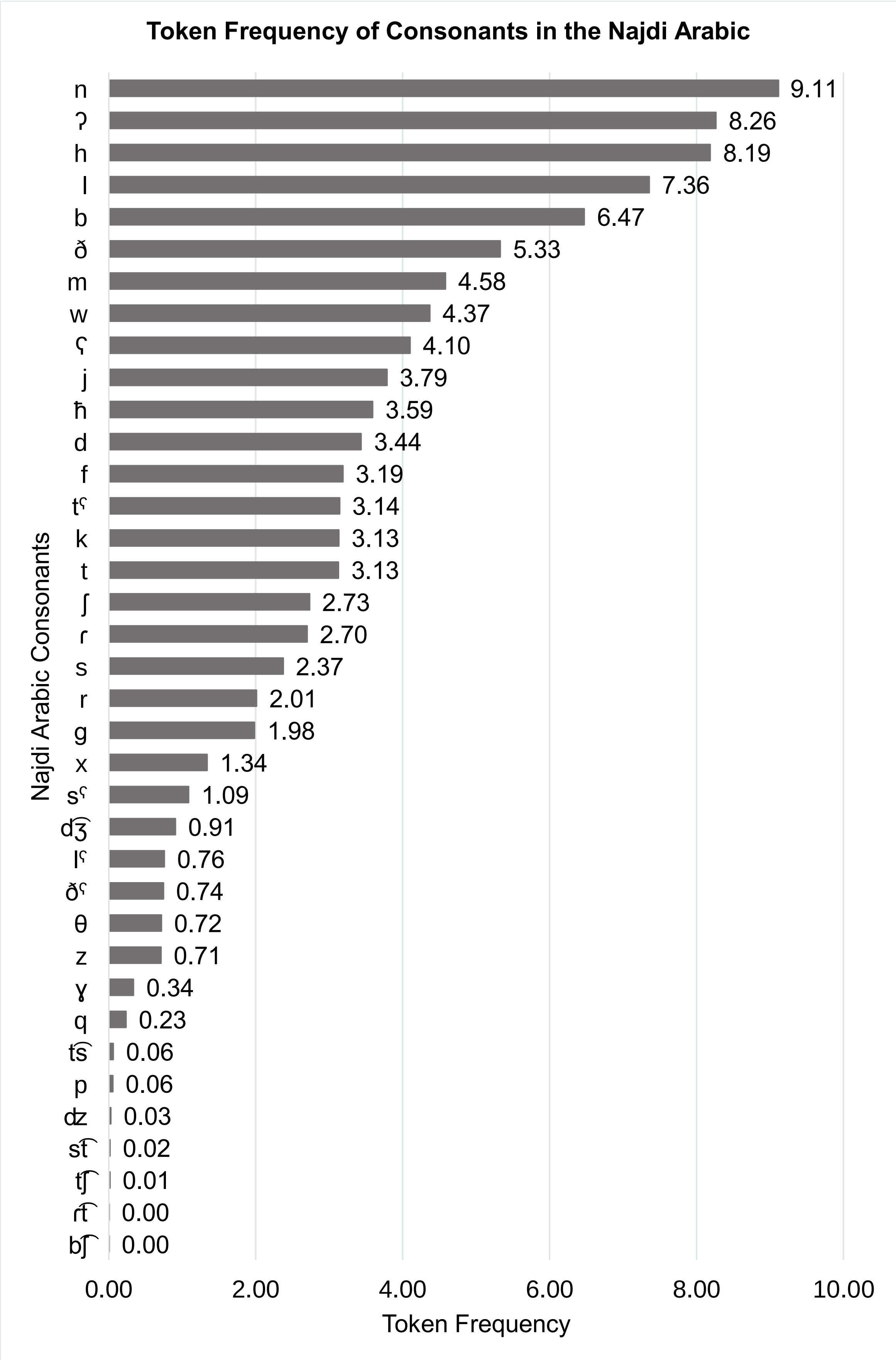

Figure 5.10. Token frequency of Najd-Arabic consonants.

5.4.2. Positional Token Frequency of Consonant

In this section, the positional token frequency of consonants in the SPON corpora is reported. Similar to the previous section, first the frequency of consonants in the consonantal manner of articulation groups is reported in section 5.4.2.1. followed by the positional token frequency of individual consonants in section 5.4.2.2.

5.4.2.1. In Relation to Manner of Articulation

Table 5.10 and Figure 5.11 (a., b. c. and d.) below present the findings of positional token frequency of consonant in relation to the manner of articulation. Similar to section 5.4.1.1. above, Najdi Arabic consonants have been divided into nine manner groups: Stops, Nasals, Fricatives, Affricates, Tap, Trill, Approximants, Laterals, and Emphatics.

Table 5.10.

Manner of Articulation Groups' Positional Token Frequency.

	SIWI %	SIWW %	SFWW %	SFWF %
Stops	37.07	21.42	14.34	26.02
Nasals	8.22	17.43	13.09	19.38
Fricatives	34.53	34.64	24.03	26.43
Affricates	1.21	1.19	1.01	0.37
Tap	1.23	5.88	1.76	0.00
Trill	0.02	0.53	3.97	8.43
Approximants	9.99	5.96	13.84	4.76
Laterals	4.44	7.93	16.66	10.66
Emphatics	3.30	5.03	11.31	3.94
Total %	100	100	100	100

Grey-shaded cells denote < 1% positional token frequency. Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

Figure 5.11.a shows that absolute onset: Syllable-Initial Word-Initial (SIWI from here after) position is predominantly occupied by a stop or a fricative (72% of the time). In contrast, in Figure 5.11.b, the word medial onset: Syllable-Initial Within-Word (SIWW

from here after) show that fricatives have the highest percentage token frequency of 35%. It is also notable that the trill /r/ does not occur in SIWI at all and occurs 1% of the time in SIWW (only as a result of a geminated trill). However, in both coda positions: medial coda; Syllable-Final Within-Word (SFWW from here after) and absolute coda; Syllable-Final Word-Final (SFWF from here after) fricatives have the highest token frequency amongst all manner of articulation groups (Figures 5.11.c. and 5.11.d). Although notably less frequently than in onset positions. Fricatives in coda positions constitute 24% of SFWW and 27% of SFWF consonants. Table 5.10 below constitutes of the exact token frequency percentages of all manner of articulation groups in all four syllable/word position.

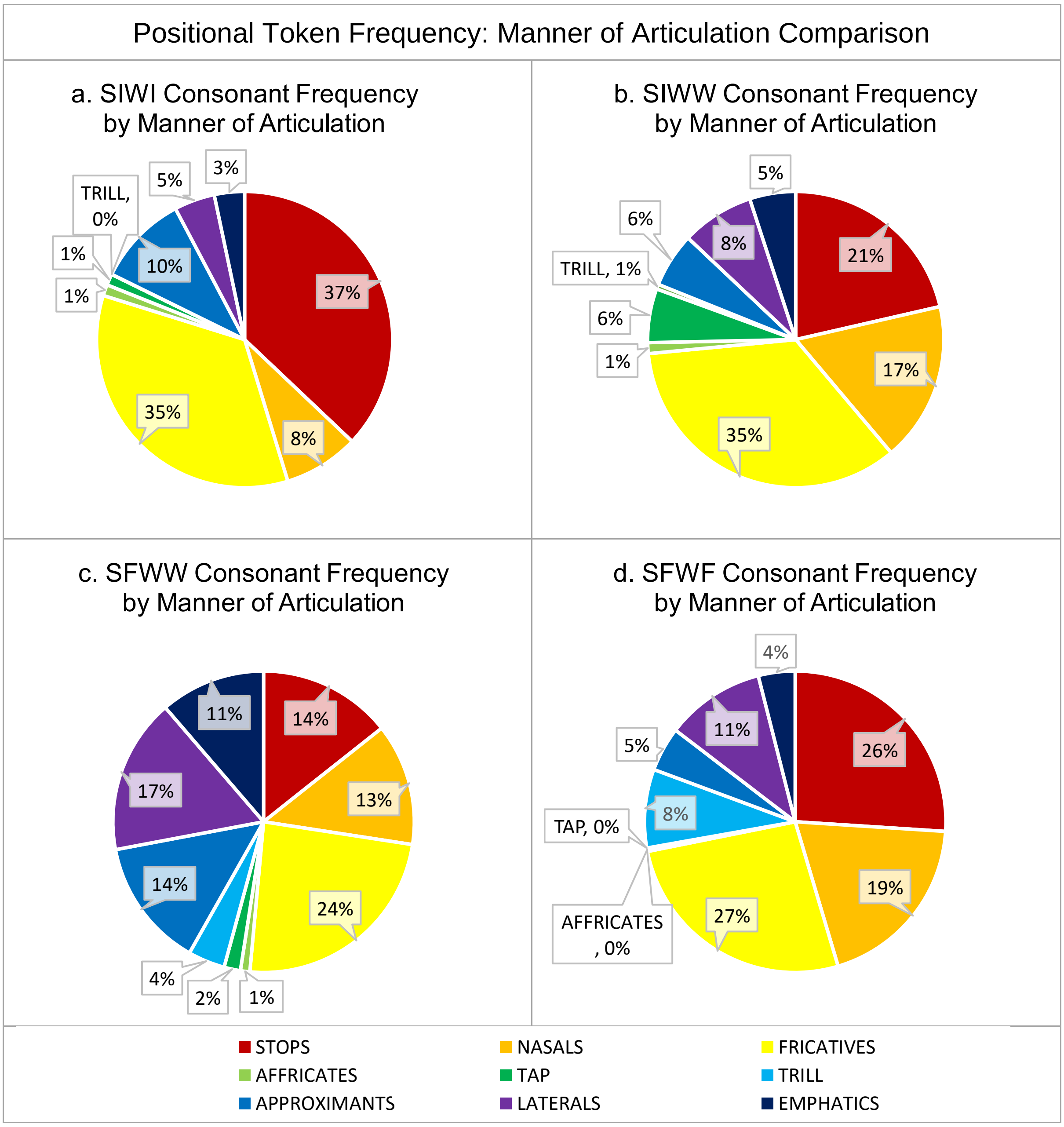

Figure 5.11. Positional token frequency of Najdi-Arabic consonants in manner of articulation groups. Key: SIWI= Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

Moreover, in Figure 5.12 below, the difference in the proportional distribution of manner of articulation groups in relation to syllable/word position can be appreciated. For example, proportionally, more than 65% of stops, nasals, fricatives, affricates, and approximants occur in SIWI or SIWW. Also, 90% of the tap /r/ tokens occur either in SIWI or SIWW positions, with the majority of tokens occurring in SIWW position. In contrast, the tap /r/ does not occur at all in SFWF. On the other hand, the trill /r/ favours coda positions in general (SFWW and SFWF) as it occurs more than 60% of the time in SFWF position and hardly occurred in SIWI position. However, when it did occur in SIWI position, it was the result of an assimilation process with SFWF trill of a proceeding word as in: [ˌbɪsmɪlˈlaːhɪr raħˈmaːnɪr raˈħiːm] “In the name of God”.

Also, in Figure 5.12, the distinction between onset and coda in word medial positions i.e. SIWW and SFWW respectively can be unmistakably appreciated. It is evident that SFWW has the least token frequency across most manner of articulation groups. Also, consonants in codas position i.e. SFWW and SFWF are by far less frequent than consonants in onset positions except for the trill /r/.

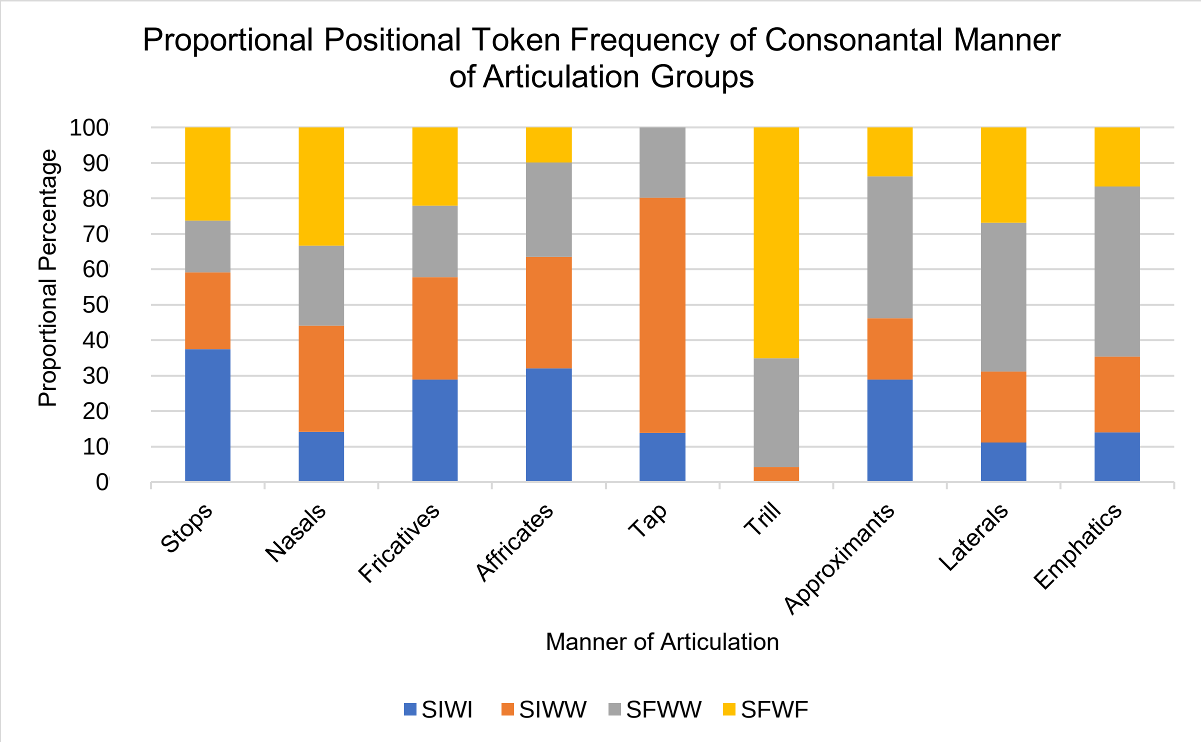

Figure 5.12. Proportional positional token frequency of consonantal manner of articulation groups. Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

5.4.2.2. Positional Token Frequency of Individual Consonant

In this section, the positional token frequency of individual consonants is reported. Figure 5.13 below presents the token frequency of each consonant in relation to four syllable/word positions: SIWI, SIWW, SFWW, and SFWF. The majority of consonants occur in all syllable/word positions except for three consonants:

- /lˤ/ only occurs in a few lexical items as a geminate in word medial positions: SIWW and SFWW. For example: /ˈwalˤ.lˤah/ "I swear", /ˈjalˤ.lˤah/ "let's go/hurry", /ʔalˤˈlˤa:h/ "God", /ʔɪˈsˤɑlˤ.lˤi/ "he prays" and /ʕabˈdɑlˤ.lˤɑh/ the male name "Abdullah".
- /ɾ/ and /r/ appear to be in complimentary distribution with one another. Whilst /ɾ/ does not occur in SFWF position and favours onset positions: SIWI and SIWW, /r/ does not occur in SIWI position (except when assimilated with a proceeding trill) and appears to favour coda positions in general: SFWW and SFWF.

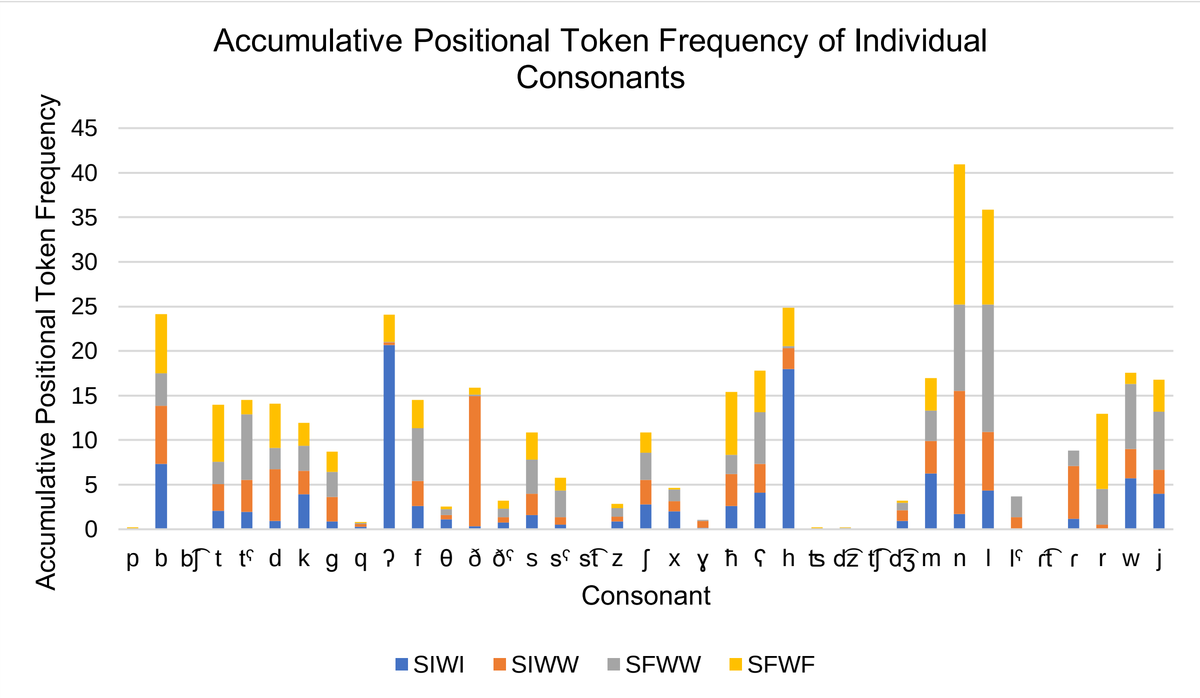

Figure 5.13. Positional token frequency of individual consonants. Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

In summary, in NA, fricative consonants were the most frequent in general (32.61%) followed by stops (26.71%). Fricatives were also the most frequent manner of articulation group in both SIWW and SFWW positions. Moreover, stops were found to be the most frequent manner group in the SIWI position. Both fricatives and stops were comparably frequent in SFWF. The least frequent manner group was the affricates. The affricate /ʤ/ is the most frequent amongst all NA affricates and yet, in the current study its token frequency is <1. The positional token frequency of manner of articulation groups was also informative with other manner groups, most clearly observed in nasal and emphatic consonants. Nasals were most frequent in SFWF and emphatics were most frequent in SFWW.

Moreover, the token frequency of individual consonant revealed that the 10 most frequent NA consonants include two nasals: /n/ (9.11) and /m/ (4.58), three fricatives: /h/ (8.19), /ð/ (5.33), and /ʕ/, two stops /ʔ/ (8.26) and /b/ (6.47), two approximants: /w/ (4.37) and /j/ (3.79) and one lateral /l/ (7.36). In contrast, the 10 least frequent NA consonants (token frequency <2) include two back stops: /g/ and /q/, four fricatives: /x/, /θ/, /z/, and /ɣ/, two emphatics: /lˤ/ and /ðˤ/, and the affricate /ʤ/[12]. Also, the positional token of frequency of individual consonants has uncovered a specific distribution of other consonants not allowed in specific syllable/word positions in the current study. For example, /lˤ/ never appeared at word boundaries, /r/ never in SIWI (except when geminated with a proceeding trill in SFWF), and /ɾ/ never in SFWF. The implications of the variation in the positional distribution of the token frequency amongst consonantal manner of articulation groups and individual consonants is discussed in more detail in chapter 7.

[12] Other less frequent consonants reported in figure 5.10 are: affricates resulting from dialectal syncope and non-Arabic consonants with token frequency <.01.

5.5. Percent Consonants Correct:

PCC is an accuracy production measure that can allow clinicians to assess the severity of their client's phonological impairment and monitor their progress objectively. Very often, PCC is used in SWAs as in the Diagnostic Evaluation of Articulation and Phonology-DEAP (Dodd et al., 2006) but it also can be calculated in a SSS. In normative studies, PCC has been used as a measure of phonological progression and maturity (Alqattan, 2014, Dodd et al., 2003, Owaida, 2015). The following section presents the results of PCC for all age groups with data collapsed across speech tasks and syllable/word position followed by speech-task, age-group, and gender comparison. Additionally, PCC is also reported in manner of articulation groups and for individual consonants.

5.5.1. All Speech Tasks in All Syllable/Word Positions

In this section, the main effect of age-group on the overall PCC is investigated. Then it is followed by exploring the effect of the gender of the participants. Figure 5.14 shows a steady increase of PCC over time. As expected, Group-1 have the lowest PCC= 54.79% and Group-5 has the highest PCC= 79.66%.

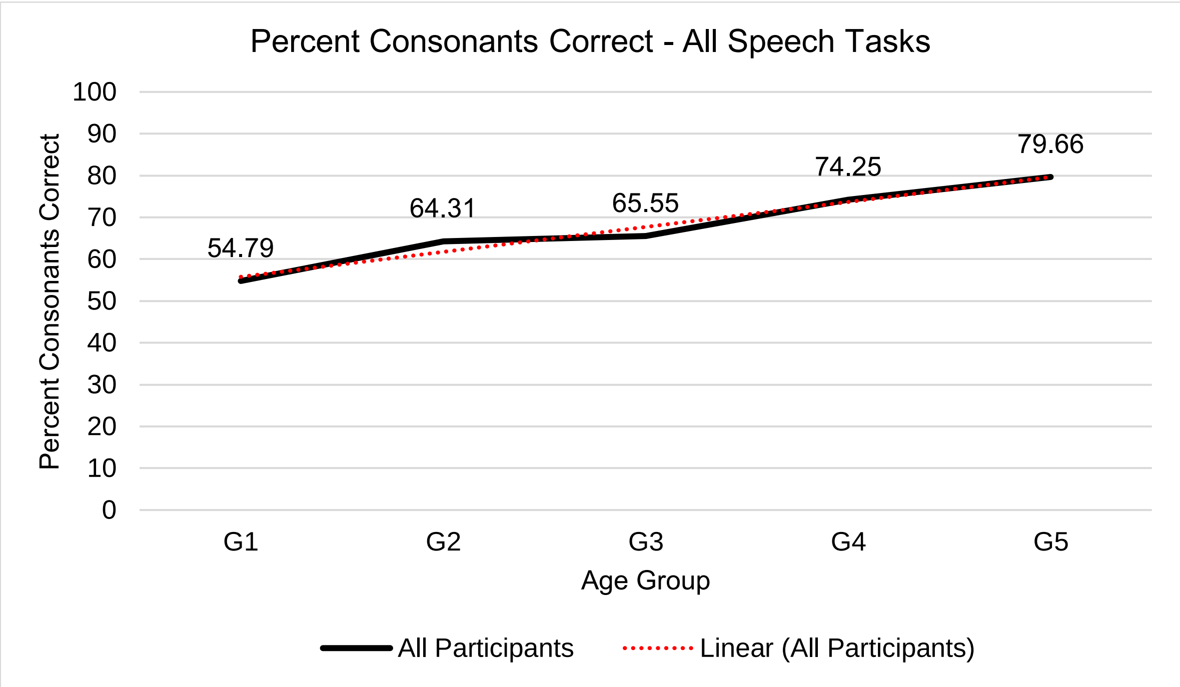

Figure 5.14. Overall PCC across all age groups.

Table 5.11 and Figure 5.15 highlight gender differences between all age-groups. Although the Group-1 means in both genders are very similar, the standard deviation (SD from here after) of each gender sub-group is not. The data points out a greater variation and individual differences amongst the male participants: male SD= 16.07 when compared to the female participants SD = 6.79. This could be the result of excluding three male participants who failed to produce any intelligible speech during the data collection session whilst none of the female participants in the same age group have been excluded for the same reason. As a result, Group-1 may appear to have three high-performing males. At the same time, PCC of females in Groups 2, 3, 4, and 5 is notably superior to their male peers.

Table 5.11.

PCC- All Speech Tasks – Gender Comparison.

Age Group	**PCC Females**	**SD Females**	**PCC Males**	**SD Males**	**PCC Group**	**SD Group**
G1	52.32	6.79	52.55	16.07	52.44	11.76
G2	65.15	10.02	57.30	12.47	61.22	11.54
G3	71.67	9.10	59.79	9.65	65.73	10.88
G4	78.26	10.39	67.49	14.34	72.87	13.20
G5	81.03	7.31	78.25	4.83	79.64	6.08

Key: PCC= Percent Consonants Correct, SD= Standard Deviation.

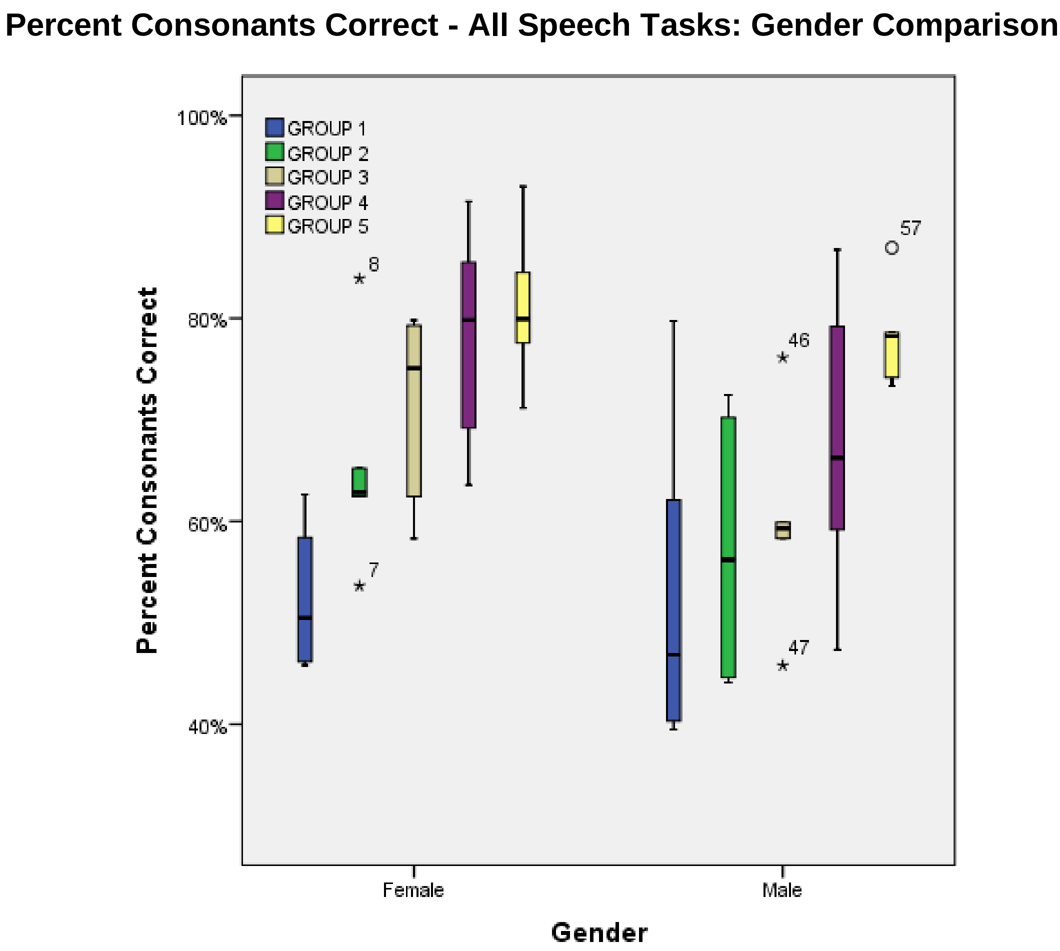

Figure 5.15. Percent consonants correct- all speech tasks- gender comparison.

The PCC data was normally distributed (see Appendix-I for details). As a result, a 2x5 two-way between-subjects ANOVA was applied with two between subjects' factors: gender with two levels (female; male) and age-group with five levels. The dependant variable was the PCC. The analysis revealed that the main effect of Age-Group was significant ($F(4, 50) = 11.689$, $p < .001$, partial $\eta^2 = .483$). Similarly, the main effect of Gender was also significant ($F(1, 50) = 5.810$, $p = .02$, partial $\eta^2 = .104$) however with low observed power = .657. Moreover, the Age-Group by Gender interaction was not significant ($F(4, 50) = .719$, $p = .583$, partial $\eta^2 = .054$). Finally, a Tukey Post Hoc test was applied to make pair-wise comparisons between the Age-Groups. Pairwise comparisons reached significance: $p < .05$ between Group-1 and Groups 3, 4, and 5, Group-2 and Group-5, and Group-3 and Group-5 (Table 5.12).

Table 5.12.

PCC Post Hoc Test between Age-Groups.

Age group	G1		G2		G3		G4		G5	
	MD	SEM	MD	SEM	MD	SEM	MD	SEM	MD	SEM
G1	NA		- 8.79	4.33	-13.29*	4.33	-20.43**	4.33	-27.20**	4.33
G2	8.79	4.33	NA		-4.50	4.33	-11.64	4.33	-18.41**	4.33
G3	13.29	4.33	4.50	4.33	NA		-7.14	4.33	-13.90*	4.33
G4	20.43**	4.33	11.64	4.33	7.14	4.33	NA		-6.76	4.33
G5	27.20**	4.33	18.41**	4.33	13.90*	4.33	6.76	4.33	NA	

*. The mean difference is significant at the .05 level. **. The mean difference is significant at the .01 level. Key: PCC= Percent Consonants Correct, MD = Mean Difference, SEM = Standard Error of the Mean, NA = Not Applicable.

5.5.1.1. PCC in relation to Manner of Articulation

This section analyses the same data in section 5.5.1. yet whilst taking the manner of articulation into consideration. Najdi-Arabic consonants are grouped into nine manner of articulations groups namely: Stops, Fricatives, Affricates, Nasals, Laterals, Tap, Trill, Approximants, and Emphatics (Table 5.13).

Table 5.13.

PCC Means in Manner of Articulation Groups.

Manner of Articulation	PCC Mean (%)				
	G1	G2	G3	G4	G5
Stops	51.51	60.79	66.42	75.12	80.40
Fricatives	16.97	33.31	41.39	53.21	67.32
Nasals	48.92	64.93	68.05	81.58	70.89
Affricates	1.25	20.35	22.03	37.08	48.73
Tap	21.75	29.78	56.88	64.58	80.99
Trill	8.33	47.89	56.49	57.76	75.69
Laterals	51.58	61.50	76.17	84.08	90.16
Approximants	57.12	67.52	67.64	84.57	85.46
Emphatics	6.04	20.74	30.74	51.09	66.84

Key: PCC= Percent Consonants Correct

As expected, Group-5 have the highest PCC average in all manner of articulation groups (except in nasals, see discussion chapter section 7.3.3. for more details) and Group-1 have the lowest PCC average in all manner of articulation groups. The greatest difference in PCC average between manner of articulation groups can be observed between Group-1 and Group-2 in fricatives, affricates, emphatics, and trill. While Group-1 (age range 1;10-2;02 years) hardly produced any affricates, emphatics, or trills and only a few fricatives correctly, Group-2 (age range 2;04-2;08 years) show a notable development in the awareness and consequently the correct production of consonants in these manner groups.

In Figure 5.16, the order of manner of articulation groups was rearranged according to their difficulty level based on the data in hand. As a consequence, it can be visually appreciated that affricates and emphatics are the most challenging in all age groups. Also, trill, fricatives, and tap are somewhat easier and the least challenging of all manner groups are: nasals, stops, laterals and approximants.

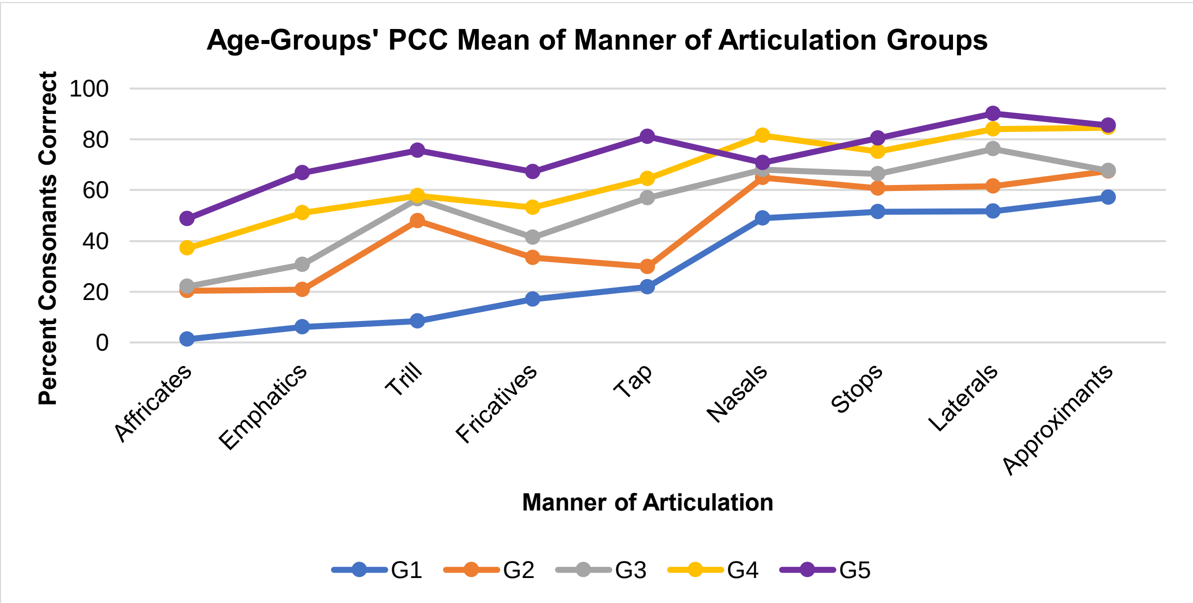

Figure 5.16. Average PCC in manner of articulation groups – all speech tasks. Key: PCC= Percent Consonants Correct.

The data of some manner of articulation groups: stops, fricatives, nasals and laterals is normally distributed. However, in all other manner of articulation groups (affricates, tap, trill, approximants, and emphatics) it is not normally distributed in all age groups (see Appendix-J for more details). Consequently, to be able to compare all manner of articulation groups to one another, Friedman's Test was completed to compare PCC in different manner of articulation groups in each age-group individually and collectively across all age groups. The results indicate significant difference between PCC and manner groups. In other words, different manner of articulation groups have different difficulty levels at each age group. Guided by the mean rank values in Table 5.14 below, manner of articulation groups can be ranked according to their difficulty. In general, affricates and emphatics have the lowest mean ranks in all age groups and thus are proven to be most challenging manner of articulation for the participants. On the other hand, approximants and surprisingly trill followed by stops and nasals have the highest mean ranks in all age groups suggesting that consonants falling into any of these manner of articulation groups are fairly easy and consequently are more likely to be produced correctly. Finally, the mean rank of the fricatives, laterals, and the tap are somewhere in the middle suggesting a moderate articulation difficulty.

Table 5.14.

Mean Rank, Chi-Sq, df, and p Value for Friedman's Test Results Comparing Manner of Articulation Groups.

	Friedman's Test results (Mean Rank)					
	G1	**G2**	**G3**	**G4**	**G5**	**All Groups**
Stops	7.33	6.41	6.33	5.50	5.50	6.15
Fricatives	4.33	3.45	3.17	3.00	3.42	3.43
Nasals	7.22	7.36	6.17	6.75	4.58	6.36
Affricates	2.00	2.64	1.75	1.92	2.04	2.06
Laterals	3.61	3.59	5.54	5.75	5.88	4.96
Tap	3.22	4.86	5.38	4.33	5.13	4.65
Trill	7.67	7.09	8.04	7.08	7.71	7.52
Approximants	7.22	7.09	6.46	7.50	7.29	7.11
Emphatics	2.39	2.50	2.17	3.17	3.46	2.76
N	9*	11*	12	12	12	56*
Chi-Sq	54.825	47.842	59.209	50.986	44.128	227.596
df	8	8	8	8	8	8
***p* value**	.000**	.000**	.000**	.000**	.000**	.000**

*Missing data/target not attempted affecting total *N* in the sample. **The mean rank is significant at the .01 level. Key: *N*= number of participants.

5.5.1.2. Percent Correct (PC) of Individual Consonants: Speech-Tasks Combined:

As clearly illustrated in Figure 5.17 (a., b., c, and d) below, the percentage correct of each individual consonant, in general, appears to increase with age to reach its highest level in Group-5. A few exceptions are observed where the highest percent correct of an individual consonant is found at a different/younger age group. For example, /m/ and /n/ are most accurately produced in Group-4. The decreased accuracy in the production of the two nasal consonants appears to be related to their positional token frequency (discussed in more detail in chapter 7 section 7.3.3.). Moreover, figure 5.17 (d) confirms in more detail what we have explored previously in figure 5.16 that affricate and emphatic consonants are the most challenging of all consonants evident here by the low PC mean of each individual consonant. Furthermore, figure 5.17 illustrates varying difficulty levels expressed in the Mean percent correct of individual consonants within the same manner group. For example, /t/ appears to be more difficult than /b/ and /ʔ/ in stops, /f/, /ħ/, and /h/ appear to be the easiest fricatives, /tˤ/ the easiest emphatic, and the affricate /ʤ/ is easier than /ʦ/.

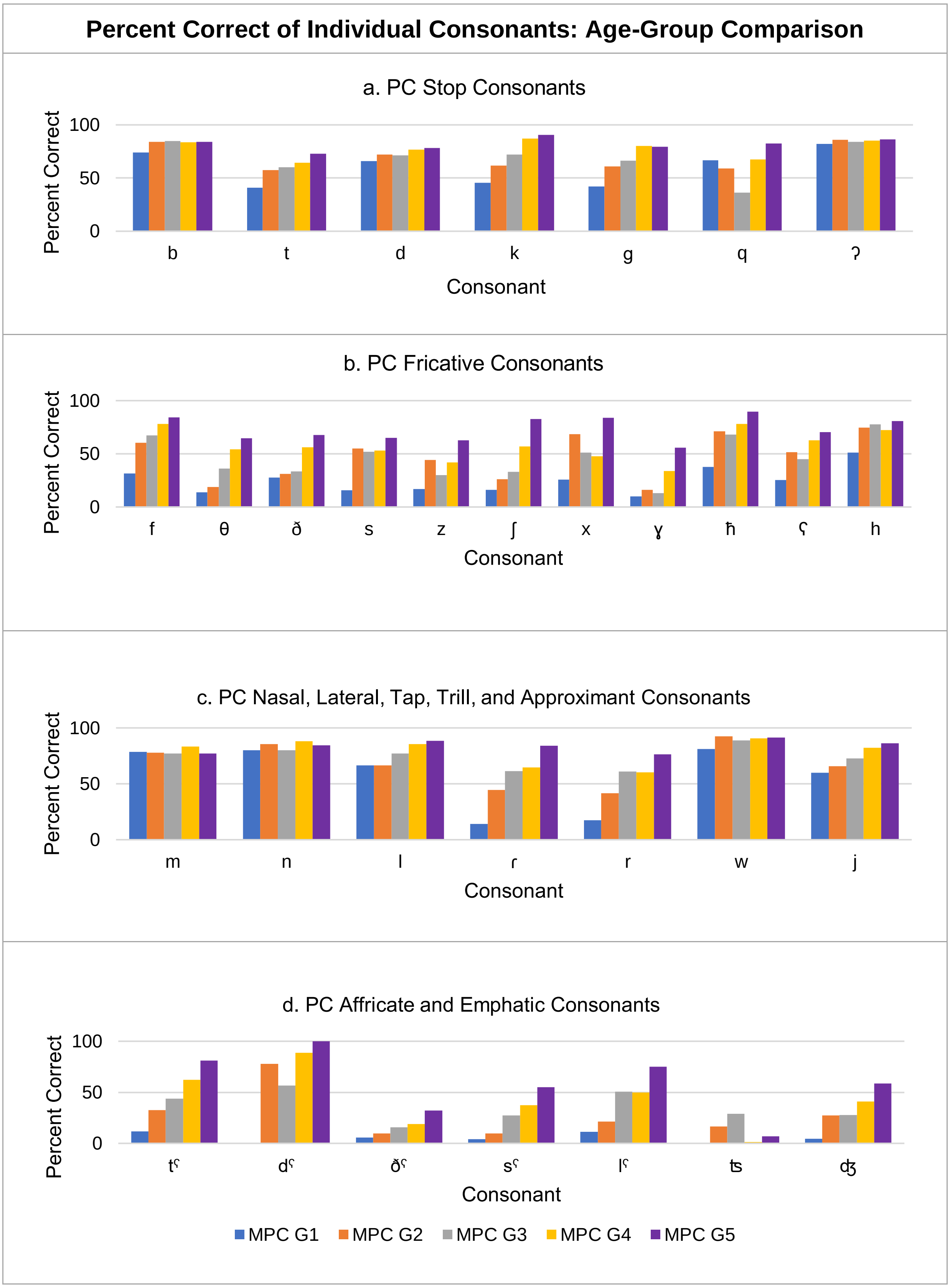

Figure 5.17. Percentage of the correct production of individual consonants across all speech tasks: age-group comparison: (a). Stop consonants, (b) Fricative consonants, (c) Nasal, lateral, Tap, trill and approximant consonants, and (d) emphatic and affricate consonants. Key: PC= Percent Correct, MPC= Mean Percent Correct.

5.5.2. Speech Task Comparison: Picture Naming vs. Spontaneous

This section presents and compares the results of PCC in two speech samples: Picture Naming (PN) and Spontaneous (SPON) across all age-groups and the gender of the participants. Then, PCC of individual consonants is presented whilst comparing both speech tasks. Finally, PCC of manner of articulation groups is also compared between speech tasks: i.e. PN-PCC vs. SPON-PCC.

5.5.2.1. Speech Task Comparison: PCC all consonants

Table 5.15 below provides descriptive statistics of PCC in both speech samples. Also, Figure 5.18, presents a comparison between age-group PCC means in two speech samples: PN vs. SPON. All participants across all age-groups have higher PCC in the SPON sample and appear to produce more errors in PN. Also, it is notable that the PCC difference between PN and SPON gradually decrease with age.

Table 5.15.

PCC: Age-Group and Speech-Task Comparison.

Age Groups	**PN PCC**		**SPON PCC**	
	Mean	Standard Deviation.	Mean	Standard Deviation.
G1	36.43	15.22	58.47	11.64
G2	48.53	13.58	66.30	11.12
G3	56.18	11.64	70.96	9.77
G4	67.68	13.75	75.36	12.23
G5	74.38	9.13	81.14	5.50

Key: PCC= Percent Consonants Correct, PN= Picture Naming, SPON= Spontaneous.

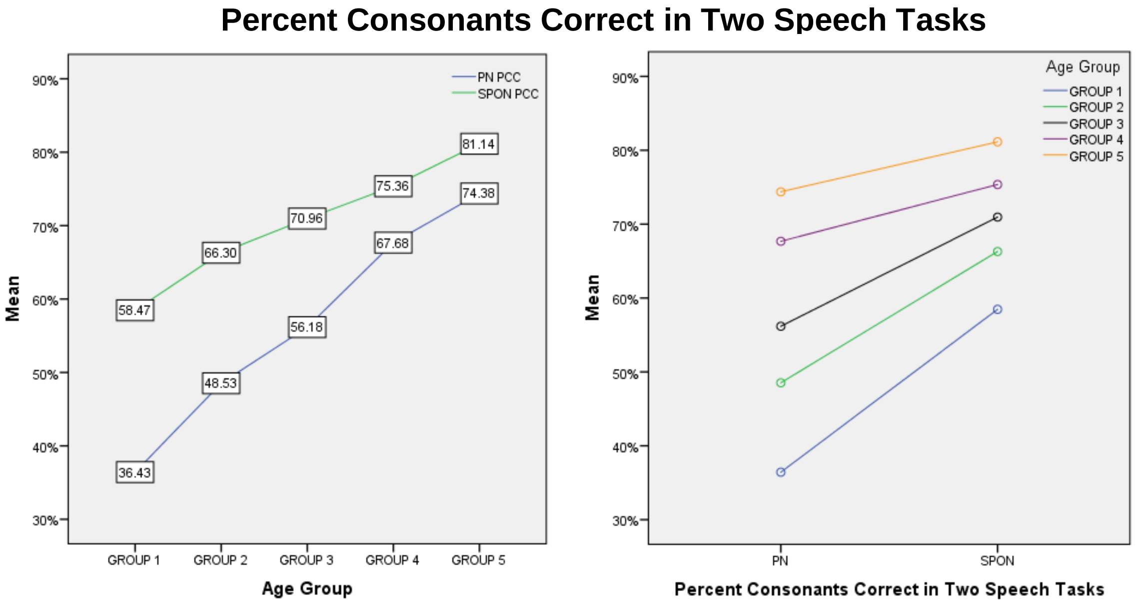

Figure 5.18. PCC in two speech tasks: as a function of age group (left) and speech samples (right). Key: PCC= Percent Consonants Correct, PN= Picture Naming, SPON= Spontaneous.

Furthermore, female participants appear to have superior PCC average when compared to their male peers except in Group-1. Only in PN sample, male participants in Group-1 have higher mean = 37.34% than their female peers *M* = 35.42% (Table 5.16). Though, this may be the result of the exclusion of three low-performing male participants in Group-1 as discussed earlier in section 5.5.1.

Table 5.16.

PCC Mean and Standard Deviation in Two Speech Tasks: Gender Comparison.

AG	PN PCC				SPON PCC			
	Females		Males		Females		Males	
	M (%)	SD	*M (%)*	SD	*M (%)*	SD	*M (%)*	SD
G1	35.42	12.11	37.43	18.97	59.16	8.77	57.77	14.82
G2	55.42	11.87	41.63	12.27	69.55	9.95	63.04	12.15
G3	60.61	13	51.73	9.02	76.92	8.18	64.99	7.5
G4	73.63	11.6	61.73	14	80.16	9.84	70.56	13.29
G5	75.75	9.62	74.37	9.12	82.71	6.69	79.55	3.96

Key: AG = Age Group, PN = Picture Naming, SPON= Spontaneous Sample, PCC = Percent Consonants Correct, *M* = Mean, SD = Standard Deviation.

The data of PN-PCC and SPON-PCC is normally distributed (see Appendix-K for more details). As a result, a 2x5x2 Mixed ANOVA was applied with two between-subjects factors: gender with two levels (female; male) and age-group with five levels and a single within-subjects factor being speech-task with two levels: picture naming (PN); spontaneous (SPON). The dependant variable was PCC. Levene's Test of Equality of Error Variances was insignificant however, Mauchly's Test of Sphericity was significant: $p < .001$ (see Appendix-L a. and b. for more details), therefore the Greenhouse-Geisser correction was applied to the degrees of freedom and the results show that the main effect of Speech-Task is significant, i.e. collapsed across age groups, the difference between PN-PCC and SPON-PCC means is significant: $F(1, 50) = 168.644$, $p < .001$, partial $\eta^2 = .771$. Similarly, the speech-task by age-group interaction was also significant: $F(4, 50) = 7.589$, $p < .001$, partial $\eta^2 = .378$. However, the speech-task by gender interaction was not significant: $F(1, 50) = .064$, $p = .801$, partial $\eta^2 = .001$. Similarly, the three-way interaction between speech-task, age-group, and gender was not significant: $F(4, 50) = .86$, $p = .494$, partial $\eta^2 = .064$. Moreover, the results of Between-Subjects Effects reveal that the effect Age-Group was significant: $F(4, 50) = 15.189$, $p < .001$, partial $\eta^2 = .549$. Also, the effect of Gender was significant: $F(1, 50) =6.232$, $p = .016$, partial $\eta^2 = .111$ however with low observed power = .687. Finally, the Age-Group by Gender interaction was not significant: $F(4, 50) = .71$, $p = .589$, partial $\eta^2 = .054$. Furthermore, a Tukey Post Hoc test was applied to make pair-wise comparisons between the age groups. Pairwise comparisons reached significance between age groups that have an age gap of at least 12 months, all results are listed in the Table 5.17 below (see Appendix-M for more details).

Table 5.17.

PCC Post Hoc Test between Age-Groups.

AG	G1		G2		G3		G4		G5	
	MD	SEM	MD	SEM	MD	SEM	MD	SEM	MD	SEM
G1	NA		9.967	4.30	16.12*	4.30	24.07**	4.30	30.31**	4.30
G2	-9.967	4.30	NA		6.15	4.30	14.1*	4.30	20.34**	4.30
G3	-16.12*	4.30	-6.15	4.30	NA		7.95	4.30	14.19*	4.30
G4	-24.07**	4.30	-14.1*	4.30	-7.95	4.30	NA		6.23	4.30
G5	-30.31**	4.30	-20.34**	4.30	-14.19*	4.30	-6.23	4.30	NA	

*The mean difference is significant at the .05 level. **The mean difference is significant at the .01 level. Key: AG= Age Group, MD = Mean Difference, SEM = Standard Error of the Mean, NA = Not Applicable.

Because the speech-task by age-group interaction was significant, a within-subjects repeated measures ANOVA was completed for each age group. Mauchly's Test of Sphericity was significant: $p < .001$ (see Appendix-N for more details), therefore the Greenhouse-Geisser correction was applied to the degrees of freedom. As a result, the means of PN-PCC and SPON-PCC were found to be significantly different at all age groups: i.e. $p < .01$ (Table 5.18).

Table 5.18.

*PCC Speech-Task*Age-Group Interaction: within-Subjects ANOVA.*

Age Group	**G1**	**G2**	**G3**	**G4**	**G5**
PN-PCC mean	36.45	48.53	56.17	67.68	74.38
SPON-PCC mean	58.47	66.30	70.95	75.36	81.14
df (ST*age-group)	1	1	1	1	1
df Error (ST*age-group)	11	11	11	11	11
F	35.922	39.723	117.665	30.897	20.294
Sig.	.000*	.000*	.000*	.000*	.001*
Partial Eta Squared	.766	.783	.915	.737	.648
Observed Power	1.000	1.000	1.000	.999	.983

*The mean difference is significant at the .01 level. Key: PCC= Percent Consonants Correct, PN= Picture Naming, SPON= Spontaneous, ST= Speech Task.

5.5.2.2. Speech Task Comparison: PCC of manner of articulation groups

In this section, PCC average of manner of articulation groups are calculated and compared in PN vs. SPON samples. It is obvious in Table 5.18 that participants in all age-groups generally have superior PCC in the SPON rather than in the PN sample. This is true for all manner of articulation and age-groups except for the Tap group in Group-1. This is the only occasion where PN PCC average (21.75%) surpasses SPON PCC average (16.66%). Also, a clear trend of increased PCC average with age in both speech tasks can be observed. However, the greater difference between PCC in PN vs. SPON samples is evident in affricates. While PCC of affricates gradually increase with age in both speech tasks, participants in Group-5 have much lower PCC-mean of affricates in PN when compared to SPON sample: 26.79% and 64.33% respectively (Table 5.19).

Table 5.19.

Average PCC in Manner of Articulation Groups: Speech-Task Comparison.

	PN					**SPON**				
	G1	**G2**	**G3**	**G4**	**G5**	**G1**	**G2**	**G3**	**G4**	**G5**
Stops	57.84	68.41	66.41	75.83	79.52	65.45	74.50	75.37	80.95	82.95
Fricatives	15.51	32.02	40.22	55.27	70.49	35.77	50.34	57.25	60.04	76.97
Nasals	56.14	67.32	69.14	83.14	72.24	85.70	84.72	83.79	88.04	85.13
Affricates	NA	21.71	22.61	20.05	26.79	NA	22.01	35.02	39.03	64.33
Laterals	58.89	62.75	76.52	61.56	85.95	66.90	69.01	76.68	85.37	86.40
Tap	21.75	29.78	56.88	64.58	80.99	16.66	50.77	67.57	66.60	83.15
Trill	NA	NA	56.49	57.76	75.69	NA	40.13	68.12	64.49	77.71
Approximants	NA	56.32	69.87	85.32	87.40	76.12	70.23	84.84	87.25	89.09
Emphatics	10.83	17.29	24.62	39.14	60.65	11.36	30.72	36.11	39.75	57.75

Key: PCC= Percent Consonants Correct, PN= Picture Naming, SPON= Spontaneous, NA = Not Available or missing data.

5.5.2.3. Speech Task Comparison: Percent Correct of Individual Consonants

In the figures 5.19 (a, b, c, d, and e), the percentage correct (PC from here after) individual consonants in PN and SPON samples is compared at different age groups. An overview of the figures suggests an overall higher percentage of correct production of all consonants in the SPON sample. Moreover, the comparison between both speech tasks highlights how participants in Group-1 were only able to correctly produce six consonants: /b/, /tˤ/, /s/, /n/, /l/, and /ɾ/ in PN sample whilst the same participants produced 16 consonants correctly in SPON sample (Figure 5.18.a). It is worth noting that, these results do not only represent incorrect production of consonants, but also account for missing PN data (not attempted). It can be predicted that limited vocabulary inventory and unfamiliarity with target words inhibited participants in all age-groups (but more so in Group-1) from attempting some of the PN targets.

Interestingly, in PN sample, all target consonants were attempted by participants in Group-4 and Group-5. On the other hand, in SPON sample, /ɣ/ and /lˤ/ were not attempted by any of the participants in any age-group and /θ/ was only attempted by participants in Group-4. These results align with the previously reported findings of token frequency analysis of consonants (section 5.3.1.2) as /ɣ/, /lˤ/, and /θ/ were found to have very low token frequency in the SPON sample, i.e.: 0.34%, 0.76% and 0.72% respectively.

Percent Correct of Individual Consonants: Speech-Task Comparison

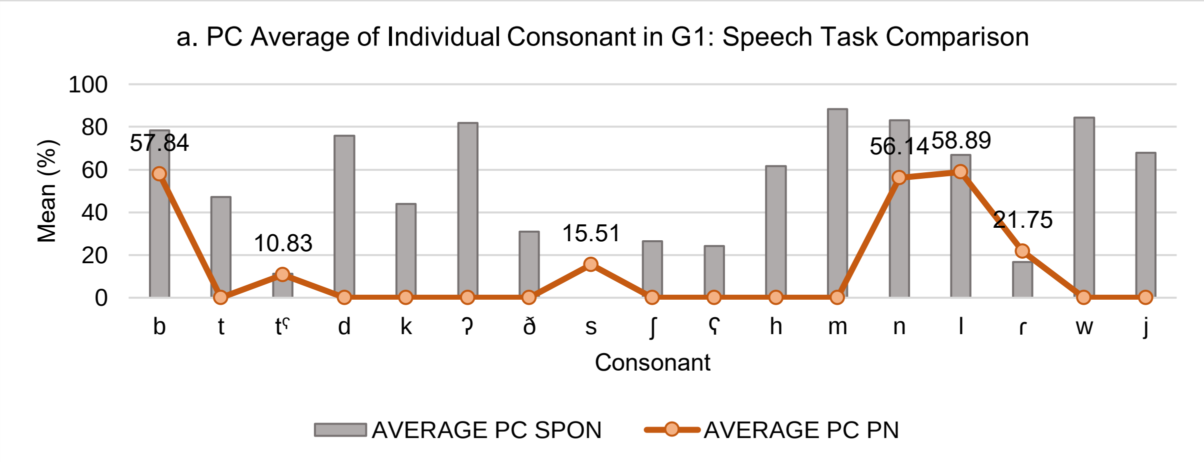

Figure 5.19.a PC of individual consonants: Speech Task Comparison Group-1 (1;10-2;02 years

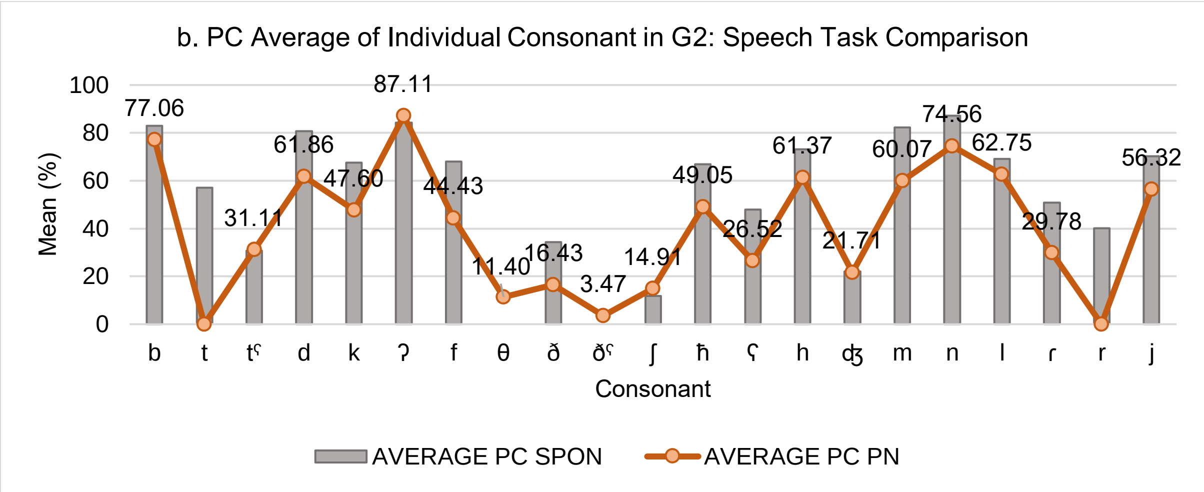

Figure 5.19.b PC of individual consonants: Speech Task Comparison Group-2 (2;04-2;08 years)

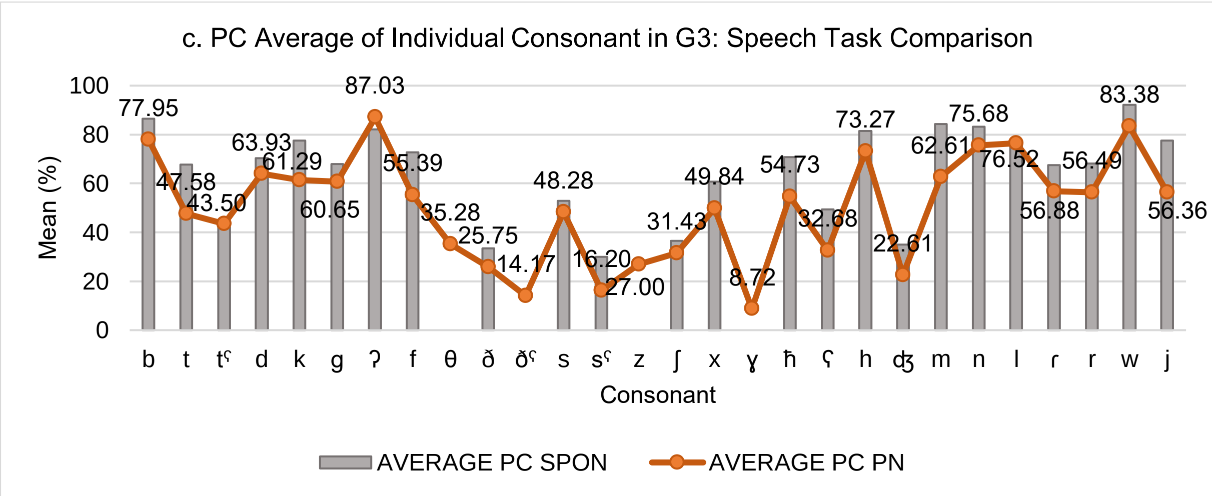

Figure 5.19.c PC of individual consonants: Speech Task Comparison Group-3 (2;10-3;02 years)

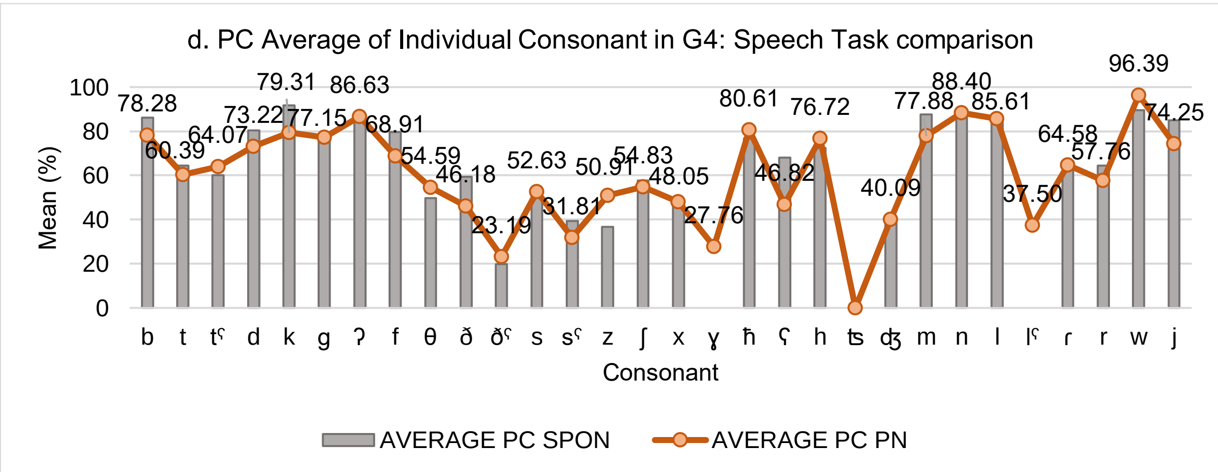

Figure 5.19.d PC of individual consonants: Speech Task comparison Group-4 (3;04-3;08 years)

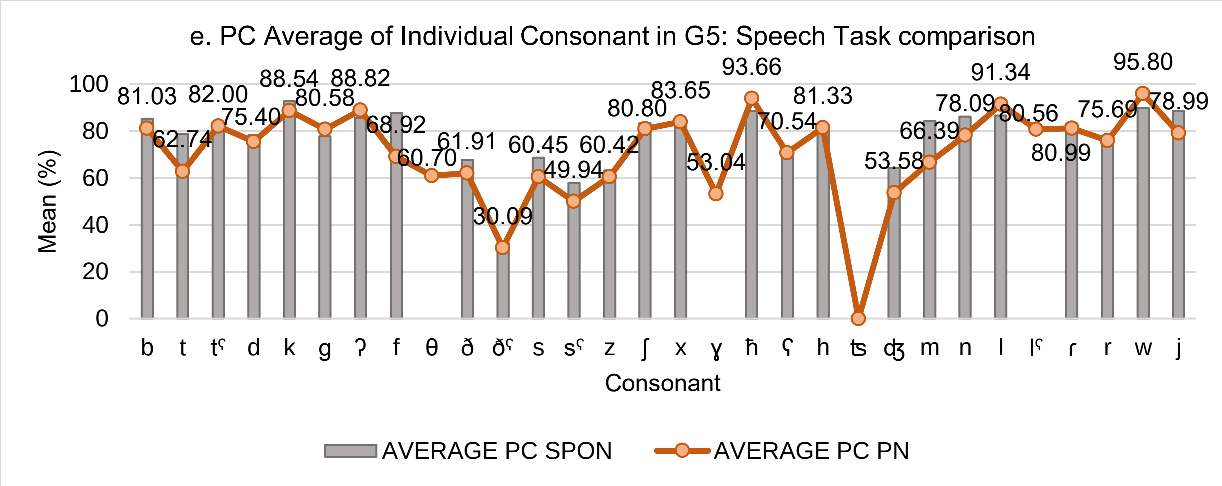

Figure 5.19.e PC of individual consonants: Speech Task Comparison Group-5 (3;10-4;02 years)

Figure 5.19. PC of individual consonants: Speech Task Comparison a. Group-1 (1;10-2;02 years), b. Group-2 (2;04-2;08 years), c. Group-3 (2;10-3;02 years), d. Group-4 (3;04-3;08 years), and e. Group-5 (3;10-4;02 years). Key: PC= Percent Correct, PN= Picture Naming, SPON= Spontaneous.

In summary, all three independent variables: speech-task, age-group, and gender of the participants had a significant effect on PCC however the latter's effect had low observed power. In other words, all participants were more accurate in the SPON sample, i.e. SPON PCC>PN PCC. Also, the older the participants the higher their PCC. Moreover, female participants had higher PCC than their male peers especially above the age of 2;06 year however with moderate effect size and insufficient power <.8. The moderate effect size indicates that the gender of the participant of a randomly selected data point might be predicted solely based on its PCC score. However, the low observed power of the test indicates that there is only a 65-68% chance that the PCC difference between the two genders is true. Because the speech-task*age-group interaction was significant, post Hoc test was conducted to reveal that PCC was significantly different in age groups that were at least 12 months apart.

Moreover, PCC of affricate and emphatic consonants had the lowest mean rank <3 which indicates that consonants in these manner groups were the most challenging. In contrast, stops, nasals, approximants, and the trill consonant had the highest mean ranks >6 indicating a relative ease of production of consonants in these groups. Finally, fricatives, laterals and the tap appear to have moderate difficulty affecting their correct production indicated by mean rank ranging between 5 and 3.5. When speech tasks were compared, the same trend continued yet with consistently higher PCC means in the SPON sample.

Finally, in general the PC of individual consonants steadily improve with age despite some observable fluctuation/regression mainly observed in groups 3 and 4[13]. Similarly, almost consistently individual consonants were produced more accurately in the SPON sample.

[13] This may have coincided with a rapid vocabulary growth period where the children focus more on content rather than on form.

5.6. Positional Percent Consonants Correct

In this section, further analysis of the results reported in section 5.5 is presented however in relation to syllable/word position. Because the collection of SPON sample often included similar prompting techniques which were also used in PN (i.e. requested naming, forced alternatives and imitation) as a result of limited vocabulary inventory especially in younger participants, no speech task comparison is carried out in this section. Instead, the focus will be on age group and gender differences. Table 5.19. below lists means and SD of each gender in all age-groups and in four syllable/word positions separately:

- Absolute onset: Syllable-Initial Word-Initial (SIWI)
- Medial onset: Syllable-Initial Within-Word (SIWW)
- Medial coda: Syllable-Final Within-Word (SFWW)
- Absolute coda: Syllable-Final Word-Final (SFWF)

Additionally, in the last row of Table 5.20, an overview of the combined medial consonants' PCC is calculated for the purpose of comparison with previous studies that did not make the distinction between medial consonants in the onset (SIWW) and coda (SFWW) positions.

Table 5.20.

Positional PCC Means and SD in Five Age-Groups.

	G1		**G2**		**G3**		**G4**		**G5**	
SW/P	*M*	SD	*M*	SD	*M*	SD	*M*	SD	*M*	SD
SIWI	56.19	14.39	65.50	12.01	69.98	11.56	74.27	13.66	80.93	5.69
SIWW	49.84	12.39	60.96	12.44	64.35	12.51	74.37	14.00	81.39	6.81
SFWW	36.54	13.30	40.70	17.93	58.78	12.60	68.04	16.42	79.18	7.04
SFWF	55.13	14.88	67.09	8.82	66.58	11.97	70.80	10.05	73.47	6.96
Medial	46.77	11.47	56.10	13.29	63.03	12.27	72.65	14.37	80.78	6.81

Key: PCC= Percent Consonants Correct, SW/P= Syllable/Word Position, *M*= Mean, SD= Standard Deviation.

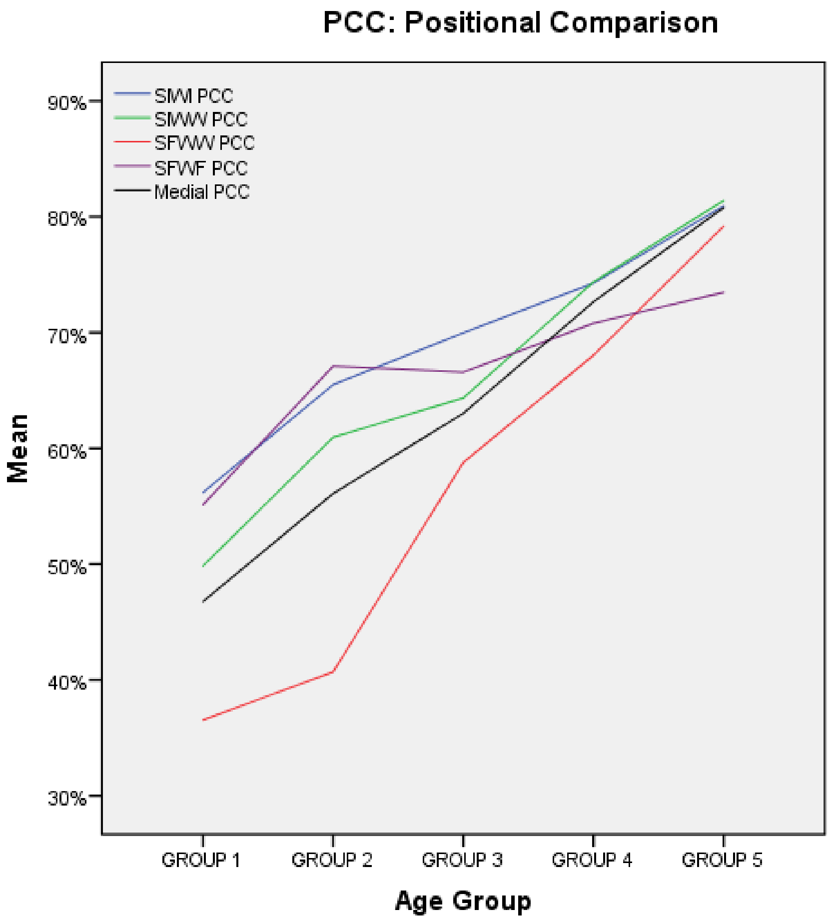

Figure 5.20. PCC positional differences across five age-groups. Key: PCC= Percent Consonants Correct, SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

From the descriptive data in Table 5.20 and Figure 5.20 above, it is obvious that between the age of 1;10 and 3;02 years, consonants at word boundaries: SIWI and SFWF have the highest PCC. In contrast, consonants in SFWW position, are the most challenging position for children in all age groups except in Group-5 (average age 3;10-4;02 years). Furthermore, consonants in medial onset position (SIWW) appear to be an easier target for children when compared to medial coda position (SFWW), supporting the discrimination between the two in the current study. Moreover, as expected, all positional PCC improve with age as all approach the 80% correct mark around the age of 4 years (Group-5) except for consonants in the absolute coda position, i.e. SFWF. To explore whether the difference between syllable/word positions is significant, Shapiro-Wilk normality test on the data was completed. PCC in all four syllable/word position: SIWI, SIWW, SFWW, and SFWF are normally distributed in each age group $p > 0.05$ except for SFWW in Group-1 $p = 0.007$ (see Appendix-O for more details). Despite of the abnormal distribution in SFWW in Group-1, a 2x5x4 Mixed ANOVA was applied with two between-subjects factors: gender with two levels (female; male) and age-group with five levels and a single within-subjects factor being Syllable/word position with four levels: SIWI, SIWW, SFWW, and SFWF (Figure 5.21). The dependant variable was PCC in each syllable/word position. Mauchly's Test of Sphericity was significant: $p < .001$ (see Appendix-P), therefore the Greenhouse-Geisser correction was applied to the degrees of freedom and a significant main effect of the syllable/word position was found i.e. across all age-groups, the means of SIWI-PCC, SIWW-PCC, SFWW-PCC, and SFWF-PCC are significantly different.: $F(2.493, 124.65) = 46.05$, $p < .001$, partial $\eta^2 = .479$. Similarly, the syllable/word position by age-group interaction was also significant: $F(9.973, 124.656) = 9.001$, $p < .001$, partial $\eta^2 = .419$. In contrast, the syllable/word position by gender interaction was not significant: $F(2.493, 124.656) = .753$, $p = .500$, partial $\eta^2 = .015$ and the three-way interaction between syllable/word position, age-group, and gender was not significant either: $F(9.973, 124.656) = 1.382$, $p = .196$, partial $\eta^2 = .100$. Additionally, the Test of Between-Subjects effect showed that the effect of Age-Group was significant: $F(4, 50) = 14.454$, $p < .001$, partial $\eta^2 = .536$ and that the effect of the Gender of the participant was also significant: $F(1, 50) = 5.833$, $p = .019$, partial $\eta^2 = .104$ however with low observed power = .659 (Figure 5.20). In contrast, the Age-Group by Gender interaction was not significant $F(4, 50) = 1.104$, $p = .365$, partial $\eta^2 = .081$.

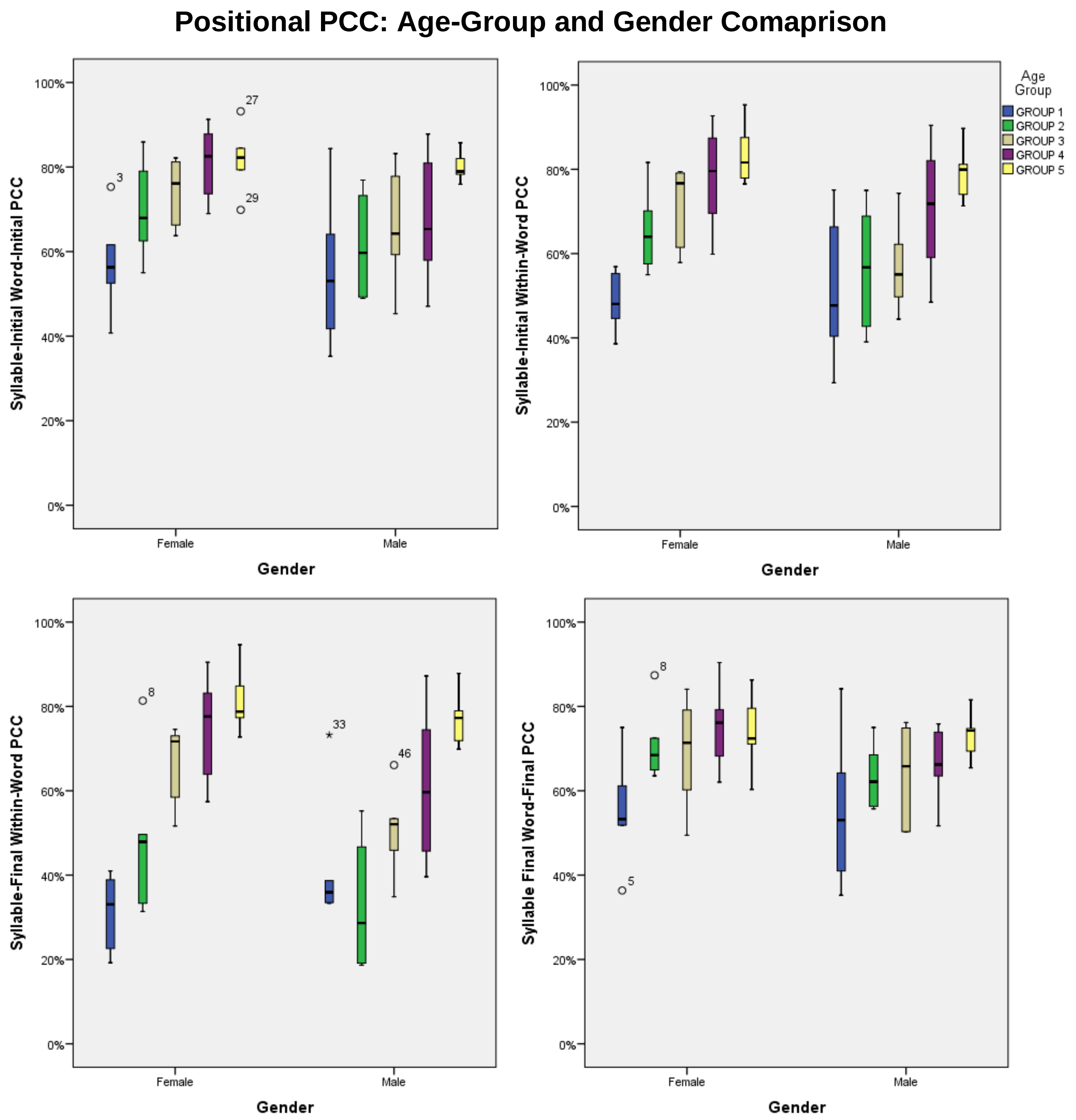

Figure 5.21. Positional PCC: age-group and gender comparison. Key: PCC= Percent Consonants Correct

Futhermore, Table 5.21 and Figure 5.22 below provide descritpive statistics of gender differences in positional PCC. It is clear that consonants in SFWW remains the most difficult syllable/word position for both genders until Group-4 (average age of 3;06 years,) after which, in Group-5 (average age 4;00 years), SFWF becomes the position where the participant have the least correct production.

Table 5.21.

Positional PCC Mean and SD Values: Age-Group and Gender Comparison.

		Age Group									
		G1		G2		G3		G4		G5	
S/WP	**G**	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
SIWI	**F**	57.13	11.39	69.73	11.26	74.28	8.17	81.14	8.44	81.88	7.57
	M	55.26	17.99	61.28	12.15	65.67	13.53	67.40	15.02	79.98	3.43
SIWW	**F**	48.59	6.94	65.39	9.59	71.89	9.59	78.13	11.99	83.43	7.16
	M	51.10	16.90	56.52	14.19	56.81	10.76	70.61	15.93	79.35	6.40
SFWW	**F**	31.31	8.96	48.59	17.91	66.84	9.45	75.03	12.51	81.18	7.66
	M	41.77	15.60	32.82	15.40	50.72	10.22	61.06	17.87	77.18	6.38
SFWF	**F**	55.15	12.68	70.88	8.67	69.28	12.78	75.36	9.81	73.67	8.76
	M	55.12	18.06	63.31	7.85	63.88	11.59	66.23	8.71	73.27	5.46
WM	**F**	44.93	5.88	60.64	11.44	70.64	9.54	77.30	11.83	82.79	7.25
	M	48.60	15.71	51.56	14.43	55.42	10.05	68.00	16.19	78.76	6.29

Key: PCC= Percent Consonants Correct, S/WP= Syllable/word position, G= Gender, SD = Standard Deviation, F= Females, M = Males, SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, WM= Word-Medial.

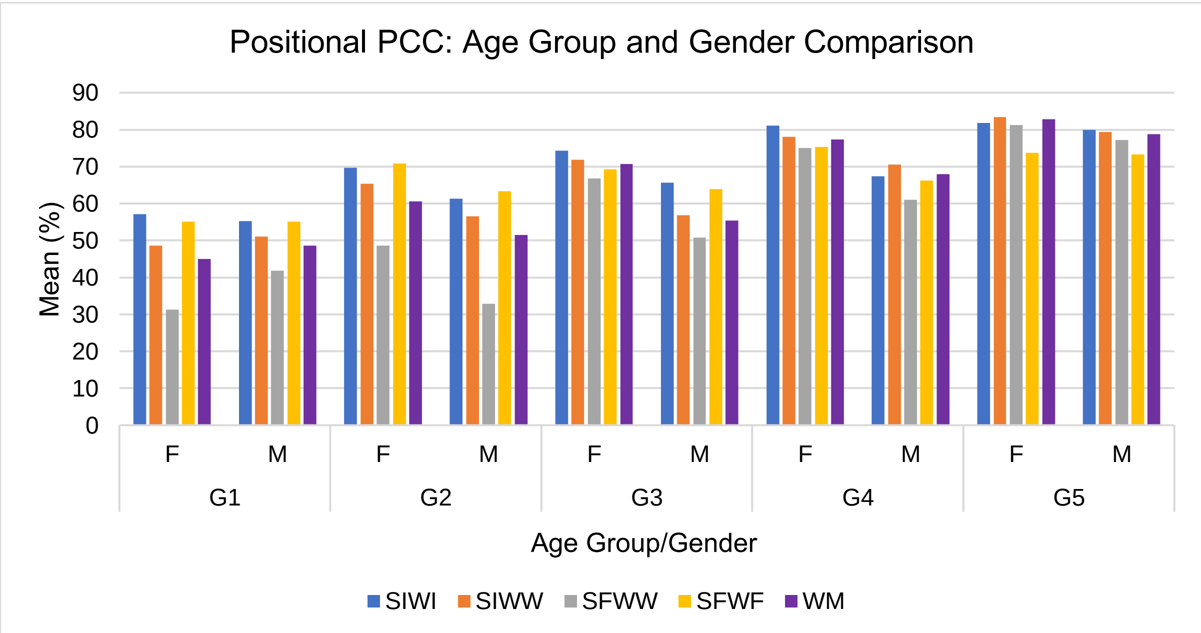

Figure 5.22. Estimated mariginal means of positional PCC: Gender differenes in five age-groups.Key: PCC= Percent Consonants Correct. F= Female, M= Male SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, WM= Word Medial.

Moreover, a Tukey Post Hoc test was applied (Table 5.22) to make pair-wise comparisons between the groups. Pairwise comparisons reached significance between age groups that have an age gap of at least 12 months.

Table 5.22.

Positional PCC Post Hoc Test between Age-Groups.

AG	G1		G2		G3		G4		G5	
	MD	SEM	MD	SEM	MD	SEM	MD	SEM	MD	SEM
G1	NA		9.13	4.23	15.49**	4.23	22.44**	4.23	29.31**	4.23
G2	-9.13	4.23	NA		6.35	4.23	13.30**	4.23	20.17**	4.23
G3	-15.49**	4.23	-6.35	4.23	NA		6.94	4.23	13.82*	4.23
G4	-22.44**	4.23	-13.30**	4.23	-6.94	4.23	NA		6.87	4.23
G5	-29.31**	4.23	-20.17**	4.23	-13.82*	4.23	-6.87	4.23	NA	

*The mean difference is significant at the .05 level. **The mean difference is significant at the .01 level.
Key: AG= Age-Group, MD = Mean Difference, SEM = Standard Error of the Mean, NA = Not Applicable

Furthermore, because the syllable/word position by age-group interaction was significant, a within-subjects repeated measures ANOVA was completed for each age group. Also, the Mauchly's Test of Sphericity was significant: $p < .01$ in Group 1 and $p < .05$ in Groups 3 and 5 (see Appendix-Q for more details), therefore the Greenhouse-Geisser correction was applied to the degrees of freedom in those Age-Groups but not in Groups 2 and 4 and found that the means of SIWI-PCC, SIWW-PCC, SFWW-PCC, and SFWF-PCC are significantly different at all age groups; i.e. $p< .01$ (Table 5.23).

Table 5.23.

*Positional PCC Syllable/word position*Age-Group Interaction: within-Subjects ANOVA.*

Age Group	**G1**	**G2**	**G3**	**G4**	**G5**
SIWI PCC mean	56.19	65.50	69.97	74.27	80.92
SIWW PCC mean	49.84	60.95	64.34	74.36	81.39
SFWW PCC mean	36.54	40.70	58.78	68.04	79.18
SFWF PCC mean	55.13	67.09	66.57	70.79	73.46
df (ST*age-group)	1.657	3	1.856	3	1.899
df Error (ST*age-group)	18.222	33	20.419	33	20.889
F	12.176	34.498	5.977	5.264	19.850
Sig.	.001*	.000*	.010*	.004*	.000*
Partial Eta Squared	.525	.758	.352	.324	.643
Observed Power	.975	1.000	.808	.896	1.000

*The mean difference is significant at the .01 level. Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, PCC= Percent Consonants Correct, ST= Speech Task.

Finally, in Table 5.24 lists *p* values for Tests-Within-Subjects Contrasts of PCC of consonants between two onset (SIWI vs. SIWW), two medial (SIWW vs. SFWW) and two coda (SFWW vs. SFWF) positions in detail.

Table 5.24.

Positional PCC: Test Within-Subjects Contrasts.

Within-Subject Contrasts	Compared positions	df	F	Sig.	Partial Eta Squared
Syllable Word Position	SIWI vs. SIWW	1	9.336	.004*	.157
	SIWW vs. SFWW	1	80.737	.000*	.618
	SFWW vs. SFWF	1	47.981	.000*	.490
Syllable Word Position*Age Group	SIWI vs. SIWW	4	1.922	.121	.133
	SIWW vs. SFWW	4	9.277	.000*	.426
	SFWW vs. SFWF	4	15.628	.000*	.556
Syllable Word Position*Gender	SIWI vs. SIWW	1	.022	.883	.000
	SIWW vs. SFWW	1	.358	.552	.007
	SFWW vs. SFWF	1	1.372	.247	.027
Syllable Word Position*Age Group*Gender	SIWI vs. SIWW	4	1.196	.324	.087
	SIWW vs. SFWW	4	1.617	.184	.115
	SFWW vs. SFWF	4	1.640	.179	.116
Error (Syllable Word Position)	SIWI vs. SIWW	50			
	SIWW vs. SFWW	50			
	SFWW vs. SFWF	50			

*The mean difference is significant at the .01 level. Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

The result showed that the main effect of syllable/word position was significant between the two onset positions (SIWI vs. SIWW): $F(1, 50) = 9.336$, $p = .004$, partial $\eta^2 = .157$, significant between the two medial positions (SIWW vs. SFWW) : $F(1, 50) = 80.737$, $p < .001$, partial $\eta^2 = .618$, and also significant between the coda positions (SFWW v. SFWF) : $F(1, 50) = 47.981$, $p < .001$, partial $\eta^2 = .490$. However, the syllable/word position by age-group interaction was not significant between the two onset positions (SIWI vs. SIWW): $F(4, 50) = 1.922$, $p = .121$, partial $\eta^2 = .133$ yet it was significant between the two medial positions (SIWW vs. SFWW): $F(4, 50) = 9.277$,

$p < .001$, partial $\eta^2 = .426$ and also significant between the two coda positions (SFWW vs. SFWF): $F(4, 50) = 15.628$, $p < .001$, partial $\eta^2 = .556$. However, the Syllable/Word position by Gender interaction was not significant between consonants in onset positions: SIWI vs. SIWW, consonants in medial positions: SIWW vs. SFWW, or consonants in coda positions: SFWW vs. SFWF: $p > .05$ (see Table 5.24 above). Similarly, the three-way interaction between Syllable/Word position, Age-Group and Gender was not significant between consonants in onset, medial, or coda positions: $p > .05$ (see Table 5.24).

Because the SIWW vs. SFWW and SFWW vs. SFWF by age-group interactions was significant, a within-subjects repeated measures ANOVA was completed for each age-group. Mauchly's Test of Sphericity was significant: $p < .001$ in all age-groups (see Appendix-R for more details), therefore the Greenhouse-Geisser correction was applied to the degrees of freedom and it was found that the means of SIWW-PCC and SFWW-PCC are significantly different at all age groups; i.e. $p < .05$ (Table 5.25). Moreover, the means SFWW-PCC and SFWF-PCC are significantly different; i.e. $p < .05$ at Groups 1, 2 and 5 with high observed power, significantly different in Group-3 with low observed power = .596, and not significantly different in Group-4 (Table 5.26).

Table 5.25.

*Medial Consonants PCC*Age-Group Interaction: within-Subjects ANOVA.*

AG	df (Syllable/word position*age-group)	df Error (Syllable/word position *age-group)	F	Sig.	Partial Eta Squared	Observed Power
G1	1	11	15.695	.002*	.588	.949
G2	1	11	32.894	.000*	.749	.999
G3	1	11	15.022	.003*	.577	.941
G4	1	11	13.604	.004*	.553	.918
G5	1	11	15.347	.002*	.582	.945

*The mean difference is significant at the .01 level. Key: AG= Age-Group.

Table 5.26.

*Coda Consonants PCC*Age-Group Interaction: within-Subjects ANOVA.*

AG	df (Syllable/word position*age-group)	df Error (Syllable/word position *age-group)	F	Sig.	Partial Eta Squared	Observed Power
G1	1	11	17.082	.002**	.608	.963
G2	1	11	42.766	.000**	.795	1.000
G3	1	11	5.837	.034*	.347	.596
G4	1	11	1.234	.290	.101	.174
G5	1	11	23.129	.001**	.678	.992

*The mean difference is significant at the .05 level. **The mean difference is significant at the .01 level. Key: AG= Age-Group.

In summary, syllable/word position had a significant effect on PCC To be exact, consonants at word boundaries (SIWI and SFWF) were the easiest up to the age of 3;02 years after which consonants in the SIWW became easier than those in SFWF. Most distinctively, consonants in SFWW appeared to be the most challenging in age-groups 1,2, 3, and 4. However, after the age of 3;06 years (i.e. group-5) consonants in the SFWF were the most challenging. Moreover, the age group of the participant had a significant effect on positional PCC. In other words, PCC in all syllable/word positions improved with age. Similarly, the gender of the participants had a significant effect on positional PCC however with moderate effect size and insufficient power <.8. The moderate effect size indicates that the gender of the participant of a randomly selected data point might be predicted solely based on its PCC score. Also, the low observed power of the test indicates that there is only a 65% chance that the positional PCC difference between the two genders is true. In general, female participants had higher positional PCC when compared to their male peers especially above the age of 2;06 year. Furthermore, the syllable/word position and age-group interaction was significant. As a result, post Hoc analysis was conducted to reveal that positional PCC mean difference was significant between age groups that were at least 12 months apart. Also, within-subjects comparison revealed that the PCC means of SIWI, SIWW, SFWW, and SFWF were significantly different in all age groups.

Additionally, the tests of within-subjects contrasts revealed that the PCC means of SIWI vs SIWW, SIWW vs SFWW, and SFWW vs SFWF were all significantly different. Finally, because the age-group's interactions with the word-medial and coda consonants comparisons were significant further analysis was carried out via within-subjects repeated measure ANOVA. The results show that the PCC mean difference was statistically significant in all age groups between consonants in word-medial positions (SIWW vs SFWW) and significant in Groups 1, 2, 3 and 5 between consonants in the two coda positions (SFWW vs SFWF) but was not significant between consonants in two onset positions (SIWI vs SIWW).

5.7. Correlation and Associations

In this section, One-Way ANOVA was used to measure the strength of statistical relationship as a measure of association between the independent variable (IV) and dependant variable (DV). This was only applicable when the IV was nominal with more than two groups and the DV is a scale variable that is normally distributed (e.g. PCC). In cases where the DV was not a scale variable or was abnormally distributed, the correlation between IV and the DV was measured using Spearman's rho test. To start, the strength of the statistical relationship between PCC (normally distributed, see section 5.5) and information gathered about the participants and/or their family is explored in sections 5.7.1. to 5.7.5. Then in section 5.7.6., the relationship between the age-group of the participant and their enrolment status in an educational system is explored. Finally, in section 5.7.7., the participants' age group is investigated for its association with how many English words were used instead of their Arabic equivalent during the sessions.

5.7.1. PCC and Family income

To establish if there was a relationship between the family's income (nominal IV) and the participant's PCC (normally distributed scale DV), a One-Way ANOVA was completed because the IV has more than two groups. Table 5.27 lists descriptive statistics between those two variables.

Table 5.27.

PCC and Family's Income.

What is your family's gross monthly income?	*N*	PCC Mean	Standard Deviation	Standard Error
less than 10,000SR	8	60.63	12.26	4.33
10,000-19,000SR	18	63.93	12.01	2.83
20,000-29,000SR	19	71.327	14.61	3.35
30,000-39,000SR	5	66.27	17.56	7.85
40,000-49,000SR	3	64.11	11.61	6.70
More than 50,000SR	4	65.39	20.38	10.19
Total	57	66.25	13.99	1.85

Key: *N* = Number of participating families, PCC = Percent Consonants Correct

In table 5.27 above, the *N* total is less than 60, which is the total number of participating families in the current study. As reported earlier in section 5.1.2. three families did not report on family income; thus this data is missing. Also, 37 of participating families (i.e. over 60%) had an average monthly income between 10,000SR and 29,000SR (i.e. £2,000-6,000). Nonetheless, there was no association between the family's income and the participant's PCC ($F(5,51) = .864$, $p = .512$).

5.7.2. PCC and time spent with non-Arabic speaking carer

To establish if there was an association between the amount of time a participant spends with a non-Arabic speaking carer (categorical IV) on their PCC (normally distributed scale DV), a One-Way ANOVA was completed because the IV has more than two groups. Table 5.28 lists descriptive statistics between those two variables.

Table 5.28.

PCC and Time Spent Daily with a Non-Arabic Speaking Carer.

How many hours does your child spend daily with a non-Arabic speaking carer?	*N*	PCC Mean	Standard Deviation	Standard Error
Not Applicable	20	65.27	13.12	2.93
0-1 hrs	15	67.19	14.99	3.87
2-3 hrs	12	69.50	16.70	4.82
4-6 hrs	7	60.95	10.46	3.95
more than 6 hrs	4	71.05	9.80	4.90
Total	58	66.52	13.81	1.81

Key: *N* = Number of participants, PCC = Percent Consonants Correct

In table 5.28 above, the *N* total is less than 60, which is the total number of participants in the current study. As reported earlier in section 5.1.5, two families did not report on the amount of time their child spends with a non-Arabic speaking carer, thus this data is missing. Even though more than 80% of the participants (i.e. 47 participants) spend 3 hours or less with a non-Arabic speaking carer on daily basis, it is concluded that there was no association between the amount of time a child spends with a non-Arabic speaking carer and their PCC ($F(4,53) = .563$, $p = .690$).

5.7.3. PCC and parent's educational level

To establish if there was an association between last maternal educational level (nominal IV) and participant's PCC (normally distributed scale DV), a One-Way ANOVA was completed because the IV has more than two groups. Table 5.29 lists descriptive statistics between those two variables.

Table 5.29.

PCC and Maternal Educational Level.

What is the highest maternal educational degree?	***N***	**PCC Mean**	**Standard Deviation**	**Standard Error**
less than High school	1	65.21	NA	NA
High school	4	66.68	13.71	6.85
BSc	41	67.01	15.00	2.34
Higher Education	13	63.01	12.32	3.41
Total	59	66.07	14.11	1.83

Key: *N* = Number of participating families, PCC = Percent Consonants Correct, NA= Not Applicable.

In table 5.29 above, the *N* total is less than 60, which is the total number of participating families in the current study. As reported earlier in section 5.1.3, one family failed to report on mother's educational level, thus this data is missing. Also, 54 of participants' mothers (i.e. over 91%) reportedly have a BSc or higher degrees, nonetheless there was no association between maternal educational level in this sample and the child's PCC ($F(3,55) = .258$, $p = .855$).

Moreover, the same process was repeated on paternal educational level to establish if there was an association between paternal educational level and participant's PCC. Consequently, a One-Way ANOVA was completed because the IV has more than two groups. Table 5.30 lists descriptive statistics between those two variables.

Table 5.30.

PCC and Paternal Educational Level.

What is the highest paternal educational degree?	*N*	PCC Mean	Standard Deviation	Standard Error
less than High school	0	NA	NA	NA
High school	9	67.05	12.43	4.14
BSc	35	64.47	14.92	2.52
Higher Education	14	68.60	13.62	3.64
Total	58	65.87	14.15	1.85

Key: *N* = Number of participating families, PCC = Percent Consonants Correct, NA= Not Applicable.

Again, the *N* total is less than 60, which is the total number of participating families in the current study. As reported earlier in section 5.1.3, two families failed to report on father's educational level, thus this data is missing. Finally, none of the fathers have less than a high-school degree and 49 of the fathers (i.e. over 84%) have a BSc or higher degrees and yet here was no significant association between paternal educational level in this sample and the child's PCC ($F(2,55) = .454$, $p = .638$).

5.7.4. PCC and the frequency of other languages spoken at home

To establish if there was an association between the frequency of use of other languages (mostly English) at home (nominal IV) and the participant's PCC (normally distributed scale DV), a One-Way ANOVA was completed because the IV has more than two groups. Table 5.31 lists descriptive statistics between those two variables.

Table 5.31.

PCC and How Frequent Other Languages Spoken at Home.

How frequently are other languages spoken at home?	*N*	PCC Mean	Standard Deviation	Standard Error
Never	17	65.01	13.24	3.21
Rarely	25	67.39	15.25	3.05
Often	15	66.05	15.16	3.91
Always	2	70.22	13.06	9.24
Total	59	66.46	14.30	1.86

Key: *N* = Number of Participants, PCC = Percent Consonants Correct

Again, the *N* total is less than 60, which is the total number of participants in this study. As reported earlier in section 5.1.6, one family failed to report on how frequently other languages are spoken at home, thus this data is missing. Also, 42 families (i.e. over 70%) never or rarely spoke in any language other than Arabic at home. Finally, it can be conclude that there was no association between how frequently other languages are spoken at home in this sample and the child's PCC ($F(3,55) = .138$, $p = .937$).

5.7.5. PCC and enrolment in Educational/day-care system

In the current study, over 75% of the participants were enrolled in an educational or day-care system (see table 5.23 below). However, two thirds of the participants in Group-1 (i.e. the youngest participants) were not enrolled in an educational or day-care system therefore this variable could not be separated from the age factor and consequently it was no tested for its association with PCC (see section 5.7.6. below for more details).

Table 5.32.

Participants' Enrolment status in an Educational/Day-care System.

Is the child enrolled in an educational or day-care system?	*N*	%
no	14	23.3
yes	46	76.66
Total	60	100

Key: *N*= Number of participants

5.7.6. Age-Group and enrolment in Educational/day-care system

In recruitment stage, there was a great difficulty finding participants in the youngest age-range: 1;10-2;02 years who are enrolled in preschool or nursery. This led to the seeking of friends and family recruits as explained previously in the methodology chapter. Table 5.33 below provides an overall raw count of the number of participants in each age-group and whether they are enrolled at preschool/nursery or not. It is evident that most children (i.e. 75%) in the current study are enrolled in pre-school or nursery. However, the majority of participants who are not enrolled in preschool/nursery are located in Group-1. In this group (average age 1;10-2;02 years), over 65% of the participants were not yet enrolled in preschool or nursery (Table 5.33 and Figure 5.23)

Table 5.33.

Age-Group and Enrolment in Nursery/Preschool.

Is the child enrolled in an educational or day-care system?	***N***				
	G1	G2	G3	G4	G5
No	8	1	2	0	3
Yes	4	11	10	12	9
Total	12	12	12	12	12

Key: *N*= Number of participants

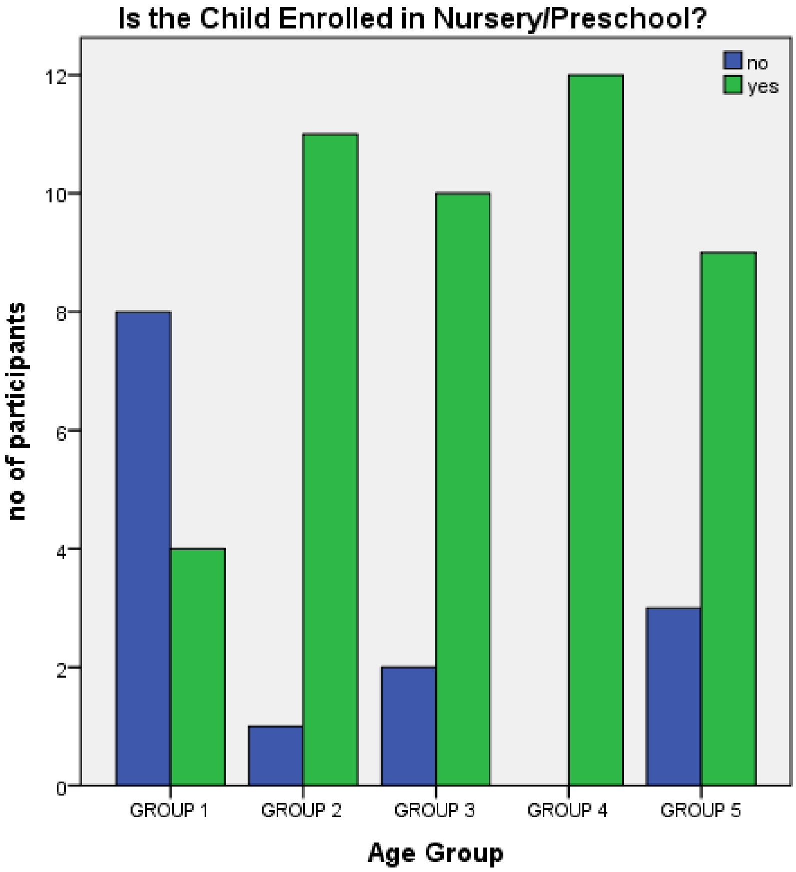

Figure 5.23. The number of participants enrolled in nursery/preschool in each age-group.

To establish whether the there was a significant correlation between the age-group (nominal IV) of participants and their enrolment in nursery or preschool (nominal DV), a Spearman's rho test between the two variables. The test results confirmed that there is a significant positive correlation between age-group and preschool/nursery enrolment: (r_s =.307. N = 60, p = .009, one-tailed). In other words, the older the child is, the more likely he/she is enrolled in nursery/preschool. Additionally, based on the descriptive statistics, Saudi children are less likely to be enrolled in nursery/preschool before their second birthday.

5.7.7. Age-Group and no. of English words

In this section, the correlation between the number of English words the children produce during the data collection session (abnormally distributed scale DV) and their age-group (nominal IV) is investigated. Table 5.34 lists the mean and SD of English words used in every age group. To establish whether the there was a significant correlation between the age-group of participants and the number of English words they produced during data collection session in either speech sample Spearman's rho test was completed. The test results showed that there is no significant correlation between age-group (IV) and the number of English words produced in PN sample (scale DV, not normally distributed): (r_s =.133, N = 60, p = .313, two-tailed) and no significant correlation between age-group and the number of English words produced in SPON sample either: (r_s = -.056, N = 60, p = .670, two-tailed).

Table 5.34.

Age-Group and Number of English Words Produced.

	Mean and SD of English Words									
	G1		**G2**		**G3**		**G4**		**G5**	
Speech Task	*M*	SD	*M*	SD	*M*	SD	*M*	SD	*M*	SD
PN	0	1	2	4	3	4	1	2	1	1
SPON	4	6	9	23	6	9	3	6	2	1

Key: M= Mean, SD= Standard Deviation, PN = Picture Naming, SPON= Spontaneous.

5.8. The Acquisition of Najdi- Arabic Consonants

The following section presents the results of Najdi-Arabic consonant mastery, acquisition, and customary production in five age groups. Without doubt, consonants that are mastered by default are also acquired and customarily produced. However, acquired consonants are customarily produced but not mastered. Finally, customarily produced consonants are neither mastered nor acquired.

5.8.1. All syllable/word positions and all speech tasks

General analysis of the entire speech samples revealed that none of the groups had mastered nor acquired any of the consonants in all syllable/word positions (SIWI, SIWW, SFWW, and SFWF) collapsing data across speech tasks. However, Group-3 customarily produced a single consonant whilst Group-5 customarily produced 9 consonants in all syllable/word positions (Table 5.35).

Table 5.35.

Mastered, Acquired, and Customarily Produced Consonants: Collapsed Data across Speech Tasks and Syllable/Word Position.

	G1	G2	G3	G4	G5
Mastered +90%	-	-	-	-	-
Acquired 75-89%	-	-	-	-	-
Customarily produced 50-74%	-	-	n	-	b, tˤ, k, f, ʃ, n, l, r, j

Because no consonants reached mastery or acquisition levels in any of the cross-sectional groups, further analysis is deemed necessary to look into what children can produce correctly at lower accuracy levels, i.e. *consistently present*. Table 5.36 contains a list of consonants produced correctly by 11/12 participants in each group at low accuracy levels:

Table 5.36.

Consistently Present Consonants: Collapsed Data across Speech Tasks and Syllable/Word Position.

G1	G2	G3	G4	G5
-	d, n, l	b, f, n, l, *ɾ, **r, j	b, d, k, g, f, ħ, ʕ, m, n, l, **r, j	b, t, tˤ, d, k, f, s, ʃ, x, ħ, ʕ, h, m, n, l, *ɾ, **r, j

Note: *ɾ and **r in were included in this table if were produced only in syllable onset and syllable coda positions respectively.

5.8.1.1. Gender comparison

This section focuses on gender comparison in consonant acquisition collapsing data across speech tasks and syllable/word positions following the same criteria of mastery, acquisition, and customary production used in section 5.7.1. However, because there are 6 participants of each gender in every age group, consonants that are included in this analysis if they were produced correctly by five of the six same gender participants in that age group, i.e. 83% of participants. For example, /k/ is said to be acquired by 4-years old females if it was produced correctly +90% of the time by five of the six female participants. Similarly, acquired consonants are the ones produced correctly 75-89% and customarily produced consonants are those produced correctly 50-74% of the time by five of the six same-gender participants in the same age group. Table 5.37 lists all consonants in Najdi Arabic that have been mastered, acquired, or customarily produced by same-gender participants in each age groups.

Table 5.37.

Gender Differences in Consonant Acquisition.

	G1		G2		G3		G4		G5	
	F	M	F	M	F	M	F	M	F	M
Mastered +90%	-	-	-	-	-	-	-	-	-	-
Acquired 75-89%	-	-	-	-	-	-	k, m, l	-	k, ħ, n, ɾ	ʃ, l, ɾ
Customarily produced 50-74%	-	m, n	b	-	b, d, k, n, l, r	m, n	b, d, g, f, ħ, ʕ, h, n, r, j	d, m, l, w	b, tˤ, d, f, ʃ, x, h, m, l, r, w, j	b, tˤ, d, f, z, x, ħ, n, r, j

Key: F= Female, M= Male.

As apparent in the table above, no consonants have been mastered by either gender in all age groups. However, gender differences are noticeable between females and males at the acquisition and customary production levels. Unexpectedly, male participants in Group-1 (average age 2;00 years) supersede their female peers with the customary production of two consonants /m/ and /n/. However, beyond the age of 2;00 years, i.e. in Groups 2, 3, 4 and 5, females appear to acquire and customarily produce more consonants than their male peers (Figure 5.24).

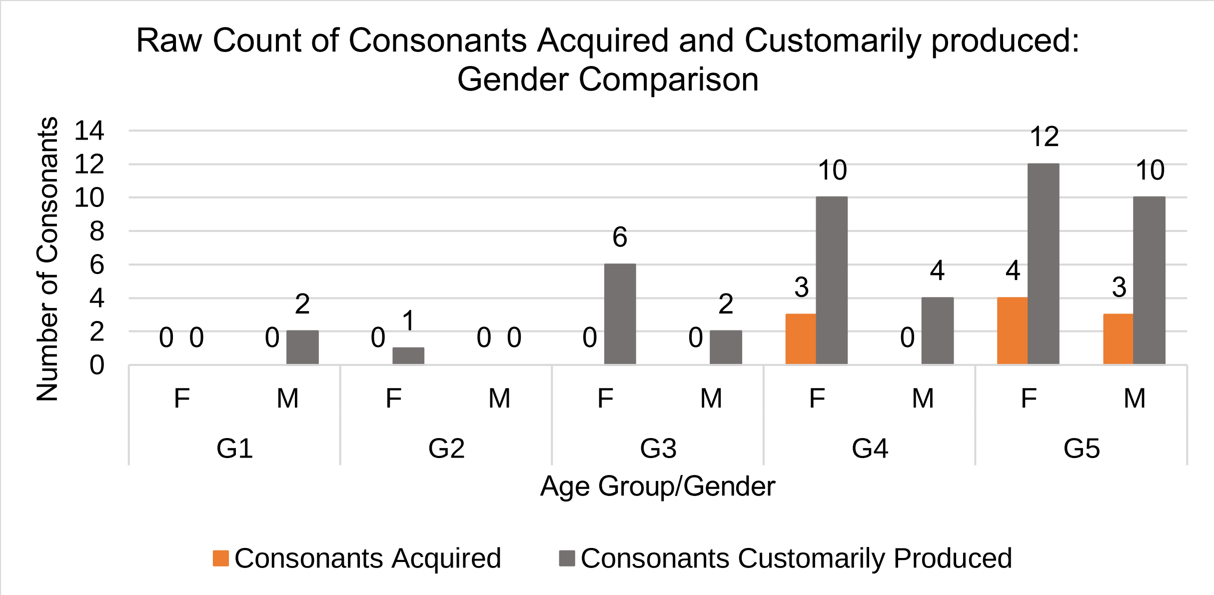

Figure 5.24. Raw count of consonants acquired and customarily produced-Gender comparison.
Key: F= Female, M= Male.

5.8.1.2 Speech task comparison

In this section, the results of consonant mastery, acquisition, and customary production are presented whilst comparing two speech tasks: PN and SPON. No consonants have been mastered by any age groups in both speech tasks. However, only /m/ was acquired by Group-4 in SPON sample and /ħ/ by Group-5 in PN sample. More obvious differences start developing at the customary production level of consonants between the two speech tasks. Although no consonants are customarily produced in Groups 1, 2, or 3, more consonants present themselves as customarily produced in the SPON sample in both Groups 4 and 5 than in PN sample (Table 5.38). Most of these consonants are classed as early acquired: /b/, /m/, /n/, and /l/ except for /r/ and /ɾ/.

Table 5.38.

Speech Task Comparison of Consonants Mastery, Acquisition, and Customary Production.

	G1		**G2**		**G3**		**G4**		**G5**	
	PN	SPON	PN	SPON	PN	SPON	PN	SPON	PN	SPON
Mastered +90%	-	-	-	-	-	-	-	-	-	-
Acquired 75-89%	-	-	-	-	-	-	-	m	ħ	-
Customarily produced 50-74%	-	-	-	-	-	-	l	b, l, j	l, r, ɾ	b, r, m, n, l

Key: PN = Picture Naming, SPON= Spontaneous.

Similar to the previous criterion used in section 5.7.1., consonants that are consistently present, i.e. produced correctly by +90% of the participants at any accuracy level below 50%, are reported in this section. Table 5.39 below contains a list of consonants that are consistently present in each age group irrespective of word/syllable positions in both speech tasks. In the SPON sample, four consonants: /n/, /l/, /ɾ/, and /r/ were produced correctly by +90% of participants in Group-3 (with variable accuracy levels) whilst no consonants where produced correctly by +90% of participants of the same age groups in PN sample. Moreover, in both Group-4 and Group-5, more consonants were produced correctly by +90% of the participants in the SPON sample when compared to PN sample which included: three front and one back fricatives /f/, /s/, /ʃ/ and /ʕ/, a palatal approximant /j/, an alveolar trill /r/, an alveolar nasal /n/ and two alveolar stops one of which is an emphatic: /t/ and /tˤ/.

Table 5.39.

Consistently Present Consonants: Speech Task Comparison across All Syllable/word Positions.

	G1	G2	G3	G4	G5
PN	-	-	-	f, n	b, d
SPON	-	-	n, l, *ɾ, **ɾ,	f, ʕ, n, **r	t, tˤ, f, s, ʃ, ʕ, j

.*r and **r are included in this table if were produced correctly in syllable onset and syllable coda positions respectively. Key: PN = Picture Naming, SPON = Spontaneous.

5.8.2. Positional Consonant Acquisition

In this section, the results of positional consonants acquisition in relation to the age of participants are presented following the same criteria of mastery, acquisition, and customary production used in section 5.7 above with an addition of **Consistently Present** category for additional analysis. In this section, consonants are judged to be *Consistently Present* if they were attempted and correctly produced by the majority of same-gender participants; i.e. 5/6 participants yet do not fall within the percent accurate range of any of the acquisition groups: Mastered, Acquired, or Customarily Produced. These consonants are typically produced with low accuracy levels (1-49%), i.e. produced correctly at least once. The addition of the *Consistently Present* category gave an insight into the consonant inventory for each age group as a whole.

Initially, gender differences are compared collapsing across speech tasks then it is followed by a comparison between PN and SPON samples. Nonetheless, because there are 6 participants of each gender in every age group, consonants are included in this analysis if they are produced correctly by five of the six participants in that age group, i.e. 83% of participants. Before the results are presented, an example is required to explain how these results are calculated. Table 5.40 below provides individual participants' data for the percentage of correct production of SIWI /n/ in Group-1. It is clear that five of six male participants correctly produced SIWI /n/ with at least 75% accuracy. As a result, SIWI /n/ is judged to be acquired by males in Group-1. However, one male participant had 0% accuracy thus the overall Group-1 males' average (67.32%) fell below the expected range of 75-89% for acquired consonants. On the other hand, although Group-1 females' average = 60.62%, SIWI /n/ is judged to have not met any of the acquisition groups criteria as only four of six participants produced SIWI /n/ correctly more than 50% of the time. Although not customarily produced, SIWI /n/ falls into Consistently Present category as it is attempted correctly by 5/6 females in Group-1.

Table 5.40.

Example Calculation of Same Gender Groups' Average of the Accurate Production of SIWI /n/ in Group-1.

G1 Males	**G1-01**	**G1-03**	**G1-05**	**G1-06**	**G1-09**	**G1-10**	**G1 male's average**	**Decision**
SIWI /n/ %	75	0	100	100	100	100	67.32	Acquired
G1 Females	**G1-02**	**G1-04**	**G1-07**	**G1-11**	**G1-12**	**G1-13**	**G1 female's average**	**Decision**
SIWI /n/ %	0	92.85	75	87.5	33.33	75	60.62	Not acquired/ Consistently Present

Key: SIWI = Syllable-Initial Word-Initial

In the next four sections, the results of positional consonant acquisition are first presented collapsing across the two speech tasks. Then it is followed by speech task comparison while simultaneously comparing gender-related differences. Starting with consonants in absolute onset position; i.e. Syllable-Initial Word-Initial (SIWI) then following by medial consonants: (1) medial onset: Syllable-Initial Within-Word (SIWW) and (2) Medial coda: Syllable-Final Within-Word (SFWW) and ending with consonants in absolute coda position: i.e. Syllable-Final Word-final (SFWF).

5.8.2.1. Absolute Onset: Syllable-Initial Word-Initial (SIWI)

Firstly, the general findings of consonants that are Mastered, Acquired, Customarily Produced, and Consistently Present in each age-group are presented collapsing data across gender and speech tasks. Table 5.41 below lists all consonants in all four categories. It is clear that no consonants have been mastered by any age-groups except for /w/ in Group-5. On the other hand, few consonants are acquired by the participants starting with a single consonants /ʔ/ in Groups 1, 2, and /b/ in Group 3 and gradually increasing in Groups 4 and 5. The Consistently Present category below often included consonants that are expected to be acquired or at least customarily produced such as /d/, /m/, /n/ and /j/ but also sheds the light on other consonants that are still produced correctly by 11/12 participants in spite of their articulation complexity or markedness. For example, /f/ is consistently present in participants' phonetic inventory as young as age 2;06 years, i.e. Group-2. Similarly, /tˤ/ and /ʤ/ in Group-3, / ħ/ and /ʕ/ in Group-4 and /sˤ/ in Group-5.

Table 5.41.

SIWI Consonant Acquisition.

SIWI	**G1**	**G2**	**G3**	**G4**	**G5**
Mastered +90%	-	-	-	-	w
Acquired 75-89%	ʔ	ʔ	b	k, ʔ, w	b, tˤ, k, ʔ, f, h, n, ɾ
Customarily Produced 50-74%	b, m, w	b, l, w	d, ʔ, f, h, n, l, w	b, f, m, l,	d, g, ʃ, ħ, ʕ, l, j
Consistently Present 1-49%	d, h	t, d, k, ʔ, f, h, m, n, j	t, tˤ, k, g, s, ʤ, m, ɾ, j	t, d, g, s, ħ, ʕ, h, n, l	t, s, sˤ, x, ʤ, m

Key: SIWI = Syllable-Initial Word-Initial

Next, the results of gender differences in the acquisition of SIWI consonants are presented. Table 5.42 below lists all Najdi-Arabic consonants and denotes by which gender and age group they are: Mastered, Acquired, Customarily produced, Not acquired, or Not attempted. Numerical values in each cell represent the same-gender average of percent correct production of the consonant in each row within that age group (columns). As explained in section 5.8.2, same-gender average percent of any consonant can be higher or lower than the percent range of the acquisition group they fall into.

In table 5.42, gender differences in the positional acquisition of consonants can be appreciated in more detail. If the data were combined across the two genders, informative data would have been lost. On many occasions, both genders show great similarities in their consonant acquisition journey, however obvious differences also arise. These differences can be in acquisition level of the individual consonant or whether the consonant is acquired at all by the opposite gender. For example, in Group-3, both female and male participants have some level of acquisition of the consonants /b/, /d/, /ʔ/, /f/ /h/, /m/, /n/, /l/, and /j/ in SIWI. However, /ʔ/ and /h/ are both acquired by the females while they are only customarily produced by their male peers. Similarly*,* the females mastered /j/ in SIWI whilst their male peers only customarily produced it. On the contrary, the females customarily produce /n/ whilst their male peers acquired it. Moreover, the female participants customarily produce /t/, /k/ and /s/ while their male peers have not acquired it at all. On the contrary, the male participants customarily produced /g/ while their female peer did not. Similar gender related patterns are also observed in other syllable/word positions (tables 5.46, 5.50, and 5.54 in the next three sections).

Table 5.42.

Age and Gender Differences in SIWI Consonant Acquisition.

	G1		***G2***		***G3***		***G4***		***G5***	
	F	M	F	M	F	M	F	M	F	M
b	73.26	78.63	87.58	78.54	**89.33**	**84.06**	89.66	82.27	**87.89**	**87.57**
t					62.10		66.02		**85.86**	
tˤ							66.61		**87.80**	**87.94**
d	88.89				54.17	62.65	70.67	60.65	77.78	74.44
dˤ	**NA**	**NA**	**NA**		**NA**	**NA**	**NA**			
k					78.42		**94.16**	**82.06**	**94.84**	**88.28**
g			68.89			67.30	71.75		**89.80**	65.00
q	**NA**									
ʔ	**77.88**	**86.41**	**88.16**	**82.93**	**87.29**	81.77	**88.07**	**83.44**	**86.57**	**86.24**
f					74.86	64.94	**93.15**	72.02	**93.66**	**91.14**
θ										
ð							75.00			
ðˤ										
s					55.83					
sˤ										
z										66.67
ʃ									69.52	**82.73**
x									74.75	80.85
ɣ										62.30
ħ							79.31		**94.60**	72.46
ʕ							**71.22**		66.62	
h			**81.19**		**81.10**	80.93	82.38		**83.65**	**83.63**
ʦ		**NA**					**NA**	**NA**		
ʤ										
m	69.42	78.39		65.98	70.96	69.74	**86.27**	73.57	76.40	
n		**79.17**			72.54	**87.65**	76.67			**88.43**
l	**76.77**		85.01	66.50	**87.00**	**71.96**	**98.03**	75.97	**94.74**	**84.75**
lˤ	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
ɾ					**89.29**				**89.17**	**85.00**
r	**NA**	**NA**	**NA**			**NA**	**NA**	**NA**		**NA**
w	66.87	**88.82**	**91.48**	89.35			**96.42**	**92.81**	**93.25**	**95.19**
j			61.35		**68.27**	33.76	**88.95**		**87.07**	**80.43**
KEY	**NA** = Not attempted or missing		(blank)= Not acquired or did not meet criteria		**Customarily produced 50-74%**		**Acquired 75-89%**		**Mastered +90%**	

Numbers in cells denote the average percent of correct production of the consonant of the same-gender participants in the group. Key: SIWI = Syllable-Initial Word-Initial, F: females, M: Males.

From the previous table, it is clear that 25 Najd-Arabic consonants are produced with very low accuracies in SIWI by all participants in Group-1 (average age 2;00 years). Interestingly, males in Group-1 consistency had higher group average than their female peers of consonants that are judged to be mastered, acquired, or customarily produced: /b/, /d/, /ʔ/, /m/, /n/, /l/, /w/ and /j/. Also in Group -1, only four consonants where not attempted: /lˤ/ and /r/ which do not occur in SIWI unless as a result of an assimilation process and /dˤ/ and /q/ which are not typical of the Najdi dialect and instead are realized as [ðˤ] and [g] respectively. Moreover, Group-3 (average age 3;00 years) appears to be the point where an abrupt increase in the number of stops produced with high accuracy levels take places in both genders. In contrast, fricatives start creeping in at age 3;00 years (Group-3) but age 4;00 years, i.e. Group-5, appear to be the age where most fricatives emerge, especially in the male participants.

In Figure 5.25 below, a quantitative summary of the results in Table 5.42 is presented. As clearly evident in the Figure 5.25, the mastery, acquisition, and customary production of consonants in SIWI steadily increase with age. In general, females in all age groups master, acquire, and customarily produce more consonants than their male peers except in Group -1. In this group, three high-performing males have been recognized. Beyond Group -1 (average age 2;00), female participants start mastering consonants in SIWI around the age of 3;00 years (Group-3) whilst male participants start mastering consonants in SIWI a year later (Group-5: average age 4;00 years). Qualitatively, whilst both female and male participants in Group-5 have 19 consonants each that are either mastered, acquired, or customarily produced, the proportion of consonants in each acquisition group differ between the two genders. As females master four consonants, males only master a single consonant. Also, females, acquired 10 consonants while males acquired 11 consonants. And finally, females customarily produced five consonants when males customarily produced seven consonants. In general, females appear to outshine their male peers in the rate at which consonants are mastered, acquired, or customarily produced in SIWI position.

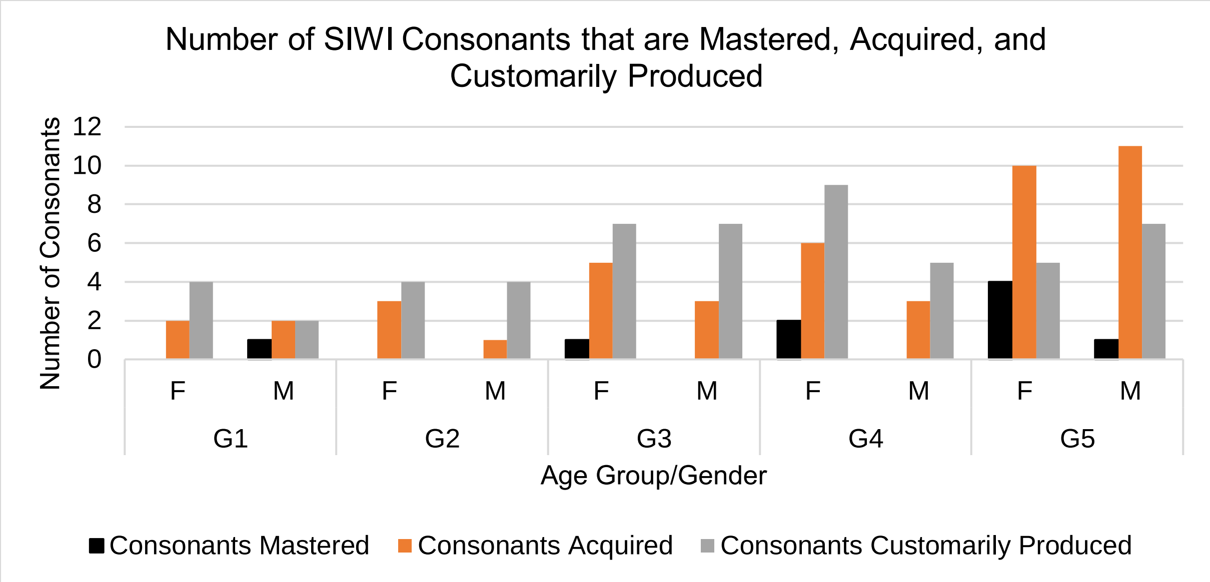

Figure 5.25. Number of SIWI consonants mastered, acquired, and customarily produced- Gender comparison. Key: SIWI= Syllable-Initial Word-Initial, F= Females, M= Males.

Finally, in tables 5.43 and 5.44 below, both the speech task and the gender of participants are compared with regard to consonants' acquisition groups. By comparing both tables, it becomes evident that more consonants present themselves as acquired and customarily produced in the SPON sample than in PN sample. However, more consonants present themselves as mastered in PN sample. Also, female participants in general in both speech tasks master, acquire, and customarily produce more consonants than their male peers, expect in Group-1 in the SPON sample. Furthermore, qualitatively, different consonants and consonantal groups are acquired at each speech task. For example. In Group-4, females master /f/, /ħ/, /l/, /ɾ/, and /w/ in PN while they master a different set of consonants in the SPON sample; i.e. /b/, /k/, /l/, and /w/ with only /l/ acquired both tasks. It is worth noting that consonants that appear as mastered in the PN sample are more complex than those mastered at the SPON sample.

Table 5.43.

SIWI Consonant Acquisition in PN Sample: Gender Comparison.

	G1		G2		G3		G4		G5	
PN sample	F	M	F	M	F	M	F	M	F	M
Mastered +90%	-	-	ʔ	-	ʔ, l, w	-	f, ħ, l, ɾ, w	w	k, ħ, n, l, ɾ, w	tˤ, ʔ, f, ħ, h, l, ɾ, w
Acquired 75-89%	-	-	b	-	-	b, ʔ	b, k, ʔ, j	b, ʔ	b, t, g, ʔ, f, j	b
Customarily produced 50-74%	ʔ	ʔ	g, h, l	ʔ, l	b, k, h, j	g, h, n, l	g, m, n	f, ħ, l	d, ʃ, ʕ, h, m	d, k, g, ʃ, x, ʕ, n, j
Consistently Present 1-50%	b, d, m	b, m	k, s, m, w, j	b, h, m, w, j	d, g, f, s, m, n	d, k, f, s, m, j	t, d θ, s	t, d, k, g, s, m, n	θ, x, ɣ, ʤ	θ, m

Key: SIWI= Syllable-Initial Word-Initial, PN= Picture Naming F: females, M: Males.

Table 5.44.

SIWI Consonant Acquisition in SPON Sample: Gender Comparison.

SPON sample	**G1** F	**G1** M	**G2** F	**G2** M	**G3** F	**G3** M	**G4** F	**G4** M	**G5** F	**G5** M
Mastered +90%	-	m, w	-	-	w	-	b, k, l, w	-	f, ħ, l, w	k, w
Acquired 75-89%	ʔ, m, l,	ʔ,	b, ʔ, h, m, l, w	b, ʔ, w,	b, k, ʔ, h, m, l, ɾ	b, d, m, n, l, w,	t, ʔ, f, ħ, ʕ, m, j	b, k, ʔ, m, w	b, t, tˤ, k, g, ʔ, x, m, n, ɾ, j	b, tˤ, ʔ, f, ʃ, h, l, j
Customarily produced 50-74%	b, n,	b,	f, n, ɾ, j	f, ʕ, h, m, l,	t, f, ħ, ʕ, j	ʔ, f, h,	tˤ, d, g, ʃ, h, n	d, g, f, h, n, l, j	s, ʃ, ʕ, h, ʤ,	t, z, x, ɣ, ʕ, m, n
Consistently Present 1-50%	h, w, j	t, d, h, l,	t, tˤ, k, s,	t, d, k, ħ, j	g, ʃ, x	tˤ, k, x, ħ, ɾ, j	θ, s, ɾ	ʃ, ħ, ʕ, ɾ,	-	g, s, ħ, ʤ,

Key: SIWI= Syllable-Initial Word-Initial, SPON= Spontaneous, F: females, M: Males.

5.8.2.2. Medial onset: Syllable-Initial Within-Word (SIWW)

Similar to section 5.8.2.1, the general findings of SIWW consonant acquisition irrespective of participant's gender or speech task are presented first. Then, it is followed by comparing gender and speech task. Table 5.45 below lists all consonants in all four acquisition categories. It is clear that /w/ is the only consonant that has been mastered by Groups 1 and 5. Also, very few consonants have been acquired before the age of 3;06 years (Group-4) however, there are more customarily produced consonants as they steadily increase with age. It is worth nothing that fricatives do not appear in any acquisition group before the age of 3;06 years (Group-4) but are consistently present in the phonetic inventory of the participants in all age groups from a very young age; i.e. 2;00 years (Group -1).

Table 5.45.

SIWW Consonant Acquisition.

SIWW	G1	G2	G3	G4	G5
Mastered +90%	w	-	-	-	w
Acquired 75-89%	-	n, w	b, w	k, g, m, n, l, w, j	b, t, k, ʔ, ʃ, x, ħ, l, ɾ, j
Customarily Produced 50-74%	d, m, n, j	b, d, ʔ	d, g, m, n, l, j	b, d, f, ʕ	tˤ, d, g, f, ʕ, h, m, n, lˤ
Consistently Present 1-49%	b, ð, l	k, ð, ħ, m, l, ɾ, j	t, k, ʔ, f, ð, s, ħ, ʕ, h, ɾ, r	ʔ, θ, ð, s, ħ, ʕ, h, lˤ, ɾ	θ, ð, s, ɣ, ʤ

Key: SIWW = Syllable-Initial Within-Word

Table 5.46 below lists all Najdi Arabic consonants and denotes by which gender and age group they are: Mastered, Acquired, Customarily produced, Not acquired, or Not attempted. Numerical values in each cell represent the same-gender average of percent correct production of the consonant in each row within that age group (columns). As explained in section 5.8.2., same-gender groups' average can fall outside the range of the acquisition group for the consonant in question.

From the table below, only six consonants (i.e. /b/, /d/, /m/, /n/ /l/, /w/, and /j/) are produced with relatively high accuracies in SIWW by all participants in Group-1 (average age 2;00 years). Also, only two consonants, i.e. /dˤ/ and /q/, were not attempted by female participants and only /dˤ/ was not attempted by male participants in Group-1. In Najdi Arabic, the emphatic /dˤ/ and glottal stop /q/ are typically realized as [ðˤ] and [g] respectively. However, both consonants emerge in children's consonant inventory as young as 2;06 years most likely as a result of the exposure to MSA at nursery or to SA via listening to the recitation the holy book of Qur'an or announced prayers.

Table 5.46.

Age and Gender Differences is SIWW Consonant Acquisition.

	G1		G2		G3		G4		G5	
	F	M	F	M	F	M	F	M	F	M
b	70.54	73.99	88.44	76.19	90.95	87.68	91.92	83.85	87.80	88.58
t			61.78		67.94	55.80	73.38		81.17	89.32
tˤ					64.70		67.78		84.60	74.48
d	70.55	70.51	71.15	76.39	76.38	80.28	79.89	80.03	79.83	76.43
dˤ	**NA**	**NA**				**NA**				
k			67.72		82.17		90.31	84.93	89.49	94.83
g			71.94		81.67		86.61	83.08	79.22	85.97
q	**NA**								87.50	
ʔ			90.15			77.25	76.67	65.83	93.92	86.51
f							69.56	64.28	77.42	60.00
θ							76.79		59.56	
ð									79.22	63.42
ðˤ										
s							62.76			
sˤ										
z										79.33
ʃ									92.36	79.75
x									86.48	93.92
ɣ									71.07	63.33
ħ					73.66		81.04	71.12	94.00	89.70
ʕ							69.19	71.43	82.04	77.05
h			75.28				73.71	67.85	77.01	76.29
ʦ							**NA**	**NA**	**NA**	**NA**
ʤ									69.50	
m	83.18	90.84		70.42	83.21	82.84	90.97	89.26	86.92	84.38
n	74.82	83.76	83.18	91.26	79.46	76.54	91.91	88.72	89.89	84.64
l	71.50		81.21		88.61	81.29	92.02	88.93	95.29	89.89
lˤ									70.83	86.11
ɾ							71.60		86.13	81.80
r					75.00		75.00		74.63	
w	92.78	100	96.75	91.67		86.43	92.90	91.82	95.70	94.33
j	69.20	76.29	80.77		83.51	79.47	93.92	89.33	85.79	93.47
KEY	**NA** = Not attempted or missing		**(blank)= Not acquired or did not meet criteria**		**Customarily produced 50-74%**		**Acquired 75-89%**		**Mastered +90%**	

Numbers in cells denote the average percent of correct production of the consonant within the same-gender participants in the group. Key: SIWW: Syllable-Initial Within-Word, F: females, M: Males.

Furthermore, females in Group-1 (average age 2;00) surpass their male peers by at least a 12 month-period in the customary production of the lateral approximant /l/. Moreover, females as young as 2;06 years (Group-2) show an earlier awareness to back stops /k/, /g/, /ʔ/ and back fricative /h/ as shown in their acquisition and customary production surpassing their males peers by at least 12-months period. Similarly, females in Group-2 surpass their male peers in the customary production of /t/ by a 6-month period and females in Group-3 surpass their male peers in the customary production of /tˤ/ by a 12-month period. Also, females in Group-3 also surpass their male peers by a 6-month period in the customary production of /ħ/. Finally, the oldest male participants in Group-5 (average age 4;00 years) do not exhibit any acquisition level of the trill consonant /r/ in SIWW position while Group-3 females, who are 12 months younger, have acquired it.

In general, male participants in Group-1 appear to have a relatively higher group average of percent correct production of consonants when compared to their female peers of consonants they both mastered, acquired, or customarily produced. In all other age groups, i.e. Groups 2, 3, 4 and 5, same-gender group average does not appear to consistently be higher in either gender. Moreover, in SIWW position, alveolar stops appear to be the last of stops to emerge in male participants. On the other hand, labio-dental followed by pharyngeal and glottal fricatives are the first to emerge and are acquired well before all other fricatives.

In figure 5.26, a quantitative summary of the results in Table 5.46 above is presented. As clearly evident in the figure below, the mastery, acquisition, and customary production of consonants steadily increase with age. In general, female participants across all age groups appear to have the same number or more consonants that are either mastered, acquired, or customarily produced than their male peers with the exception of acquired consonants in Group-1 and customarily produced consonants in Group-5.

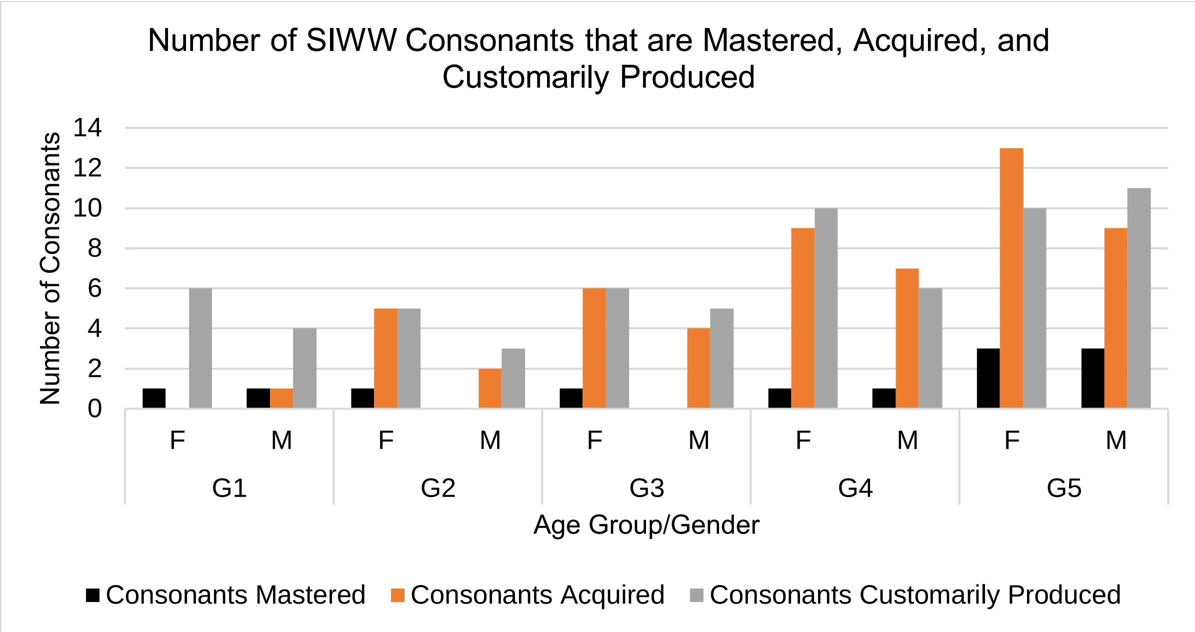

Figure 5.26. Number of SIWW consonants mastered, acquired, and customarily produced- Gender comparison. Key: SIWW= Syllable-Initial Within-Word, F= Females, M=Males.

Finally, in tables 5.47 and 5.48 both the speech task and the gender of participants are compared in regard to consonants' acquisition groups. In general, more consonants present themselves as mastered in PN sample in all age groups. Conversely, more consonants present themselves as acquired or customarily produced in the SPON sample across all age groups. Additionally, female participants in general appear to master, acquire, and customarily produce more consonants than their male peers in both speech tasks however, the difference between the two genders is greater in the PN sample for mastered consonants and in SPON sample for acquired and customarily produced consonants. Furthermore, a notable qualitative difference between the two samples within the same participants can be observed. For example, Group-4 females mastered seven consonants in the PN sample: /t/, /g/, /ʔ/, /h/, /n/, /w/, and /j/ while in the SPON sample the same consonants: /g/, /n/, /w/, and /j/ are acquired but not mastered, /h/ is customary produced, /t/ is consistently present and /ʔ/ is not even consistently present in their phonetic inventory.

Table 5.47.

SIWW Consonant Acquisition in PN sample: Gender Comparison.

	G1		G2		G3		G4		G5	
PN sample	F	M	F	M	F	M	F	M	F	M
Mastered +90%	w	-	ʔ, w	-	g, l, lˤ, w	-	t, g, ʔ, h, n, w, j	g, w	t, g, ʔ, ʃ, x, ħ, l, r, w	t, ʔ, x, ɣ, ħ, l, w
Acquired 75-89%	-	-	b, d	-	-	-	b, m, l	m, n, l	b, tˤ, k, ʕ, m	b, tˤ, k, s
Customarily produced 50-74%	m, n, l	l	k, n, l	b, d, ʔ, n	b, tˤ, d, k, j	b, d, g, ʔ, m, n, l, w	d, k, θ, ħ, ɾ	b, d, ħ	d, h, ʤ, n, ɾ, j	d, ð, ʃ, ʕ, n, lˤ, ɾ, j
Consistently Present 1-49%	b, s	-	tˤ, s, m, j	ð, m, l, w	ʔ, f, ʤ, m, n, ɾ	k, f, ð, s, ɾ	tˤ, f, s, ʕ	t, k, ʔ, f, s, ʕ, ɾ	f, θ, s, ɣ	ʤ, m

Key: SIWW= Syllable-Initial Within-Word, PN= Picture Naming, F= Females, M= Males

Table 5.48.

SIWW Consonant Acquisition in SPON Sample: Gender Comparison.

SPON sample	**G1**		**G2**		**G3**		**G4**		**G5**	
	F	M	F	M	F	M	F	M	F	M
Mastered +90%	-	m, w	w, j	n, w	w	j	b, k	k, j	ħ, m, n, w	b, k, m
Acquired 75-89%	d, m, w	d	d, n,	d,	b, k, ħ, ʕ, m, n, l, j	b, m, l, w,	d, g, ħ, ʕ, m, n, l, ɾ, w, j	b, d, ʕ, m, n, l, w	b, t, tˤ, k, ʃ, x, ɣ, h, l, ɾ,	t, ʃ, x, ħ, n, l, lˤ, w, j
Customarily produced 50-74%	b, n, l, j	b, t, n	b, t, k, g, s, f, h, m , l	b, m, l	t, d, g, ʃ, h	t, d, k, g, f, h, n, r	tˤ, f, θ, ð, h	g, f, h	d, g, q, f, ð, s, ʕ, ʤ, j	d, g, f, s, z, ʕ, h, ʤ, ɾ
Consistently Present 1-49%	ð	ð, ħ, l	ʕ, ɾ, r	k, ð, ħ, ɾ, r	ð, s, ɾ	ð, s, ħ, ɾ	t, s, ʃ, ʤ	t, ð, s, ʃ, ħ, lˤ, ɾ	θ, z	tˤ, ð, sˤ

Key: SIWW= Syllable-Initial Within-Word, SPON= Spontaneous, F= Females, M= Males.

5.8.2.3. Medial coda: Syllable-Final Within-Word (SFWW)

Similar to section 5.8.2.1., the general findings of SFWW consonant acquisition irrespective of participant's gender or speech task are presented first. Then, it is followed by gender and speech tasks comparisons. Table 5.49 below lists all consonants in all four acquisition categories. It is clear that SFWW consonants mastery starts in Group-5 (average age 4;00 years) with two back fricatives /ħ/ and /h/, consonant acquisition starts in Group-4 (average age 3;06 years) with: /g/ and /ħ/, and customary production of consonants starts in Group-3 (average age 3;00 years) with: /k/, /ħ/, /n/ , /w/, and /j/. Finally, /n/ is the only consonant that is consistently present in SFWW position in Group-1 (average age 2;00 years) and continues to do so until it reaches mastery level 12 months later. Interestingly, despite its early emergence in this position, /n/ does not reach mastery or even acquisition level in the eldest participants; Group-5 (average age 4;00 years). This example may indicate that consonants in SFWW position are the most challenging.

Table 5.49.

SFWW Consonant Acquisition.

SFWW	**G1**	**G2**	**G3**	**G4**	**G5**
Mastered +90%	-	-	-	-	ħ, h
Acquired 75-89%	-	-	-	g, ħ	k, ʃ, x, m l
Customarily Produced 50-74%	-	-	k, ħ, n , w, j	b, d, k, m, n, l, w, j	b, t, tˤ, f, s, ʕ, n, r, w, j
Consistently Present 1-49%	n	d, n, l, w, j	b, d, f, s, l, r	f, s, ʕ, r	d, ð, z

Key: SFWW= Syllable-Final Within-Word

Next, in Table 5.50 gender differences in the acquisition of consonants are investigated in detail. The table lists all NA consonants and denotes by which gender and age group they are: Mastered, Acquired, Customarily produced, Not acquired, or Not attempted. Numerical values in each cell represent the same-gender average of percent correct production of the consonant in each row within that age group (columns). As explained in section 5.8.2., same-gender groups' average can fall outside the range of the acquisition group for the consonant in question.

Although both genders in Group-1 appear to customarily produce /n/, it is it not considered as customarily produced by Group-1 as a whole. This is because only five female and five males (10 in total) customarily produced it in SFWW whilst the criteria for age-group acquisition requires /n/ to at least be customarily produced by 11/12 participants in that group. Also, male participants in Group-1 appear to have mastered /m/ while their female peers did not. Beyond Group-1, female participants in Groups 2, 3, 4 and 5 appear to master, acquire, and customarily produce more consonants than their male peers. For example, females in Group-4 customarily produced: /t/, /tˤ/, /ʕ/, /h/, and /r/ while their male peers did not. Furthermore, consonants that are produced correctly by both genders, female participants appear to have an overall higher group average of percent correct often elating them to a higher acquisition group. For example, /b/, /l/, /w/, and /j/ are acquired by the female participants in Group-4 while they are only customarily produced by their male peers.

Table 5.50.

Age and Gender Differences is SFWW Consonant Acquisition.

	G1		G2		G3		G4		G5	
	F	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**
b			58.33	48.67	76.51		90.64	75.15	87.22	78.51
t							69.66		79.79	66.10
tˤ							65.98		84.56	74.68
d					71.57		79.63	68.14	74.07	81.11
dˤ	NA	NA	NA	NA		NA		NA	NA	NA
k			60.14		71.11	80.00	95.83		90.19	
g					86.83		85.56	91.67		78.52
q	NA		NA				NA	NA		
ʔ	NA	NA	NA	NA		NA	NA			
f							89.91		92.92	90.42
θ									72.22	65.74
ð									73.61	
ðˤ									59.13	
s			75.99		72.05					72.28
sˤ										
z									64.72	65.18
ʃ									78.58	95.83
x									86.67	93.27
ɣ										
ħ			61.19		83.33	61.24	94.44	80.56	100	95.15
ʕ							71.94		73.45	71.71
h							75.00		100	83.33
ʦ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ʤ										
m		91.67				98.48	84.49	85.58	97.22	82.15
n	62.22	65.94	67.80	63.97	75.01	84.41	88.97	77.31	88.69	80.06
l					73.69		88.15	73.43	85.58	87.90
lˤ										80.00
ɾ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
r					54.89		65.04		79.11	75.61
w			78.12		92.96	77.51	90.97	77.16	88.49	85.07
j			74.17		88.51	83.33	81.51	73.54	85.34	95.40
KEY	NA = Not attempted or missing		(Blank)=Not acquired or did not meet criteria		**Customarily produced 50-74%**		**Acquired 75-89%**		**Mastered +90%**	

Numbers in cells denote the average percent of correct production of the consonant of same gender participants within the group. Key: F= Females, M= Males, SFWW= Syllable-Final Within-Word.

In figure 5.27, a quantitative summary of the results in table 5.50 above is presented. As clearly evident in the figure below, the mastery, acquisition, and customary production of consonants steadily increase with age. In general, female participants across all age groups appear to have the same number or more consonants that are either mastered, acquired, or customarily produced than their male peers. In comparison to other syllable-word positions, SFWW appears to be the most challenging of all syllable-word positions clearly noted in the small number of consonants mastered, acquired, or even customarily produced especially in Groups 1, 2 and 3.

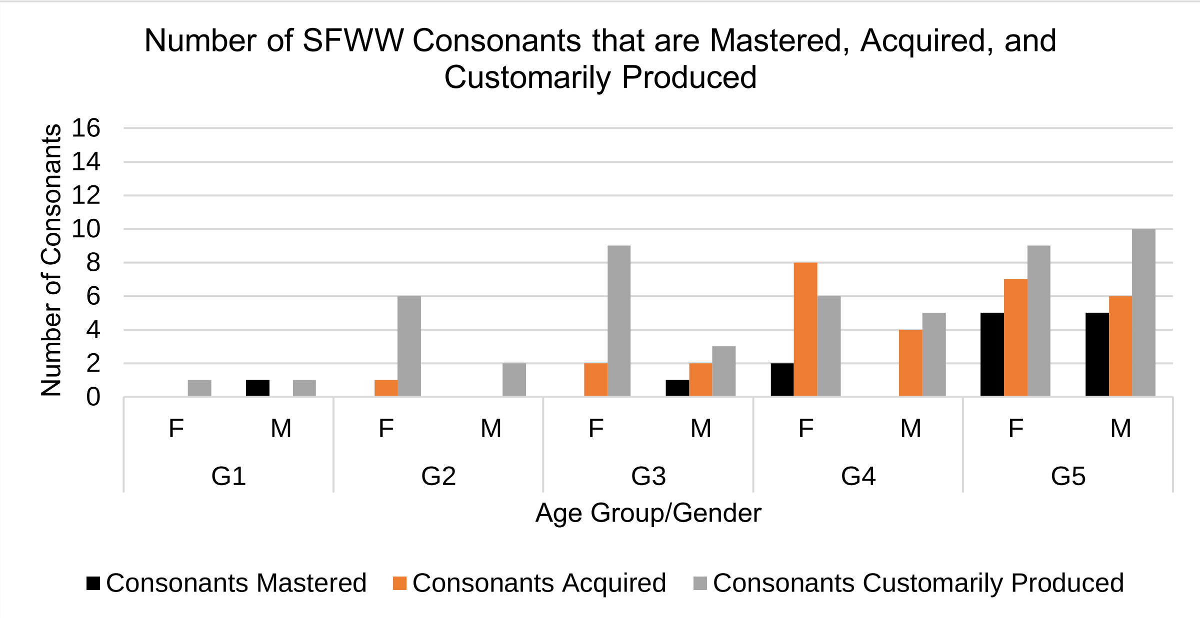

Figure 5.27. Number of SFWW consonants mastered, acquired, and customarily produced- Gender comparison. Key: SFWW= Syllable-Final Within-Word, F= Females, M= Males.

Finally, in Tables 5.51 and 5.52 both the speech task and the gender of participants are compared in regard to consonants' acquisition groups. Similar to the findings in section 5.8.2.1., more consonants present themselves as mastered in the PN sample when compared to the SPON sample. Also female participants in both speech samples appear to master, acquire, and customarily produce more consonants than their male peers most evident in Groups 4 and 5. Furthermore, the back fricatives /ħ/ appear sooner than front fricatives in PN sample while the front fricative /f/ is the first of fricatives to appear in the SPON sample at age 2;06 years. In either speech samples, no fricatives are customarily produced before the age of 3;00 years (Group-3).

Table 5.51.

SFWW Consonant Acquisition in PN Sample: Gender Comparison.

PN	**G1**		**G2**		**G3**		**G4**		**G5**	
Sample	F	M	F	M	F	M	F	M	F	M
Mastered +90%	-	-	-	-	w, j	m, n	b, k, g, f, ħ, h, n, w, j	g, f, n	b, f, x, ħ, h m, j	b, f, sˤ, ʃ, x, ħ, w
Acquired 75-89%	-	-	-	-	-	-	d, θ, l	ħ	ʕ, l	d, z, ʕ
Customarily produced 50-74%	-	-	w	-	d, ħ, l	d, w	ʕ, r	d, l, w, j	t, tˤ, d, k, θ, ð, s, z, r, w	tˤ, θ, ð, s, l, r, j
Consistently Present 1-49%	-	-	d, s, ħ, l	l	tˤ, s, ʕ, r	θ, s, ħ, l	t, tˤ, ð, s, z	tˤ, s, ʕ	ʃ	n

Key: SFWW= Syllable-Final Within-Word, PN= Picture Naming, F= Females, M= Males.

Table 5.52.

SFWW Consonant Acquisition in SPON Sample: Gender Comparison.

SPON sample	**G1** F	**G1** M	**G2** F	**G2** M	**G3** F	**G3** M	**G4** F	**G4** M	**G5** F	**G5** M
Mastered +90%	-	m	-	d	-	k, m	-	ħ	f, m,	j
Acquired 75-89%	-	-	n, w, j	n	g, w, j	n, w	b, k, f, ħ, m, n, l, w	b, m, w	b, s, n, l, w	g, f, m, n, l, w
Customarily produced 50-74%	n, l,	-	k, s,	w	b, f, s, n, l	j	t, d, g, z, ʕ, r, j	g, f, ʕ, n, l, r, j	t, tˤ, d, ʃ, ʕ, r, j	b, t, d, s, ʃ, ħ, ʕ, lˤ, r
Consistently Present 1-49%	-	-	t, f, l	m	tˤ, d, ʕ, r	d, l, r	tˤ, s	t, k,	-	tˤ, sˤ, z

Key: SFWW= Syllable-Final Within-Word, SPON= Spontaneous, F= Females, M= Males.

5.8.2.4. Absolute coda: Syllable-Final Word-Final (SFWF)

Similar to section 5.8.2.1., the general findings of SFWF consonant acquisition irrespective of participant's gender or speech task are presented first. Then, it is followed by comparing gender and speech tasks. Table 5.53 lists all consonants in all four acquisition categories. It is clear that SFWF consonants mastery starts in Group-5 (average age 4;00 years) with a single back fricatives /x/, consonant acquisition starts in Group-2 (average age 2;06 years) also with a single back fricative /ħ/, and customary production of consonants starts in the youngest age group Group-1 (average age 2;00 years) with: /m/, /n/ and /w/. Moreover, the trill /r/ appears in the consonant inventory of children in SFWF position as early as 2;06 years (Group-2) but takes over 18 months of practice before it reaches customary production level at age 4;00 years (Group-5).

Table 5.53.

SFWF Consonant Acquisition.

SFWF	G1	G2	G3	G4	G5
Mastered +90%	-	-	-	-	x
Acquired 75-89%	ʔ	ħ	-	m, n	ħ
Customarily Produced 50-74%	m, n, w	b, ʔ, n, l	b, ʔ, f, m, n, l, j	k, g, ʔ, f, ħ, l, j	b, tˤ, d, k, ʔ, f, θ, ʃ, m, n, l, r, j
Consistently Present 1-49%	b, d, h,	t, d, f, ʕ, m, r	t, θ, ħ, h, r	b, t, d, θ, ʕ, h, r	g, s, ʕ, h

Key: SFWF= Syllable-Final Word-Final.

Next, in Table 5.54, gender differences in the acquisition of consonants are compared. The table lists all Najdi-Arabic consonants and denotes by which gender and age group they are: Mastered, Acquired, Customarily produced, Not acquired, or Not attempted. Numerical values in each cell represent the same-gender average of percent correct production of the consonant in each row within that age group (columns). As explained in section 5.8.2., same-gender groups' average can fall outside the range of the acquisition group for the consonant in question.

Although females in Group-1 did not master any consonants in SFWF position, they acquired /ʔ/ and /n/ and customarily produced /b/, /d/ and /m/. On the other hand, their male peers mastered /w/, acquired /ʔ/ and /n/ but only customarily produced /b/ and /m/ and consistently had higher group average percent of correct production when compared to their female peers. Moreover, although female participants in Group-2 did not master any consonants, they manage to nearly double the total number of consonants that are either acquired or customarily produced (total of 11 consonants) while their male peers show gradual increase of the acquisition and customary production of consonants over time (total of 6 consonants). In general, interdental, alveolar and post-alveolar fricatives are the last to be mastered, acquired, or customarily produced in SFWF position.

Table 5.54.

Gender Differences is SFWF Consonant Acquisition.

	G1		G2		G3		G4		G5	
	F	M	F	M	F	M	F	M	F	M
b	64.96	78.67	86.28	80.41	72.99	69.86	80.66		66.70	67.82
t			75.81		64.91	69.62				61.91
tˤ									82.00	76.79
d	83.33		84.04		64.04		77.42	70.93	81.53	81.55
dˤ	NA	NA	NA	NA			NA	NA	NA	
k			79.17		69.72		94.29	74.44	92.86	80.28
g					56.98		79.17	79.17	83.61	
q	NA		NA		NA	NA	NA	NA		NA
ʔ	85.12	86.41		71.43	97.22	73.83	83.92	85.42	79.97	81.67
f			89.58		70.42	74.12	88.87	90.15	97.62	84.92
θ							82.50		52.78	87.78
ð										55.56
ðˤ										
s			61.11		74.72			57.31		69.78
sˤ										75.00
z										76.67
ʃ									80.28	83.73
x									83.33	100.0
ɣ										
ħ			88.19	91.92	68.35	75.83	85.05	89.72	89.15	96.15
ʕ					70.65		72.28			
h				77.12	81.50	78.20	75.22	53.61	78.60	
ʦ		NA	NA	NA			NA		NA	NA
ʤ									77.78	
m	64.47	78.39	91.67		78.24	95.15	97.22	81.09	68.89	77.39
n	76.21	79.17	81.42	82.01	75.67	83.21	88.95	87.08	79.69	76.22
l			66.92	64.92	76.72	62.20	83.49	72.23	79.76	83.27
lˤ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ɾ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
r					66.76	64.73	68.35		82.80	72.62
w		88.82						89.70	80.48	
j			81.83		91.13	59.44	76.77	79.44	86.78	72.32
KEY	NA = Not attempted or missing		(Blank)=Not acquired or did not meet criteria		Customarily produced 50-74%		Mastered 75-89%		Acquired +90%	

Numbers in cells denote the average percent of correct production of consonants by the same-gender participants within the group. Key: SFWF= Syllable-Final Word-Final, F= Females, M= Males.

In figure 5.28, a quantitative summary of the results in Table 5.54 is presented. As clearly evident in the graph below, the mastery, acquisition, and customary production of consonants steadily increase with age. In general, female participants across all age groups appear to master, acquire, and customarily produced more consonants than their male peers.

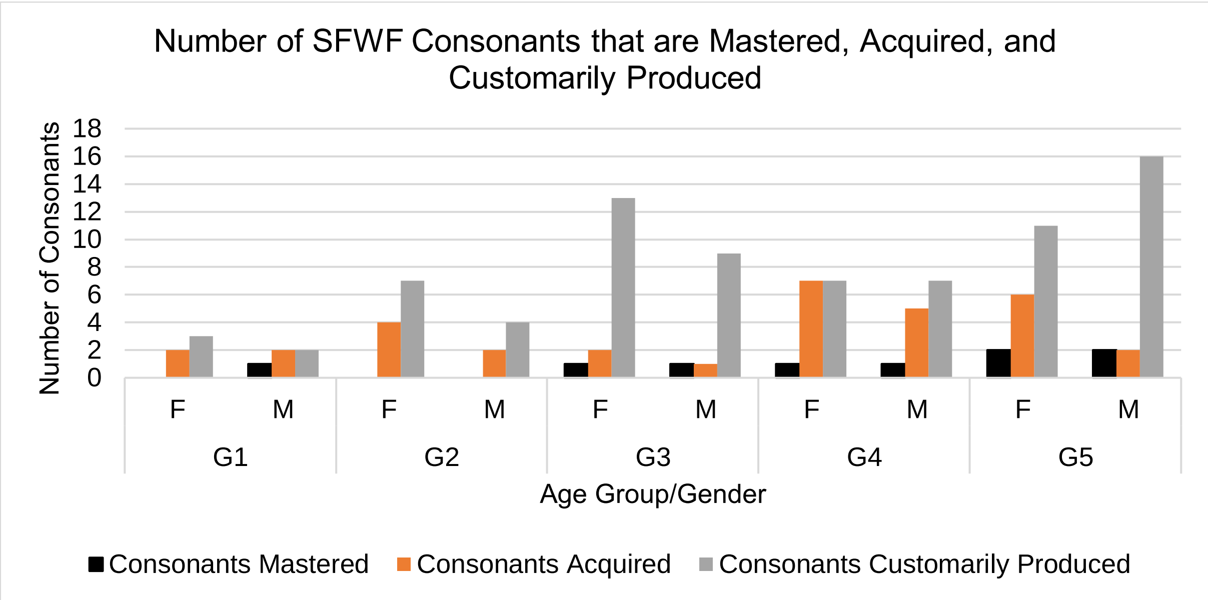

Figure 5.28. Number. of SFWF consonants mastered, acquired, and customarily produced- Gender comparison. Key: SFWF= Syllable-Final Word-Final, F= Females, M= Males.

Finally, consonant acquisition and gender differences are compared between the two speech samples: PN and SPON (Tables 5.55 and 5.56). Similar to the findings in section 5.8.2.1., more consonants present themselves as mastered in the PN sample when compared to the SPON sample. Also, female participants in both speech samples appear to master, acquire, and customarily produce more consonants than their male peers most evident in Groups 3, 4, 5. Furthermore, the age of acquisition of consonants differs drastically between the two samples. For example, the labio-dental fricatives /f/ is the first fricative to be mastered in PN sample at age 2;06 yet it is not mastered in the SPON sample until the age of 4;00 years.

Table.5.55.

SFWF Consonant Acquisition in PN Sample: Gender Comparison.

PN	**G1**		**G2**		**G3**		**G4**		**G5**	
Sample	F	M	F	M	F	M	F	M	F	M
Mastered +90%	-	-	ʔ, f, m, j	-	ʔ, j	m	k, g, ʔ, f, ħ, m, n	ʔ, f, ʃ, j	d, k, g, f, ʃ, x, ħ, ʤ	tˤ, d, k, f, θ, ʃ, x, j
Acquired 75-89%	-	-	b, n	-	-	-	θ	n	l, r	l
Customarily produced 50-74%	ʔ, n	-	t, d, k, s	b, ħ, n, l	b, g, θ, n, l, r	b, t, ʔ, f, θ, n, l, r, j	b, t, l, r	t, d, k, g, l	t, θ, n	b, ʔ, s, n, r
Consistently Present 1-49%	-	b	θ, l, r	r	t, f	-	-	b, s, r	b, ʔ	t, ð

Key: SFWF= Syllable-Final Word-Final, PN= Picture Naming, F= Females, M= Males.

Table.5.56.

SFWF Consonant Acquisition in SPON Sample: Gender Comparison.

SPON Sample	**G1**		**G2**		**G3**		**G4**		**G5**	
	F	M	F	M	F	F	M	F	M	F
Mastered +90%	-	m, w	m	-	ʔ	-	m,	-	f	ħ
Acquired 75-89%	ʔ, n	ʔ,	b, t, ħ	ħ	ħ, j	ħ, m, n,	b, k, f, ħ, n,	ʔ, ħ, m, n	d, ħ, n, r, j	d, ʔ, l
Customarily produced 0-74%	m, l,	b,	k, ʔ, n	b, d, h, n	b, t, d, k, f, s, ʕ, h, m, n, l, r	b, k, f, h, r,	tˤ, d, g, ʔ, ʕ, h, l, r, j	b, d, s, l, w, j	b, k, g, ʔ, s, ʃ, h, m, l, w	b, t, k, f, s, ʃ, h, m, n, r
Consistently Present 1-49%	b, w	t, d, h, l,	d, g, s, ʕ, l, r	t, g, ʕ, m, l, r	-	t, d, l,	t	t, f, ʕ, h, r,	t, tˤ, ʕ,	tˤ, g, ʕ, j

Key: SFWF= Syllable-Final Word-Final, SPON= Spontaneous, F= Females, M= Males.

5.8.3. Additional consonant analysis

In this analysis, consonants which are neither Mastered, Acquired, Customarily produced, or Consistently present were not included in the tables above. Therefore, one additional group: ***Consistently Absent*** is presented in this section. Consonants that are not attempted, incorrectly produced, or missing from the consonant inventory of all the participants (12/12 participants) are considered as *Consistently Absent*. In this group, speech task and positional differences are two variables considered in the reporting of consonants that are not attempted at all or had 0% accuracy by all the participants in each age-group (Table 5.57 and 5.58).

Table 5.57.

PN Consonants that are Consistently Absent from the Participants' Consonant Inventory.

PN	G1	G2	G3	G4	G5
SIWI	dˤ, ðˤ, ʦ, ʤ, lˤ, r	ð, ðˤ, sˤ, ʦ, lˤ, r	q, ðˤ, ʦ, lˤ	ʦ, lˤ, r	ʦ, lˤ, r
SIWW	dˤ, q, sˤ, z, ʦ, lˤ	q, sˤ, ʦ	z	q, ʦ	dˤ, q, ʦ
SFWW	dˤ, q, ʔ, ðˤ, ʦ, ʤ, lˤ, ɾ	dˤ, q, ʔ, sˤ, ʦ, lˤ, ɾ	dˤ, q, ʔ, ʦ, lˤ	q, ʔ, ʦ, lˤ, ɾ	dˤ, q, ʦ, ɾ
SFWF	dˤ, ʦ, ʤ, lˤ	dˤ, q, ðˤ, ɣ, ʦ, lˤ, ɾ, w	q, ʦ, lˤ, ɾ	dˤ, q, ʦ, lˤ, ɾ	dˤ, q, ʦ, lˤ, ɾ, w

Key: PN = Picture Naming, SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

Table 5.58.

SPON Consonants that are Consistently Absent from the Participants' Consonant Inventory.

SPON	G1	G2	G3	G4	G5
SIWI	dˤ, ð, ðˤ, ʦ, lˤ, r	dˤ, ð, ðˤ, lˤ, r	ðˤ, lˤ, r	dˤ, lˤ, r	lˤ, r
SIWW	dˤ, q, sˤ, ʦ	dˤ, ʦ	ʦ	ʦ	ʦ
SFWW	dˤ, q, ʔ, ɣ, h, ʦ, ʤ, lˤ, ɾ	dˤ, ʔ, θ, ð, ɣ, h, ʦ	dˤ, h, ʦ, ɾ	dˤ, q, ʦ, ɾ	dˤ, ʦ, ɾ
SFWF	dˤ, ð, ðˤ, ʦ, lˤ	dˤ, q, ðˤ, ɣ, ʤ, ʦ, lˤ, ɾ	dˤ, q, ɣ, ʦ, ʤ, lˤ	dˤ, q, ɣ, ʦ	q, ɣ, lˤ, ɾ, ʦ

Key: SPON = Spontaneous, SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

A revised version of Tables 5.57 and 5.58 above is needed (Tables 5.59 and 5.60) to eliminate consonants that are:

- Not typically associated with the Najdi dialect: /dˤ/ and /q/. Both consonants are alternatively realized as [ðˤ] and [g] respectively by the majority of participants in PN task and by all participants in the SPON sample
- The affricate /ʦ/ that appears to very low token frequency.
- Consonants that do not naturally occur in specific positions: i.e. /r/ in both SIWI and SIWW and /r/ in SFWW and SFWF except in geminates.
- Consonants that are rare and specific to very few lexical items: /lˤ/

Table 5.59.

Modified List of PN Consonants that are Consistently Absent from Participants' Consonant Inventory.

PN	G1	G2	G3	G4	G5
SIWI	ðˤ, ʤ	ð, ðˤ, sˤ	ðˤ	-	-
SIWW	sˤ, z	sˤ	z	-	-
SFWW	ʔ, ðˤ, ʤ	ʔ, sˤ	ʔ	ʔ	-
SFWF	ʤ	ðˤ, ɣ, w	-	-	w

Key: PN = Picture Naming, SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

Table 5.60.

Modified List of SPON Consonants that are Consistently Absent from Participants' Consonant Inventory.

SPON	G1	G2	G3	G4	G5
SIWI	ð, ðˤ	ð, ðˤ	ðˤ	-	-
SIWW	sˤ	-	-	-	-
SFWW	ʔ, ɣ, h, ʤ	ʔ, θ, ð, ɣ, h	h	-	-
SFWF	ð, ðˤ	ðˤ, ɣ, ʤ	ɣ, ʤ	ɣ	ɣ

Key: SPON = Spontaneous, SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

The two table above represent the true inventory of consonants that are either missing from the data due to missing data (in PN sample), lexical choice (in SPON sample), or had 0% accuracy by all the participants in each age-group. As expected, hardly any consonants are missing from the inventory of the participants by the age of 3;06 years (i.e. Group-4) in either speech sample.

In Summary, when no distinction has been made between speech tasks, no consonants were mastered (produced correctly +90 of the time by 90% of the participants) in any age group. Similarly, when the speech task or the gender of the participants was taken into consideration, no consonants were mastered either. However, an obvious effect of the gender can be observed in the acquired and customarily produced consonants in favour of the females past the age of 2;06 years. The difference is not only quantitative in the number of consonants acquired and customarily produced but also qualitative differences are noted.

Moreover, greater differences between the consonant acquisition categories were observed when the speech-task, syllable/word position, and the gender of the participants were taken into consideration in the same analysis. Both quantitative and qualitative differences arose. In general, more consonants appeared as mastered in the PN sample whilst many more consonants appeared as acquired, customarily produced, and consistently present in the SPON sample. Moreover, consonants produced correctly in the PN sample in any acquisition category appear to include more complex or marked consonants while those reported in the same position in the SPON sample are easier and unmarked.

Although likely to be linked to the natural distribution of consonants in Najdi Arabic, the positional comparison was extremely informative. For example, the smallest number of consonants have been mastered, acquired, and customarily produced in the medial coda position. Similarly, some consonants did not occur in specific positions emphasizing the role of the phonotactic rules in consonant acquisition in Najdi Arabic.

Finally, hardly any consonants where consistently absent from the phonetic inventory of the participants in group-5 (age 3;10-4;02 years). Interestingly, similar consonants have been reportedly absent from both speech tasks (in various age groups and syllable/word positions) which may qualify them to be the most marked and thus the likely to be latest to be acquired in Najdi Arabic: /ð/, /ðˤ/, /sˤ/, /ʤ/, and /ɣ/. A follow-up study with older participants is necessary to confirm these conclusions.

5.9. Summary

Sixty participants aged 1;10-4;02 years, were enrolled in the current study then stratified into five gender balanced age-groups The total word count = 28,457 words; 98.67% of which is in Arabic and 1.33% in English. Only Arabic words were included in the analysis. Over 76% of the data came from the SPON sample and 23% of data came from the PN sample. The majority of words in both speech samples across all age-groups were bi-syllabic. Moreover, in Table 5.61 below, a summary of the socioeconomic data is provided.

Table 5.61.

Socioeconomic Data Summary.

Variable	**Summary**
Family Monthly income	over 61% of the families has a monthly income between 10,000 and 29,000 SR
Parents' Education	90% of mothers have BSc or higher degree 81.6% of fathers have BSc or higher degree
Maternal occupation and working hours	11.7 % of mother are unemployed 3.3% are full-time students 81.7% are employed in full or part-time jobs.
Time spent daily with a non-Arabic speaking carer	78.3% of the participants spend 3 hours or less. 21.7% spend more than 4 hours daily.
How often are other languages spoken at home?	70% rarely or never speak other languages 28.3 % always or often spoke in English.

The results suggest that family's income, parent's (maternal or paternal) educational level, time spent daily with a non-Arabic speaking carer, or how often other languages are spoken at home is not related to PCC. Consequently, it can be concluded that in the current study the participants' PCC score was not affected (positively or negatively) by any of socioeconomic variables above. However, it is worth noting that the data was not designed to test for these factors hence the lack of variability amongst them which may have influenced the association findings. Also, there was no relation between the participant's age-group and the number of

English words produced during data collection. In contrast, the enrolment in the educational/day-care system was positively related to the Age-Group of the participants. In other words, Saudi children are more likely to be enrolled in an educational/day-care system as they grow older.

In the non-positional frequency analysis of Najdi Arabic consonants, fricatives (32.61%) followed by stops (26.71%) were the most frequent manner groups and affricates (1.04%), the trill (2.01%), and the tap (2.70%) were the least frequent. Other manner of articulation groups, i.e. nasals, approximants, laterals, and emphatics frequencies all ranged between 4.9% and 13.7%. However, in the positional token frequency analysis of consonants, stops were the most frequent in SIWI while fricatives were the most frequent in all other syllable/word positions. Also, affricates were consistently the least frequent in all syllable/word positions. Additionally, the non-positional frequency analysis of individual consonants in the SPON sample was also investigated. The six most-frequent and the six least-frequent consonants with their token frequencies are listed in Table 5.62 below.

Table 5.62.

The Token Frequency of Most and Least Frequent Najdi Arabic Consonants in the SPON sample.

Most frequent		**Least frequent**	
Consonant	Token Frequency	Consonant	Token Frequency
/n/	9.11	/θ/	.72
/ʔ/	8.26	/z/	.71
/h/	8.19	/ɣ/	.34
/l/	7.36	/q/	.23
/b/	6.74	/p/	.06
/ð/	5.33	/d͡z/	.03

Moreover, the positional analysis of individual consonant token frequency in SPON sample suggest that almost all consonants occur in all syllable/word positions except for: /r/ in SIWI position, /ʔ/ in SFWW position (although permissible in MSA), /ɾ/ in SFWF, and /ɣ/ in SFWF (although permissible in MSA).

Furthermore, the speech elicitation/sampling method, age-group, gender of participants, syllable/word position, and manner of articulation were investigated for their relationship to PCC and the summary of findings is presented below.

- *Speech-Task:* In general, there was a significant effect of speech task on PCC, i.e. all participants had higher SPON-PCC when compared to PN-PCC.
- *Age-Group:* In positional and non-positional PCC, there was a significant effect of age-group. In other words, the older the participants the higher their PCC score.
- *Gender:* In positional and non-positional PCC, there is a significant main effect of the gender of the participants on their PCC score but with moderate effect size and insufficient power <.8. In other words, the gender of the participant of a randomly selected data point might be predicted solely based on its PCC or positional PCC score. Nonetheless, the low observed power of the test indicates that there is only a 65-68% chance that the positional and non-positional PCC difference between the two genders is true.

  In both speech samples and all syllable/word positions, female participants had higher PCC average when compare to their male peers especially evident in Groups 2, 3, 4, and 5. However, males in Group-1 have slightly higher PCC average than their female peers in both speech samples and in SIWW and SFWW.
- *Syllable/word position:* Overall, the syllable/word position had a significant main effect of PCC. The results suggest that children are more likely to correctly produce consonants in SIWI than SIWW, consonants in SIWW than in SFWW, and consonants in SFWF than in SFWW. In other words, consonants in SFWW are the most challenging and thus are the most likely to incur higher production errors.
- *Manner of Articulation:* Approximants, laterals, stops, and nasals and were the easiest and thus had the highest PCC average for all participants followed by tap, trill, and fricatives. In contrast, affricates and emphatics

appeared to be the most challenging of all manner of articulation groups across all age groups.

Moreover, qualitative analysis of NA consonant acquisition revealed that there are obvious Speech-Task and Gender differences at the level of consonant acquisition and customary production. In general, few consonants appear in the inventory of female participants before they do in their male peers. Similarly, more consonants appear in the SPON sample when compared to PN sample. However, the same pattern was not observed at the level of consonant mastery perhaps due to the upper limit of the age-range of participating children being 4;02 years. Similarly, the Age-Group of the participants appear to have a strong effect on the acquisition of NA consonants over time, i.e. as the participants grow older, they master, acquire, and customarily produce more consonants. A summary of the positional differences in consonant acquisition with age-group and gender comparison is presented in table 5.63. below. The numbers in each cell represent the total number of consonants that are mastered, acquired, or customarily produced by the same gender participants within each specific age-group. It is clear that in Groups 1, 2, and 3 SFWW appears to be the most challenging position for both genders to produce consonants correctly. However, in Groups 4 and 5, female participants struggle with consonants in SFWF position while male participants find consonants in SIWI the most challenging.

Table 5.63.

The Total Number of Consonants That Are Mastered, Acquired, and Customarily Produced in Each Syllable/Word Position across All Age-Groups: Gender Comparison.

		Females				Males			
		SIWI	*SIWW*	*SFWW*	*SFWF*	*SIWI*	*SIWW*	*SFWW*	*SFWF*
Total Number of Consonants	*G1*	6	7	1	5	5	6	2	5
	G2	7	11	7	11	5	5	2	6
	G3	13	13	11	16	10	9	6	11
	G4	17	20	16	15	8	14	9	13
	G5	19	26	21	19	19	23	21	20

* The total number of consonants that are mastered, acquired, and customarily produced. Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final. Dark-Green cells = highest number of consonants, light-green cells= second highest, light-red cells=second lowest, dark-red cells= lowest, white cells = shared middle value.

Finally, Tables 5.64 and 5.65 below present the summary timeline at which consonants are mastered at different syllable/word positions by NA- speaking children in PN and SPON samples consecutively. The start of the shaded area in each row indicate the age at which the consonant appears in the phonetic inventory in that specific syllable/word position in that age group. Moreover, X-marked cells indicate the age of which the consonant has been mastered. The 4+ yrs column is shaded (without X) when the mastery of that consonant in that specific syllable/word position has not been accomplished by participants in Group-5, i.e. the eldest participants in the current study. Therefore, the exact age of mastery for that consonants in that specific syllable/word position cannot be determined using the current data.

In general, many consonants appear sooner in the SPON sample. For example, /t/ and /k/ appear 6-12 months earlier in the SPON sample when compared to PN sample in all syllable/word positions. In contrast, some consonants appear to be mastered sooner in the PN sample than in SPON sample. For example, /g/ and /f/ in SFWW are mastered in PN sample at age 3;06 years whilst in SPON sample their mastery age is undetermined and extends beyond the age of 4;02 years.

Table 5.64.

Summary of Positional Consonant Mastery in PN Sample

S/WP	SIWI						SIWW						SFWW						SFWF					
Age	2;00	2;06	3;00	3;06	4;00	4+	2;00	2;06	3;00	3;06	4;00	4+	2;00	2;06	3;00	3;06	4;00	4+	2;00	2;06	3;00	3;06	4;00	4+
b																								
t																								
tˤ																								
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Key: PN= Picture Naming, S/WP= Syllable/Word Position, SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, NA= Not Applicable.

Table 5.65.

Summary of Positional Consonant Mastery in SPON Sample.

S/WP	SIWI						SIWW						SFWW						SFWF					
Age	2;00	2;06	3;00	3;06	4;00	4+	2;00	2;06	3;00	3;06	4;00	4+	2;00	2;06	3;00	3;06	4;00	4+	2;00	2;06	3;00	3;06	4;00	4+
b	■	■	■	■	■	■	■	■	■	■	■	■				■	■	■	■	■	■	■	■	■
t		■	■	■	■	■			■	■	■	■				■	■	■		■	■	■	■	■
t̪				■	■	■					■	■					■	■						■
d				■	■	■	■	■	■	■	■	■			■	■	■	■		■	■	■	■	■
d̪						■						■						■						■
k		■	■	■	■	■		■	■	■	■					■	■	■			■	■	■	■
g				■	■	■			■	■	■	■				■	■	■					■	■
q						■						■						■						■
ʔ		■	■	■	■	■						■						■	■	■	■	■	■	■
f		■	■	■	■	■				■	■	■				■	■	■				■	■	■
θ						■						■						■						■
ð						■	■	■	■	■	■	■						■						■
ð̪						■						■						■						■
s					■	■			■	■	■	■					■	■					■	■
s̪						■						■						■						■
z						■					■	■						■						■
ʃ				■	■	■				■	■	■					■	■					■	■
x			■	■	■	■					■	■						■						■
ɣ						■						■						■						■
ħ			■	■	■	■			■	■	■	■						■		■	■	■	■	■
ʕ				■	■	■			■	■	■	■				■	■	■		■	■	■	■	■
h	■	■	■	■	■	■			■	■	■	■						■			■	■	■	■
ʦ						■						■						■						■
ʤ					■	■					■	■						■						■
m	■	■	■	■	■	■	■	■	■	■	■					■	■	■	■	■	■	■	■	■
n				■	■	■	■	■	■	■	■	■		■	■	■	■	■		■	■	■	■	■
l	■	■	■	■	■	■	■	■	■	■	■	■			■	■	■	■	■	■	■	■	■	■
lˤ	*NA*											■						■	*NA*					
ɾ			■	■	■	■		■	■	■	■	■	*NA*						*NA*					
r	*NA*											■			■	■	■	■		■	■	■	■	■
w	■	■	■	■	■		■	■						■	■	■	■	■	■	■	■	■	■	■
j		■	■	■	■	■					■	■			■	■	■	■				■	■	■

Key: SPON= Spontaneous, S/WP= Syllable/Word Position, SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, NA= Not Applicable.

Chapter 6. Results: Phonological Process in Najdi Arabic

This chapter aims to explore the effect of the speech elicitation method, age and gender of participants on the frequency of occurrence of phonological errors at the level of singleton consonants, syllables, and consonant clusters. First, phonological processes related to errors in the primary or secondary place of articulation of singleton consonants are reported, i.e. Velar-fronting, Coronal-backing, Glottalization, and De-emphasis errors. Then, it is followed by the exploration of phonological processes related to errors in voicing of singleton consonants, i.e. Voicing and Devoicing errors. Similarly, phonological processes related to the errors in the manner of articulation of singleton consonants were also investigated: Fricative-stopping, Deaffrication, Lateralization, and Liquid gliding/vocalization. Moreover, the findings of phonological deletion errors are presented in two main areas: singleton consonant deletion and weak-syllable deletions in addition to phonological errors in the production of consonant clusters: Cluster Reduction and Cluster Epenthesis. At the end of each section, the results of positional frequency of occurrence of the phonological errors of singleton consonants are presented in four syllable/word positions: Syllable-Initial Word-Initial (SIWI, Syllable-Initial Within-Word (SIWW), Syllable-Final Within-Word (SFWW), and Syllable-Final Word-Final (SFWF). However, in the case of positional weak-syllable deletion, the comparison is conducted between three word-positions: Word-Initial (WI), Word-Medial (WM), and Word-Final (WF). Similarly, positional comparison between Cluster Reduction and Epenthesis took place at word boundaries: Word-Initial (WI) and Word-Final (WF) only. Finally, the chapter is concluded by presenting a summary and the overall trends of all the findings.

6.1. Data Analysis Strategy

In each section of the analysis, results that incurred changes in the target feature of the sound production mechanism under investigation were included. For example, changes in manner of articulation and voicing are disregarded when place of articulation was target of the analysis in velar-fronting, coronal-backing and glottalization errors. Similarly, changes in place and manner of articulation were disregarded when voicing errors were the target of the analysis in voicing and devoicing errors. Moreover, changes in place of articulation and voicing were disregarded when the manner of articulation was the target of the analysis in fricative-stopping, deaffrication, Lateralization, and liquid gliding/vocalization errors. On the contrary, any changes in place/manner of articulation or voicing have been excluded from the calculations when de-emphasis of emphatic consonants was the target of the analysis.

Additionally, wherever possible and where the data allowed, parametric tests were conducted (i.e. ANOVAs) to allow detailed investigation of the IV and DV including tests of interactions. To determine whether parametric tests were justified, the following systematic approach was used in each analysis. First, the data's distribution was checked for normality within each grouping of the dependent variable. Where this was not the case, the following decision-making sequence was applied. For DV data where all or the large majority of the groups had normal distribution, parametric tests were applied as the analysis of variance is robust to some deviation from the normality assumption (Norušis, 2006). Similarly ANOVA was also used even when there was a significant *p* value of Levene's test for equality of variance but only when the number of cases in each of the groups was identical (Norušis, 2006). In other cases which did not meet these criteria, first an attempt will be made to obtain normal distribution via the data transformation. However, in cases when most of the data was not normally distributed even after using multiple data transformation measures, the analysis was carried away using non-parametric tests. However, data that isn't normally distributed was often retested using parametric tests to confirm the findings and to explore interactions between the dependant and independent variables otherwise inaccessible via non-parametric tests.

6.2. Errors in Place of Articulation

Phonological errors involving the place of articulation include three error types: Velar-Fronting, Coronal-backing, and Glottalization. The results of these errors are reported in sections 6.2.1., 6.2.2. and 6.2.3. below.

6.2.1. Velar Fronting:

In the current study, the phonological process of velar-fronting is defined as the realisation of any consonant with velar place of articulation as a consonant that is produced in advance of the velum: palatal, coronal, bilabial, etc. One common recurring example in the corpus is realisation of /k/ as [t] in the word /kalb/ (dog) → [talb]. Table 6.1 provides descriptive statistics: Mean and standard deviation values for the occurrence of velar fronting errors in both speech tasks: PN and SPON. It appears that all participants produce more velar fronting errors in the PN sample than in SPON sample (Figure 6.1) even though the number of target words with velar consonants in the SPON sample (3,815 words) is almost double the number of target words with velar consonants in the PN sample (1,902 words).

Table 6.1.

The Percentage of Velar Fronting Errors in Two Speech Tasks.

	PN Velar Fronting Errors		**SPON Velar Fronting Errors**	
Age Group	Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	14.97	14.69	8.21	8.41
G2	17.27	27.02	6.81	5.71
G3	7.27	6.33	6.18	5.07
G4	4.51	3.67	1.73	1.83
G5	4.18	4.01	1.54	1.81

Key: PN= Picture Naming, SPON= Spontaneous.

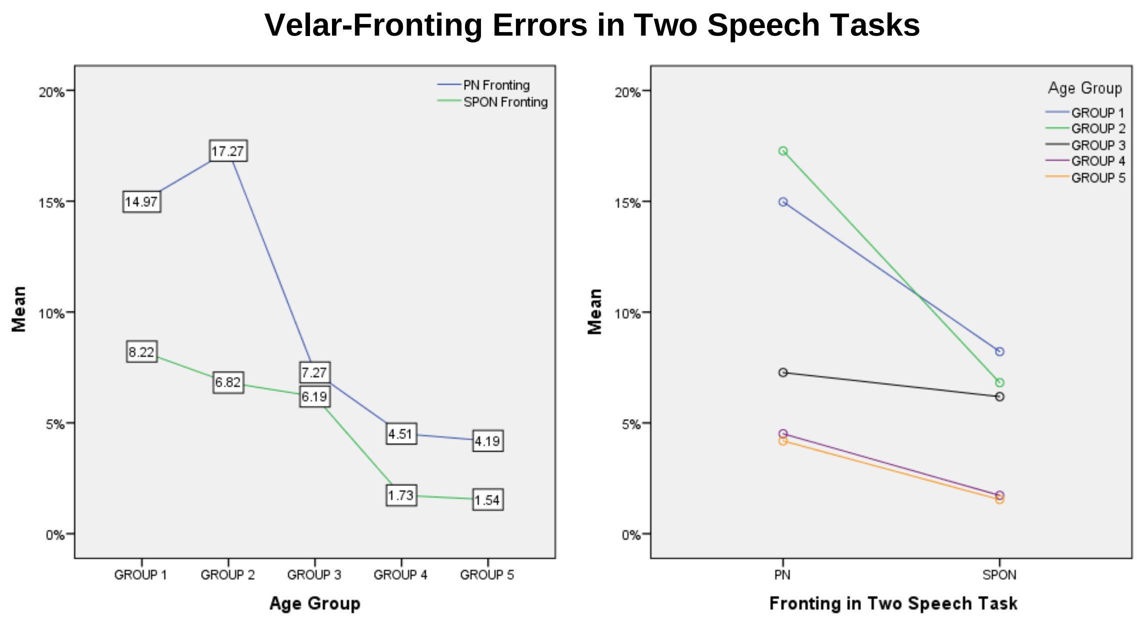


Figure 6.1. The percentage of velar fronting errors in two speech tasks: as a function of age group (left) and speech task (right). Key: PN= Picture Naming, SPON= Spontaneous.

Also, by comparing the mean values across gender, it is notable that males consistently produce more velar fronting errors than the females in both speech-tasks. Moreover, male participants have a higher SD value than their female peers (more so in PN sample) suggesting greater individual differences amongst the young male participants especially in Groups 1 and 2.

Table 6.2.

The Occurrence of Velar Fronting Errors in Two Speech Tasks: Gender Comparison

Age Group	Gender	PN Velar Fronting		SPON Velar Fronting	
		Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	Females	12.56	8.70	6.45	7.03
	Males	17.38	19.63	9.98	9.94
G2	Females	5.93	3.73	7.39	4.35
	Males	28.61	35.83	6.23	7.21
G3	Females	4.67	5.80	5.12	5.38
	Males	9.86	6.18	7.24	4.99
G4	Females	3.98	2.57	1.03	1.03
	Males	5.03	4.73	2.42	2.27
G5	Females	3.95	4.39	1.23	1.51
	Males	4.41	4.00	1.84	2.16

Key: PN= Picture Naming, SPON= Spontaneous.

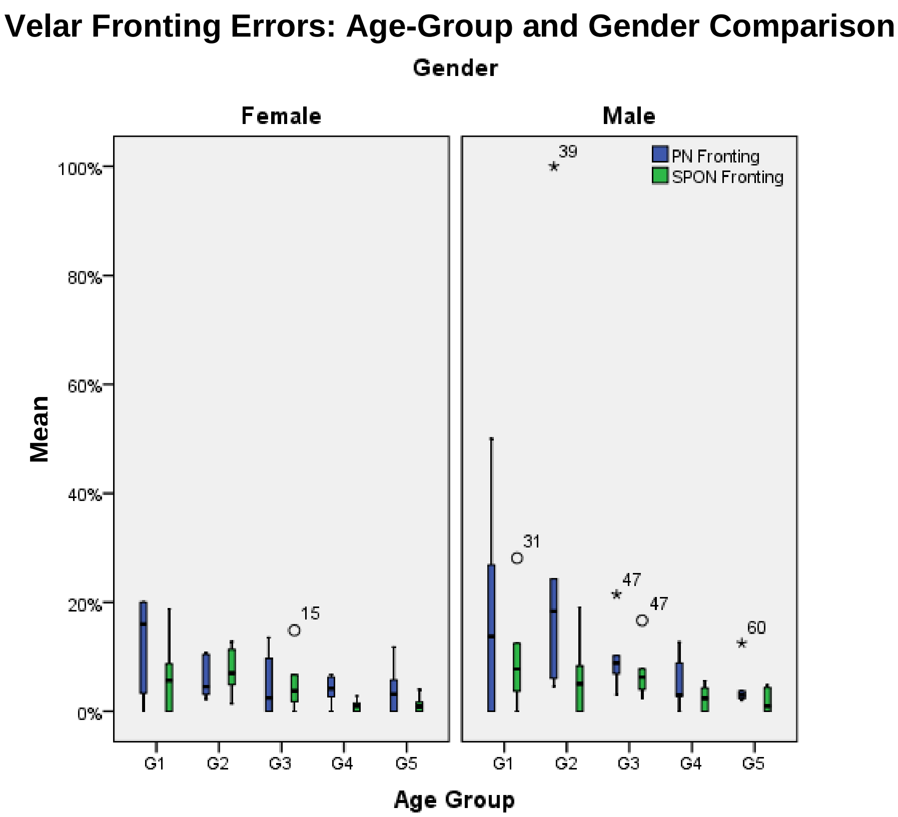


Figure 6.2. The occurrence of velar fronting errors in two speech tasks: gender comparison. Key: PN= Picture Naming, SPON= Spontaneous.

The velar-fronting data is mostly normally distributed except for two age-groups in the PN sample (Group-2 and Group-5) and one age-group in the SPON sample (Group-5), see Appendix-S for more details. As a result, a 2x5x2 Mixed ANOVA was applied with two between-subjects factors: gender with two levels (female; male) and age-group with five levels and a single within-subjects factor being speech task with two levels: picture naming (PN); spontaneous (SPON). The dependant variable was proportion of velar fronting errors. Mauchly's Test of Sphericity was significant: $p < .001$ (see Appendix-T for more details), therefore the Greenhouse-Geisser correction was applied to the degrees of freedom and consequently a significant main effect of Speech-Task was found, i.e. across all age-groups, the means of PN-fronting and SPON-fronting are significantly different: $F(1, 50) = 7.542$, $p = .008$, partial $\eta^2 = .131$. However, the speech-task by age-group interaction was not significant: $F(4, 50) = .977$, $p = .429$, partial $\eta^2 = .072$ suggesting that the differences are similar across the different age groups. The speech-task by gender interaction was not significant either: $F(1, 50) = .2.571$, $p = .115$, partial $\eta^2 = .049$. Similarly, the three-way interaction between speech-task, age-group, and gender was not significant: $F(4, 50) = 1.783$, $p = .147$, partial $\eta^2 = .125$.

Additionally, the Test of Between-Subjects Effect showed that the effect of Age-Group was significant: $F(4, 50) = 3.657$, $p = .011$, partial $\eta^2 = .226$. However, the effect of the Gender was not significant: $F(1, 50) = 3.860$, $p = .055$, partial $\eta^2 = .072$ and the Age-Group by Gender interaction was not significant either $F(4, 50) = .763$, $p = .555$, partial $\eta^2 = .058$. Finally, a Tukey Post Hoc test was applied to make pair-wise comparisons between the Age-Groups. No pairwise comparisons reached significance: $p > .05$ but differences between group 1 and groups 4 and 5 and group 2 and groups 4 and 5 approached significance (see Appendix-U for details).

Table 6.3 and Figure 6.3 below provide age, speech task and positional comparison in relation to velar fronting. Although there is a general tendency for fronting to decrease with age, the slope is much steeper in SIWW and SFWF where the highest levels of fronting occur at the Groups 1 and 2 then drop significantly at Group-3 in both speech samples.

Table 6.3.

Positional Differences in the Occurrence of Velar Fronting Errors in Two Speech Tasks.

	Mean of Velar Fronting Errors (%)							
S/WP	**SIWI**		**SIWW**		**SFWW**		**SFWF**	
ST	PN	SPON	PN	SPON	PN	SPON	PN	SPON
G1	12.32	9.32	19.67	20.77	12.25	13.89	22.40	12.22
G2	14.64	8.58	19.90	16.75	12.12	10.29	22.49	13.56
G3	8.48	4.54	9.05	7.88	8.91	6.72	7.30	4.69
G4	3.11	1.80	4.96	3.62	3.78	2.37	5.78	2.82
G5	2.84	1.71	5.16	2.37	3.27	1.78	3.53	2.44

Key: S/WP= Syllable/Word Position, ST= Speech Task, SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, PN= Picture Naming, SPON= Spontaneous.

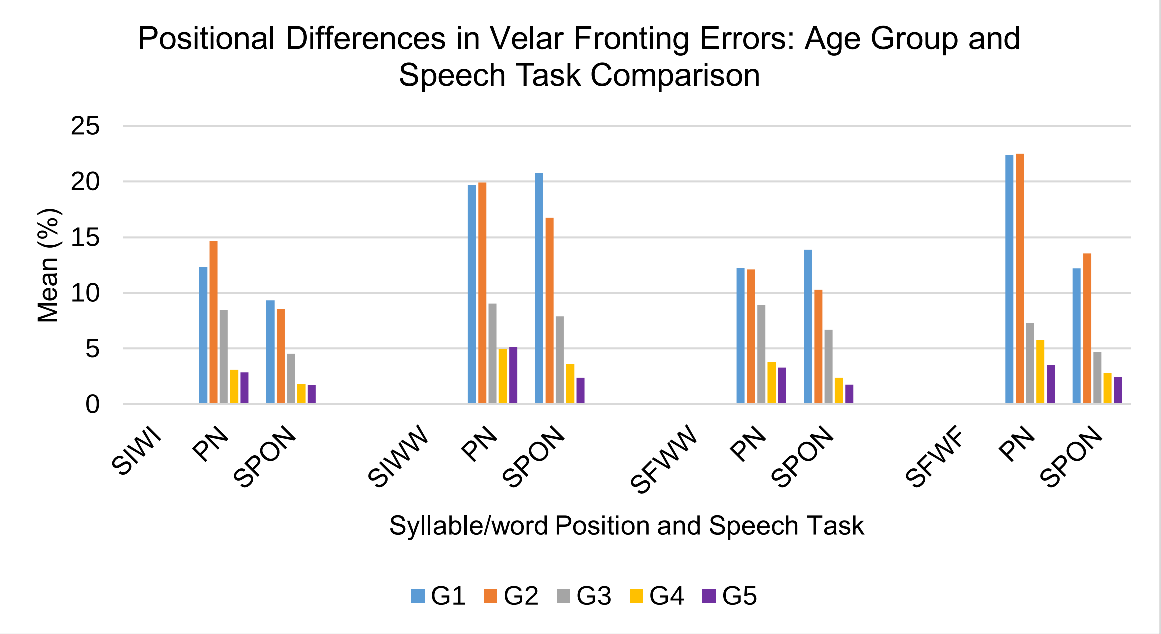


Figure 6.3. Positional differences in velar fronting Errors: Age-Group and Speech Task comparison. Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, PN= Picture Naming, SPON= Spontaneous.

To statistically compare the difference between the occurrences of velar fronting errors in different syllable/word position in SPON sample, Friedman test was completed as the positional velar fronting data is not normally distributed in several age groups per each syllable/word position (see Appendix-V). The test was run on each group separately and again between all four syllable/word positions collapsing across age groups (Table 6.4). Results show that syllable/word position has an effect on the occurrence of velar fronting errors across the sample as a whole. However, when the test was run on each age-group separately, the positional differences in velar fronting errors were mostly prominent under the age of three years as *p* value were not significant in Groups 3, 4 and 5. In general, consonants in SIWW position has the highest mean rank of velar fronting errors, followed by consonants in SFWF then SFWW positions and is least in SIWI position.

Table 6.4.

Positional Velar Fronting: Mean Rank, N, Chi-Sq, df, and p Value for Friedman Test.

	G1	**G2**	**G3**	**G4**	**G5**	**All Groups**
			Mean Rank			
SIWI	1.63	1.79	2.08	1.96	2.04	1.09
SIWW	3.38	3.13	3.04	3.00	2.88	3.08
SFWW	2.50	2.00	2.54	2.54	2.04	2.33
SFWF	2.50	3.08	2.33	2.50	3.04	2.69
			Friedman Test			
N	12	12	12	12	12	60
Chi-Square	11.813	11.043	4.086	4.856	7.531	31.403
df	3	3	3	3	3	3
***p* value**	.008**	.011*	.252	.183	.057	.000**

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

Table 6.5 shows the results of a series of Wilcoxon Singed Rank Tests conducted to compare mean ranks of velar fronting at word boundaries (SIWI vs. SFWF), in onset positions (SIWI vs. SIWW), in medial positions (SIWW vs. SFWW), and in coda positions (SFWW vs. SFWF). Since each dependent variable is only tested twice, the Bonferroni corrected/adjusted *p* value was calculated using the following equation:

Finally, the test results were compared to the new and adjusted *p* value $\alpha = .025$ as the higher boundary for significance. Results show significant differences in the occurrence of velar fronting between consonants at word boundaries: SIWI vs. SFWF, between consonants in onset positions: SIWI vs. SIWW, and consonants in medial positions: SIWW vs. SFWW (Appendix-W). Consonants in SFWF are more likely to incur fronting errors than consonants in SIWI. Similarly, consonants in SIWW positions are more likely to incur fronting errors than consonants in SIWI or SFWW positions. However, no significant difference is detected in the occurrence of velar fronting errors between the two coda positions: SFWW vs. SFWF (Table 6.5).

Table 6.5.

Difference in the Occurrence of Velar Fronting Errors between Several Syllable/word positions: Wilcoxon Signed Ranks Test.

	Wilcoxon Signed Ranks Test	
	Z	Sig. (two-Tailed)
SIWI vs. SFWF	-2.951[a]	.003*
SIWI vs. SIWW	-3.971[a]	.000*
SIWW vs. SFWW	-3.430[b]	.001*
SFWW vs. SFWF	-1.253[a]	.210

a. Based on negative ranks.
b. Based on positive ranks.
*. The mean rank is significant at the .025 level.
Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

In summary, the occurrence of velar fronting errors in the PN sample ranged from 17.3% in Group-1 to 4.2% in Group-5 and 8.2% Group-1 to 1.5% in Group-5 in the SPON sample. In general, all participant had more errors in the PN sample, i.e. the speech task had a significant effect in favour of the SPON sample. Similarly, the effect of the age-group was also significant, but gender was not. In other words, older participants produced significantly less velar fronting errors than younger participants with no difference between the number of errors produced by the female and male participants. Additionally, the lack of interaction between the speech-task and the Age-group and Gender suggest that the differences in velar fronting errors between both speech tasks and both genders are similar across the different age groups. Moreover, post Hoc analysis revealed that the mean difference of velar fronting errors between two speech samples did not reach significant levels between any of the five age groups.

Furthermore, the syllable/word position also had a significant effect on velar fronting errors but only in age groups 1 and 2 (i.e. under 3 years of age). In general, the occurrence of velar fronting errors favoured consonants at different syllable/word positions in the following order: SIWW>SFWF=SFWW>SIWI.

6.2.2. Coronal Backing

In the current study, the phonological process of coronal backing is defined as the realisation of any coronal consonant by another consonant with a place of articulation that is further back in the vocal tract, i.e. dorsal. For example, the realisation of /sˤ/ as [k] in /sˤɑrˈsˤuːr/ (cockroach) → [kakˈkuːɹ]. Table 6.6. provides descriptive statistics: Mean and standard deviation values for the occurrence of coronal backing errors in both speech tasks: PN and SPON. From the table, it is notable that coronal backing errors in general have a low frequency of occurrence in NA not exceeding 5% at any age group in either speech task. It is also apparent that coronal backing occurred more frequently in the PN sample than in SPON sample. However, the difference between PN and SPON samples is very small. Overall, the developmental progression illustrated in Figure 6.4. below shows a linear reduction in frequency of errors with age despite the slight fluctuation.

Table 6.6.

The Percentage of Coronal Backing Errors in Two Speech tasks.

Age Group	**PN Coronal Backing Errors**		**SPON Coronal Backing Errors**	
	Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	4.29	6.71	2.06	2.65
G2	2.40	2.09	1.92	2.19
G3	2.94	2.33	1.08	.92
G4	1.13	1.32	2.01	3.02
G5	.48	.65	.77	.75

Key: PN= Picture Naming, SPON= Spontaneous.

Coronal Backing Errors in Two Speech Tasks

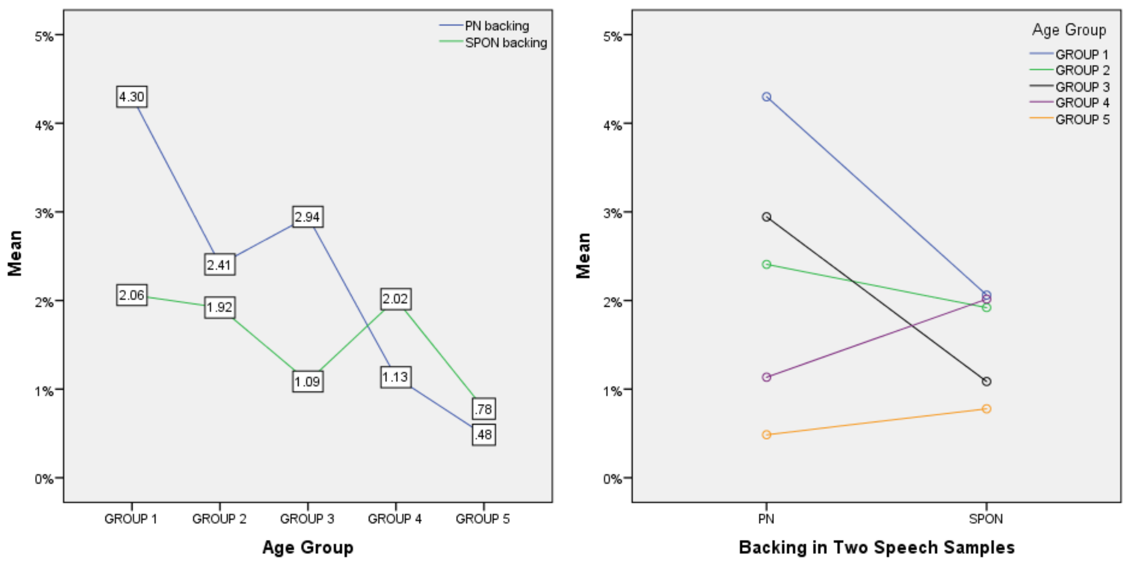


Figure 6.4. The percentage of coronal backing errors in two speech tasks: : as a function of age group (left) and speech task (right). Key: PN= Picture Naming, SPON= Spontaneous.

Table 6.7 and Figure 6.5 show that the greatest difference between female and male participants is in the PN sample is found amongst the youngest participants in Group-1. Male participants in Group-1 produced more than double the backing errors (*M* = 5.61, SD =8.69) their female peers produced (*M*= 2.98, SD = 4.41). Overall, both genders in all age-groups produce fewer errors in the SPON sample (except in Group-5).

Table 6.7.

The Occurrence of Coronal Backing Errors in Two Speech Tasks: Gender Comparison.

Age Group	**Gender**	**PN Coronal Backing Errors**		**SPON Coronal Backing Errors**	
		Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	Females	2.98	4.41	.15	.38
	Males	5.61	8.69	.81	.72
G2	Females	2.11	1.96	2.43	2.62
	Males	2.70	2.35	1.68	2.88
G3	Females	3.42	2.69	1.66	1.79
	Males	2.46	2.05	2.17	2.67
G4	Females	.22	.53	1.21	1.04
	Males	2.04	1.24	.95	.86
G5	Females	.15	.38	.61	.80
	Males	.81	.72	3.42	3.84

Key: PN= Picture Naming, SPON= Spontaneous.

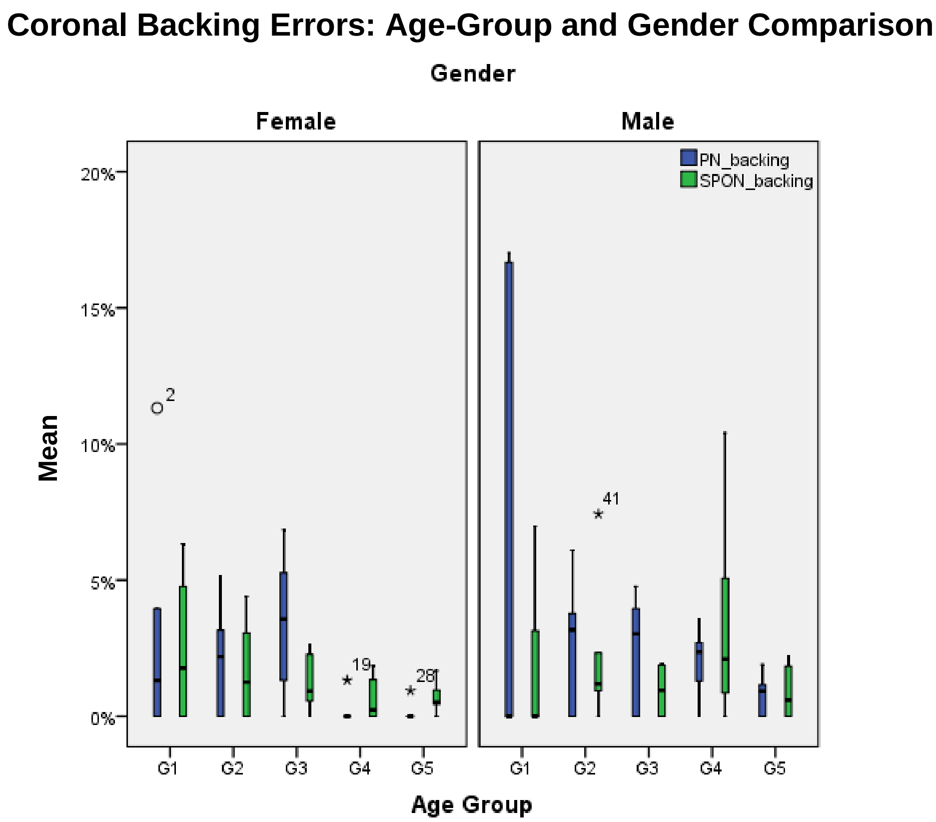


Figure 6.5. The occurrence of coronal backing errors in two speech tasks: gender comparison. Key: PN= Picture Naming, SPON= Spontaneous.

The coronal backing data is not normally distributed in several age groups in both speech samples (see Appendix-X). As a result, Wilcoxon Singed Ranks Test was completed which revealed no significant different in the occurrence of coronal backing errors between the two Speech Tasks: PN vs. SPON (z = .897, *N* – Ties = 48, p = .369, two-tailed). Moreover, Kruskal-Wallis Test was applied to explore whether participant's age-group had an effect on the occurrence of coronal backing errors in either speech task and the results suggest there was no significant difference between age groups in the occurrence of coronal backing in either speech task: p= .064 in PN and p= .78 in SPON (Appendix-Y). Additionally, Mann-Whitney Test was also completed to explore if gender had an effect on Coronal backing in either speech task and the results suggest no significant differences between female and male participants in either speech task: p= .288 in PN and p=.679 in SPON sample (Appendix-Z).

Moreover, Table 6.8 and Figure 6.6 below provide age, speech task and positional comparison in relation to coronal backing. Although there is a general tendency for backing to decrease with age, the highest levels of coronal backing occur at the Group-1 and drop significantly at Group-2 in PN sample. On the other hand, the decrease of coronal backing between the Group-1 and Group-2 in SPON sample is less pronounced.

Table 6.8.

Positional Differences in the Occurrence of Coronal Backing Errors in Two Speech Tasks.

	Mean of Coronal Backing Errors (%)							
S/WP	**SIWI**		**SIWW**		**SFWW**		**SFWF**	
ST	PN	SPON	PN	SPON	PN	SPON	PN	SPON
G1	4.30	2.06	3.50	2.17	4.85	3.02	3.34	1.46
G2	2.41	1.92	1.70	0.95	3.07	2.43	0.97	0.80
G3	2.94	1.09	2.18	0.95	2.54	1.19	2.41	0.88
G4	1.13	2.02	1.60	1.18	1.26	1.79	1.58	1.37
G5	0.49	0.78	0.75	0.45	0.91	0.78	0.42	0.44

Key: S/WP= Syllable/Word Position, ST= Speech Task, SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, PN= Picture Naming, SPON= Spontaneous.

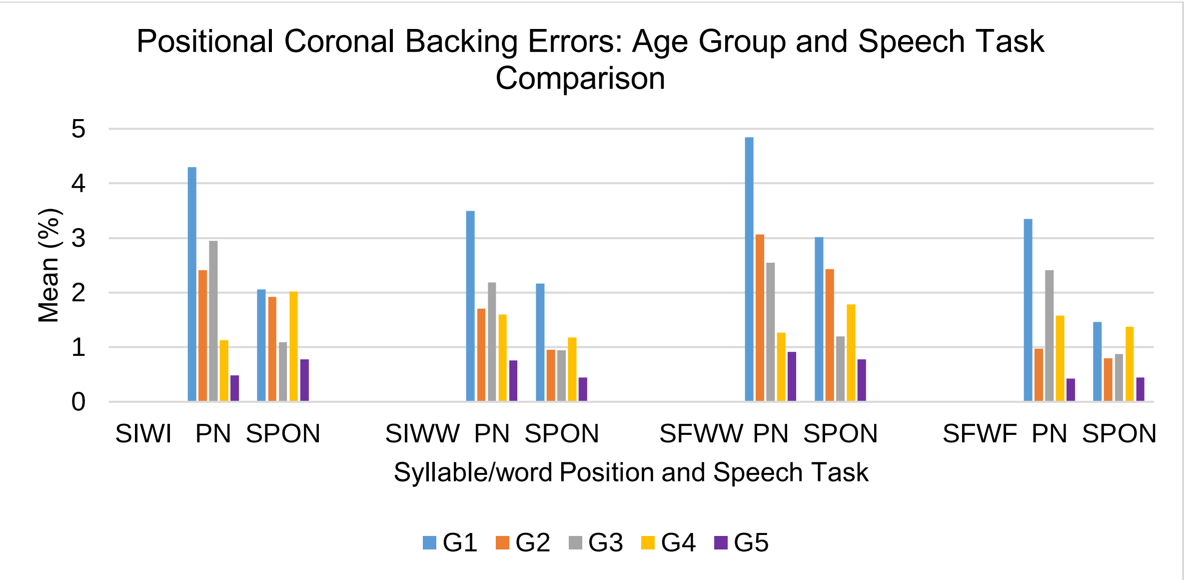


Figure 6.6. Positional differences in coronal backing: Age-Group and Speech-Task comparison. Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, PN= Picture Naming, SPON= Spontaneous.

To statistically compare the difference between the occurrences of coronal backing errors in different syllable/word position, Friedman test was completed as the positional coronal backing data is not normally distributed in most age groups per each syllable/word position (see Appendix-AA). The test was run on each group separately and again between all four syllable/word positions collapsing across age groups (Table 6.9).

Table 6.9.

Positional Coronal Backing: Mean Rank, N, Chi-Sq, df, and p Value for Friedman Test

	G1	**G2**	**G3**	**G4**	**G5**	**All Groups**
			Mean Rank			
SIWI	2.46	2.96	2.46	2.42	2.58	2.58
SIWW	2.50	2.00	2.58	2.54	2.38	2.40
SFWW	2.96	2.71	2.83	2.71	2.79	2.80
SFWF	2.08	2.33	2.13	2.33	2.25	2.23
			Friedman Test			
N	12	12	12	12	12	60
Chi-Square	3.433	5.157	2.103	.645	1.374	7.722
df	3	3	3	3	3	3
***p* value**	.330	.161	.551	.886	.712	.052

Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

From Table 6.9 above, it can be concluded that syllable/word position has no effect on the percentage of coronal backing occurrence: $p > 0.05$ in any age-group or amongst the participants as a whole.

In summary, the occurrence of Coronal backing errors in this study does not exceed 5% at any age-group in either speech task. All four independent variables: Speech task, Age-group, gender, and syllable/word position had no significant effect on the occurrence of coronal backing errors.

6.2.3. Glottalization Errors

In the current study, glottalization errors are defined as the realisation of non-glottal consonants as a glottal one. This is the extreme form of backing and is not restricted to coronal consonants. For example, the realisation of /ɣ/ as [ʔ] in /jɪt.ˈɣɑtˤ.tˤɑ/ (covers himself) → [ˈʔat̠.t̠a]. Table 6.10 provides descriptive statistics: Mean and standard deviation values for the occurrence of glottalization in both speech samples: PN and SPON. It appears that all participants produce more glottalization errors in the PN sample than in SPON sample (Figure 6.7). However, the gap between PN and SPON samples narrows over time to reach its lowest point in Group-5 (average age 4:00 years). Overall, the developmental progression illustrated in the figure suggests a broadly linear trend reducing in frequency with age.

Table 6.10.

The Percentage of Glottalization Errors in Two Speech Tasks.

	PN Glottalization Errors		**SPON Glottalization Errors**	
Age Group	Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	8.99	5.62	7.4	3.86
G2	9.44	6.59	4.96	2.95
G3	7.2	4.76	4.67	2.86
G4	5.13	3.68	3.32	1.94
G5	2.92	1.73	2.34	1.09

Key: PN= Picture Naming, SPON= Spontaneous.

Glottalization Errors in Two Speech Tasks

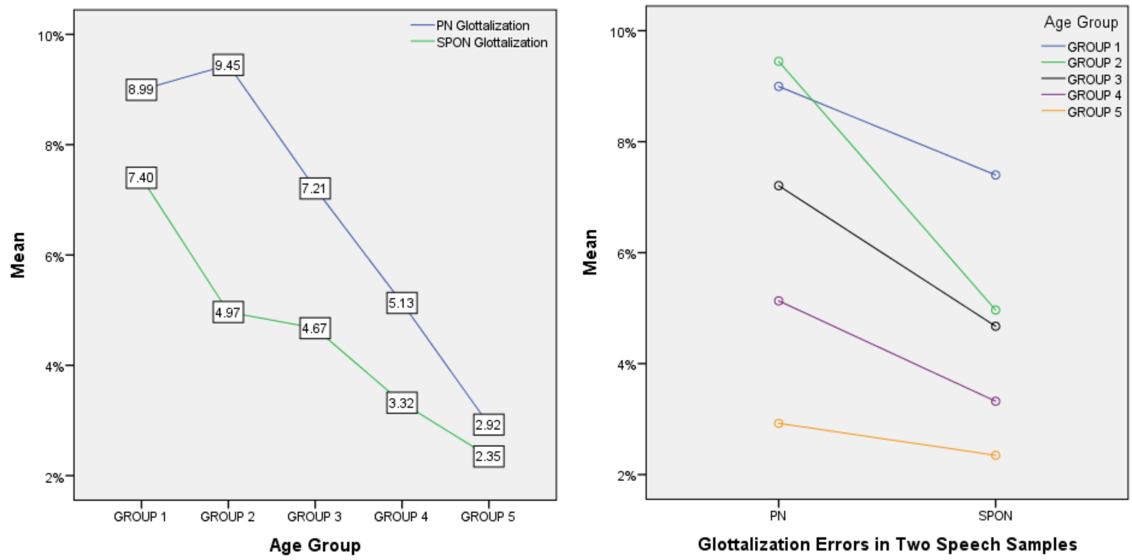


Figure 6.7. The percentage of glottalization errors in two speech tasks: as a function of age group (left) and speech task (right). Key: PN= Picture Naming, SPON= Spontaneous.

By comparing the mean values across gender, it is apparent that young females up to the age of 2;06 years (Age-Groups 1 and 2) produce more glottalization errors than their male peers in both speech tasks (Table 6.11 and Figure 6.8). However, older males appear to make more glottalization errors than their female peers in age groups 3, 4 and 5.

Table 6.11.

The Occurrence of Glottalization Errors in Two Speech Tasks: Gender Comparison.

Age Group	**Gender**	**PN Glottalization Errors**		**SPON Glottalization Errors**	
		Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	Females	10.07	6.17	7.08	2
	Males	7.91	5.36	7.71	5.34
G2	Females	9.77	8.79	5.64	3.36
	Males	9.11	4.25	4.29	2.25
G3	Females	6.55	2.77	3.45	1.88
	Males	7.86	6.41	5.89	3.31
G4	Females	3.05	1.36	2.91	1.89
	Males	7.21	4.19	3.72	2.08
G5	Females	3.26	2.08	2.59	1.42
	Males	2.5	1.41	2.1	.69

Key: PN= Picture Naming, SPON= Spontaneous.

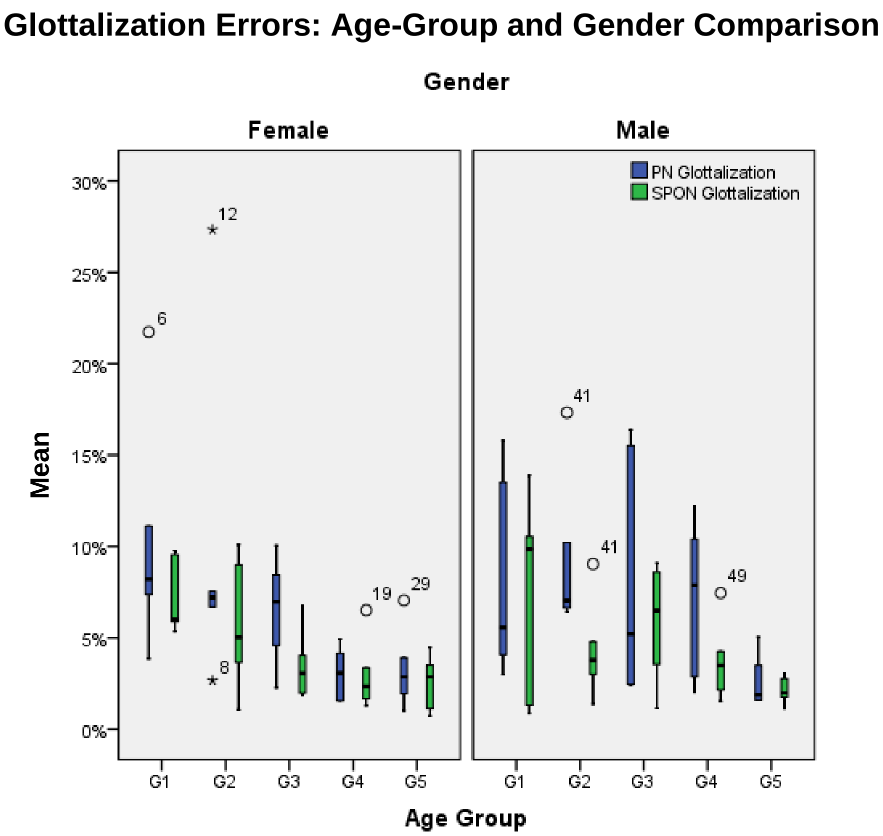


Figure 6.8. The occurrence of glottalization errors in two speech tasks: gender comparison.
Key: PN= Picture Naming, SPON= Spontaneous.

The glottalization data is mostly normally distributed except for two Age-groups in PN sample: Group-2 and Group-4 that is not normal distributed (see Appendix-AB for more details). As a result, a 2x5x2 Mixed ANOVA was applied with two between-subjects factors: gender with two levels (female; male) and age-group with five levels and a single within-subjects factor being speech task with two levels: picture naming (PN); spontaneous (SPON) The dependant variable was proportion of glottalization errors. Mauchly's Test of Sphericity was significant: $p < .001$ (see Appendix-AC for more details), therefore the Greenhouse-Geisser correction was applied to the degrees of freedom and consequently a significant main effect of Speech-Task was found, i.e. across all age-groups, the means of PN-glottalization and SPON-glottalization are significantly different: $F(1, 50) = 18.559$, $p < .001$, partial $\eta^2 = .271$. However, the speech-task by age-group interaction was not significant: $F(4, 50) = 1.625$, $p = .183$, partial $\eta^2 = .115$. Also, the speech-task by gender interaction was not significant: $F(1, 50) = .000$, $p = .985$, partial $\eta^2 = .000$.

Similarly, the three-way interaction between speech-task, age-group, and gender was not significant: $F(4, 50) = 1.002$, $p = .415$, partial $\eta^2 = .074$.

Additionally, the Test of Between-Subjects effect showed that the effect of Age-Group was significant: $F(4, 50) = 5.145$, $p = .001$, partial $\eta^2 = .292$ and that the effect of the Gender was not significant: $F(1, 50) = .205$, $p = .653$, partial $\eta^2 = .004$. Moreover, the Age-Group by Gender interaction was also not significant $F(4, 50) = .693$, $p = .600$, partial $\eta^2 = .053$. Finally, a Tukey Post Hoc test was applied to make pair-wise comparisons between the age groups. Pairwise comparisons reached significance between age groups that have an age gap of at least 18 months, all results are listed in the Table 6.12 (see Appendix- AD for more details).

Table 6.12.

Glottalization Errors Post Hoc Test between Age-Groups.

AG	**G1**		**G2**		**G3**		**G4**		**G5**	
	MD	**SEM**	**MD**	**SEM**	**MD**	**SEM**	**MD**	**SEM**	**MD**	**SEM**
G1	NA		-.99	1.39	-2.25	1.39	-3.97*	1.39	-5.56*	1.39
G2	.99	1.39	NA		-1.26	1.39	-2.98	1.39	-4.57*	1.39
G3	2.25	1.39	1.26	1.39	NA		-1.71	1.39	-3.30	1.39
G4	3.97*	1.39	2.98	1.39	1.71	1.39	NA		-1.59	1.39
G5	5.56*	1.39	4.57*	1.39	3.30	1.39	1.59	1.39	NA	

*. The mean difference is significant at the .05 level.
Key: AG = Age Group, MD = Mean Difference, SEM = Standard Error of the Mean, NA = Not Applicable

Table 6.13 and Figure 6.9 below provide age-group, speech-task, and positional comparison in relation to glottalization errors. Although there is a general tendency for glottalization to decrease with age, the highest levels of errors occur in the youngest two age groups, Groups 1 and 2, regardless of speech-task. Interestingly, glottalization errors in SIWW and SFWF positions show a similar/gradual decrease over time in both speech tasks. On the other hand, glottalization errors in SIWI and SFWW show a much higher frequency of occurrence in the two youngest age groups (Groups 1 and 2) in PN sample then drop notably at Group-3 (age 3;00

years). However, in the SPON sample, glottalization errors in SIWI and SFWW has its highest frequency of occurrence in Group-1 which is then followed by a sizeable drop in Group-2 followed by a more gradual decrease over time between the remaining age groups.

Table 6.13.

Positional Differences in the Occurrence of Glottalization Errors in Two Speech Tasks.

	Mean of Glottalization Errors (%)							
S/WP	**SIWI**		**SIWW**		**SFWW**		**SFWF**	
ST	PN	SPON	PN	SPON	PN	SPON	PN	SPON
G1	9.83	9.31	4.20	2.71	9.93	11.25	4.15	3.55
G2	11.22	5.71	4.35	2.76	9.93	6.86	4.44	2.65
G3	7.69	5.28	3.36	2.32	6.85	5.34	3.62	2.55
G4	4.96	3.55	2.14	1.69	4.07	3.31	2.65	2.02
G5	2.47	2.21	1.42	1.32	2.14	2.09	1.60	1.43

Key: S/WP= Syllable/Word Position, ST= Speech Task, SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, PN= Picture Naming, SPON= Spontaneous.

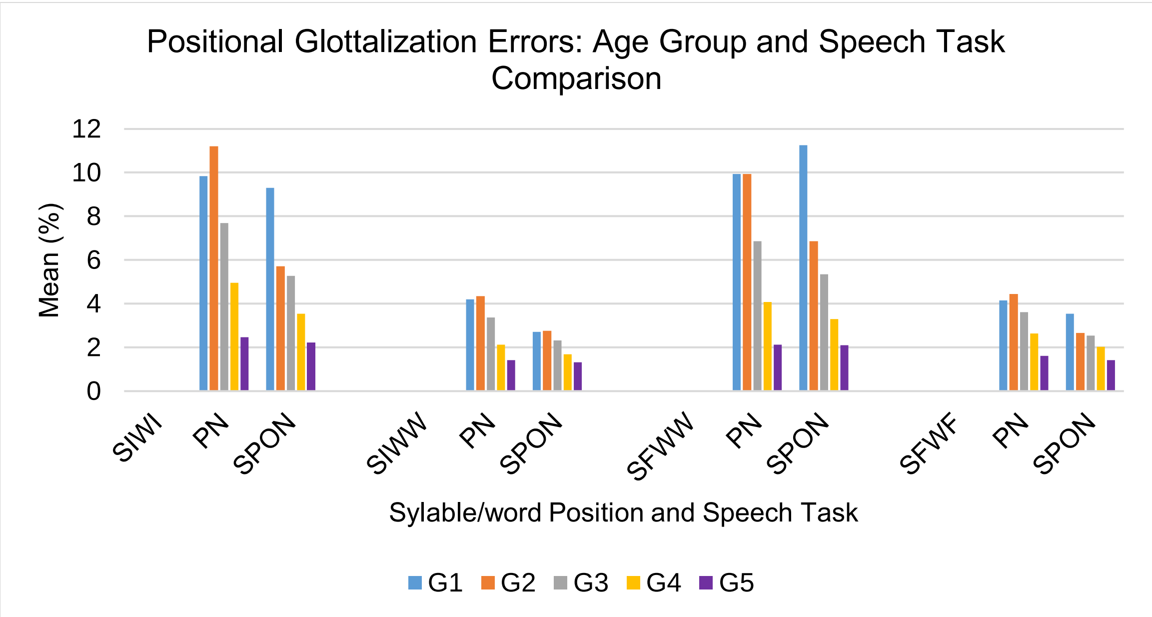


Figure 6.9. Positional differences in the occurrence of glottalization errors: Age-Group and Speech-Task comparison. Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, PN= Picture Naming, SPON= Spontaneous.

To statistically compare the difference between the occurrence of glottalization errors in different syllable/word position, Friedman test was completed as the positional glottalization data is not normally distributed in almost all age-groups per each syllable/word position (see Appendix-AE). The test was run on each group separately and again between all four syllable/word positions collapsing across age groups (Table 6.14). From the results it can be concluded that syllable/word position has no effect on the occurrence of glottalization errors: $p > 0.05$ in any age-group or amongst the participants as a whole.

Table 6.14.

Positional Glottalization Errors: Mean Rank, N, Chi-Squ, df, and p Value for Friedman Test.

	G1	**G2**	**G3**	**G4**	**G5**	**All Groups**
			Mean Rank			
SIWI	2.46	2.96	2.46	2.42	2.58	2.58
SIWW	2.50	2.00	2.58	2.54	2.38	2.40
SFWW	2.96	2.71	2.83	2.71	2.79	2.80
SFWF	2.08	2.33	2.13	2.33	2.25	2.23
			Friedman Test			
N	12	12	12	12	12	60
Chi-Square	3.433	5.157	2.103	.645	1.374	7.722
df	3	3	3	3	3	3
***p* value**	.330	.161	.551	.886	.712	.052

Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

In summary, glottalization errors occurred between 9.5-2.9% in the Group1-to-Group5 range in the PN sample and between 7.5-2.5% in the SPON sample. In general, the effect of the speech-task was significant with less errors occurring in the SPON sample. Similarly, the age-group also had a significant effect on glottalization errors with a clear tendency for errors to decrease with age. Moreover, post Hoc test revealed that the occurrence of glottalization errors was only significantly different between age groups that were at least 18 months apart (i.e. between group-1 and groups 4 and 5). Moreover, the gender of the participants had no effect on glottalization errors in this sample. Similarly, syllable/word position had no effect on the occurrence of glottalization errors. In other words, glottalization errors occurred equally in all syllable/word positions.

6.3. Errors in voicing

In the current study, errors in voicing refer to adding or removing the voicing quality from a consonant in the IPA target in its realization in the IPA actual. In sections 6.3.1 and 6.3.2 below the results of the two types of errors in voicing are presented: voicing and devoicing errors respectively.

6.3.1. Voicing errors

In the current study, voicing errors are defined as the realisation of voiceless consonants as a voiced consonant. For example, the realisation of /k/ as [g] in the word /kalb/ → [gɐlb] which in this incident also changes the meaning from 'dog' to 'heart'. Table 6.15 provides descriptive statistics: Mean and standard deviation values for the occurrence of voicing errors in both speech samples: PN and SPON.

Table 6.15.

The Percentage of Voicing Errors in Two Speech Tasks.

Age Group	PN Voicing Errors		SPON Voicing Errors	
	Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	16.12	8.20	11.33	7.28
G2	15.95	5.10	9.79	4.16
G3	11.25	5.21	5.67	4.05
G4	8.88	7.78	6.11	6.63
G5	5.21	2.03	3.70	1.49

Key: PN= Picture Naming, SPON= Spontaneous.

In Figure 6.10 below, it is apparent that voicing errors occurred more frequently in the PN sample than in SPON sample. However, the gap between PN and SPON samples reduces/narrows over time to reach its lowest point in Group-5 (average age 4;00 years). Overall, the developmental progression illustrated in the figure suggests a broadly linear trend reducing in frequency with age despite the presence of a slight fluctuation.

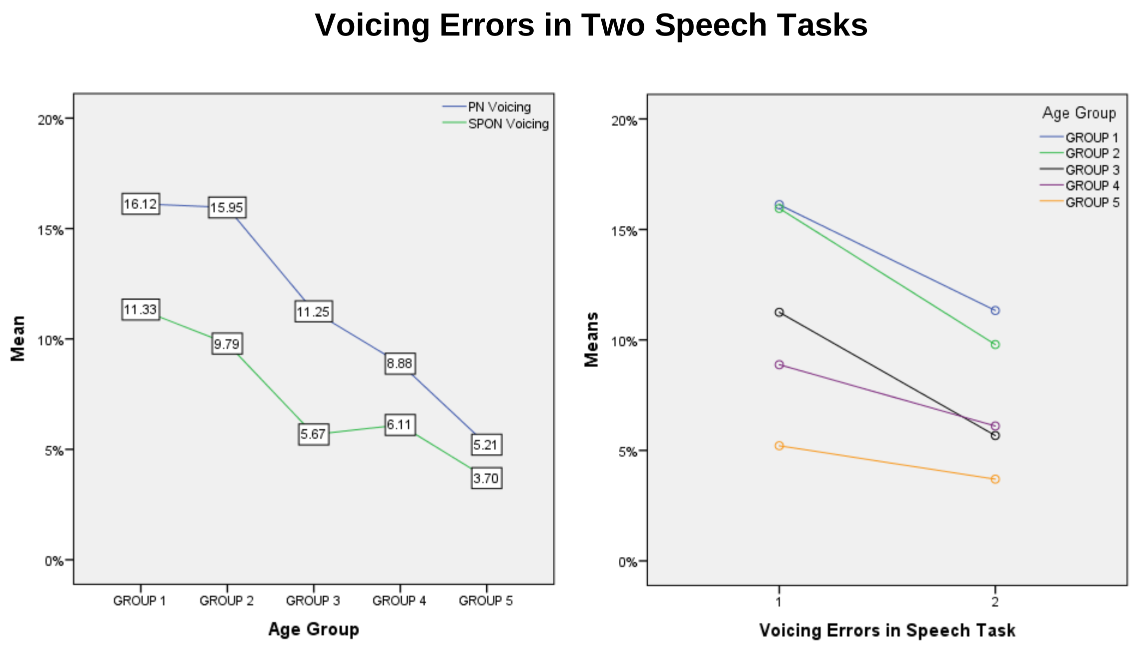


Figure 6.10. The percentage of voicing errors in two speech tasks: as a function of age group (left) and speech task (right). Key: PN= Picture Naming, SPON= Spontaneous.

Also, by comparing the mean values across gender it is notable that male participants aged 2;06 years or older (Groups 2, 3, 4 and 5) consistently produce more voicing errors in both speech-tasks than their female peer. In contrast, younger males in Group-1 appear to produce fewer voicing errors when compared to their female peers in both speech tasks. Moreover, males generally show greater individual differences amongst them, i.e. higher SD values, when compared to their female peers (see Table 6.16 and Figure 6.11).

Table 6.16.

The Occurrence of Voicing Errors in Two Speech Tasks: Gender Comparison.

Age Group	**Gender**	**PN Voicing Errors**		**SPON Voicing Errors**	
		Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	Females	17.55	5.73	12.18	8.32
	Males	14.67	10.48	10.47	6.74
G2	Females	14.7	2.18	8.38	3.59
	Males	17.19	6.97	11.2	4.5
G3	Females	10.42	3.36	3.11	1.06
	Males	12.08	6.84	8.23	4.38
G4	Females	6.24	3.02	3.84	2.04
	Males	11.51	10.36	8.36	8.95
G5	Females	4.99	1.96	3.32	2.02
	Males	5.43	2.25	4.07	.68

Key: PN= Picture Naming, SPON= Spontaneous.

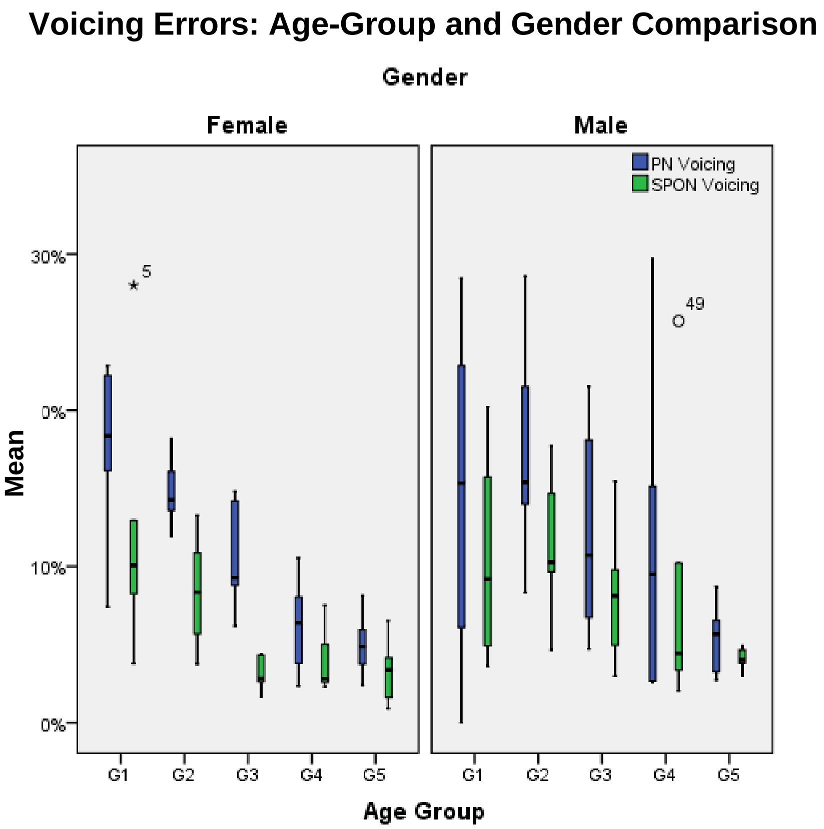


Figure 6.11. The occurrence of voicing errors in two speech tasks: gender comparison. Key: PN= Picture Naming, SPON= Spontaneous.

The voicing data is mostly normally distributed except for one Age-group in PN sample (Group-4) and two Age-Groups in the SPON sample (Groups 3 and 4) (see Appendix-AF for more details). As a result, a 2x5x2 Mixed ANOVA was applied with two between-subjects factors: gender with two levels (female; male) and age-group with five levels and a single within-subjects factor being speech task with two levels: picture naming (PN); spontaneous (SPON). The dependant variable was the proportion of voicing errors. Mauchly's Test of Sphericity was significant: $p < .001$ (see Appendix-AG for more details), therefore the Greenhouse-Geisser correction was applied to the degrees of freedom and consequently a significant main effect of Speech-Task was found, i.e. across all age-groups, the means of PN-voicing and SPON-voicing are significantly different: $F(1, 50) = 28.966$, $p < .001$, partial $\eta^2 = .367$. However, the speech-task by age-group interaction was not significant: $F(4, 50) = 1.282$, $p = .290$, partial $\eta^2 = .093$.The speech-task by gender interaction was not significant either: $F(1, 50) = .344$, $p = .56$, partial $\eta^2 = .007$. Similarly, the three-way interaction between speech-task, age-group, and gender was not significant: $F(4, 50) = .209$, $p = .932$, partial $\eta^2 = .016$.

The Test of Between-Subjects effect showed that the effect of Age-Group was significant: $F(4, 50) = 7.827$, $p < .001$, partial $\eta^2 = .385$. However, the effect of the Gender of was not significant: $F(1, 50) = 2.238$, $p = .141$, partial $\eta^2 = .043$. The Age-Group by Gender interaction was not significant either $F(4, 50) = 1.018$, $p = .407$, partial $\eta^2 = .075$. Finally, A Tukey Post Hoc test was applied to make pair-wise comparisons between the groups. Pairwise comparisons reached significance between age groups that have an age gap of at least 18 months. All results are listed in the Table 6.17 below (see Appendix-AH for more details).

Table 6.17.

Voicing Errors Post Hoc Test between Age-Groups.

AG	G1		G2		G3		G4		G5	
	MD	**SEM**	**MD**	**SEM**	**MD**	**SEM**	**MD**	**SEM**	**MD**	**SEM**
G1	NA		.85	1.95	-5.26	1.95	-6.23*	1.95	-9.27*	1.95
G2	.85	1.95	NA		-4.4	1.95	-5.37	1.95	-8.41*	1.95
G3	5.26	1.95	4.4	1.95	NA		-.97	1.95	-4.01	1.95
G4	6.23*	1.95	5.37	1.95	.97	1.95	NA		-3.03	1.95
G5	9.27*	1.95	8.41*	1.95	4.01	1.95	3.03	1.95	NA	

*. The mean difference is significant at the .05 level.
Key: AG = Age Group, MD = Mean Difference, SEM = Standard Error of the Mean, NA = Not Applicable

Table 6.18 and Figure 6.12 below provide age, speech task and positional comparison in relation to voicing errors. Although there is a general tendency for voicing to decrease with age, it is notable that the highest levels of voicing errors occur in the youngest age group: Group-1 regardless of speech task (with the exception of post-vocalic voicing in PN sample in SFWF position). Interestingly, voicing errors in SIWI and SFWW positions show a similar/gradual decrease over time in both speech tasks. In comparison, voicing errors in SIWW and SFWF show higher frequency of occurrence in the two youngest age groups (Groups 1 and 2) then drop notably at Group-3 (average age 3;00 years).

Table 6.18.

Positional Differences in the Occurrence of Voicing Errors in Two Speech Tasks.

	Mean of Voicing Errors (%)							
S/WP	**SIWI**		**SIWW**		**SFWW**		**SFWF**	
ST	PN	SPON	PN	SPON	PN	SPON	PN	SPON
G1	14.93	9.66	23.82	20.82	18.32	11.57	20.28	14.03
G2	11.56	8.96	22.52	17.93	13.34	9.70	22.26	13.25
G3	8.49	4.93	13.77	9.73	10.39	5.90	12.04	6.61
G4	6.25	5.28	12.26	10.61	8.43	5.28	10.93	8.66
G5	4.58	3.48	8.26	4.02	6.69	3.65	5.76	3.73

Key: S/WP= Syllable/Word Position, ST= Speech Task, SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, PN= Picture Naming, SPON= Spontaneous.

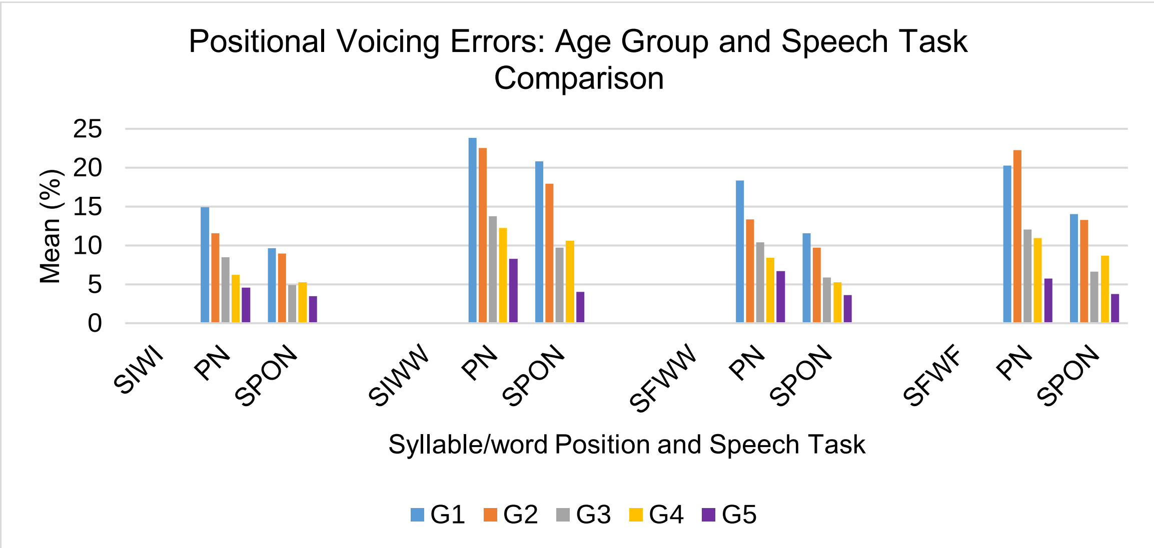


Figure 6.12. Positional differences in the occurrence of voicing errors: Age Group and Speech Task comparison. Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, PN= Picture Naming, SPON= Spontaneous.

To statistically compare the difference between the occurrences of voicing errors in different syllable/word position, Friedman test was completed as the positional voicing data is not normally distributed in Groups 3 and 4 in all syllable/word position (see Appendix-AI). The test was run on each group separately and again between all four syllable/word positions with age groups combined. The results in Table 6.19 show that there is a significant difference in the occurrence of voicing errors in different syllable/word positions in Groups 1, 2, and 3 (i.e. up to the age of 3;06 years) and amongst all participants as a whole. In general, consonants in SIWW or SFWF positions have the highest mean rank of voicing in comparison with consonants in SIWI or SFWW positions.

Table 6.19.

Positional Voicing Errors: Mean Rank, N, Chi-Squ, df, and p Value for Friedman Test.

	G1	**G2**	**G3**	**G4**	**G5**	**All Groups**
			Mean Rank			
SIWI	1.33	1.83	1.58	2.00	2.17	1.78
SIWW	4.00	3.50	3.58	3.00	3.00	3.42
SFWW	1.92	1.92	2.25	2.08	2.33	2.10
SFWF	2.75	2.75	2.58	2.92	2.50	2.70
			Friedman Test			
N	12	12	12	12	12	60
Chi-Square	28.900	13.300	15.000	6.100	2.800	55.940
df	3	3	3	3	3	3
***p* value**	.000*	.004*	.002*	.107	.423	.000*

*. The mean difference is significant at the .01 level.
Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

Moreover, a series of Wilcoxon Singed Rank Test were also completed to compare consonants mean ranks of voicing at word boundaries (SIWI vs. SFWF), in onset positions (SIWI vs. SIWW), in medial positions (SIWW vs. SFWW), and in coda positions (SFWW vs. SFWF) (see Appendix-AJ for more details). Since each dependent variable is only tested twice, the Bonferroni corrected/adjusted *p* value was calculated using the following equation:

$$\alpha = \frac{.05}{2} = .025$$

Finally, the test results were compared to the new and adjusted *p* value *α* = .025 as the higher boundary for significance. As a result, it can be concluded that the occurrence of voicing errors in consonants at word boundaries (SIWI vs. SFWF), onset positions (SIWI vs. SIWW), medial positions (SIWW vs. SFWW), and coda positions (SFWW vs. SFWF) is significantly different (Table 6.20). Consonants in SFWF position are more likely to incur voicing errors than consonants in SIWI or SFWW positions. Similarly, consonants in SIWW position are more likely to incur voicing errors than consonants in SIWI or SFWW positions.

Table 6.20.

Difference in the Occurrence of Voicing Errors between Several Syllable/word positions: Wilcoxon Signed Ranks Test.

	Wilcoxon Signed Ranks Test	
	Z	Sig. (two-Tailed)
SIWI vs. SFWF	-4.888[a]	.000*
SIWI vs. SIWW	-5.271[a]	.000*
SIWW vs. SFWW	-5.197[b]	.000*
SFWW vs. SFWF	-3.548[a]	.000*

a. Based on negative ranks.
b. Based on positive ranks.
*. The mean rank is significant at the .025 level.
Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

In summary, voicing errors in the current study occurred more in the PN sample with a Group1-to Group5 range of 16.1-5.2% while its occurrence in the SPON sample ranged between 11.3 and 3.7%. The difference between the two speech tasks was confirmed to be statistically significant. Similarly, the age-group of the participants also had a significant effect with a clear tendency for voicing errors to decrease with age, but post Hoc analysis revealed that the difference was only significant between age groups that were at least 18 months apart. In contrast, the gender of the participants had no effect on the occurrence of voicing errors. Moreover, syllable/word position had a significant effect on the occurrence of voicing errors but only in age groups 1, 2, and 3 (i.e. up to the age of 3;02 years) after which voicing errors appear to occur equally in all syllable/word positions. In this study, voicing errors favoured consonants at different syllable/word positions in the following order: SIWW>SFWF>SFWW>SIWI.

6.3.2 Devoicing errors

In the current study, devoicing errors are defined as the realisation of voiced consonant as a voiceless one. For example, the realisation of /z/ as [θ] in /ˈmuːzə/ (banana) → [ˈmuːθə] or /g/ as [k] in /ˈgɑlˤɑm/ (pen) → [ˈkɑlˤɑm]. Table 6.21 below provides descriptive statistics: Mean and standard deviation values for the occurrence of devoicing errors in both speech tasks: PN and SPON. It appears that all participants produce more devoicing errors in the PN sample than in SPON sample (Figure 6.13).

Table 6.21.

The Percentage of Devoicing Errors in Two Speech Tasks.

Age Group	**PN Devoicing Errors**		**SPON Devoicing Errors**	
	Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	28.38	9.99	14.96	6.96
G2	27.68	8.06	13.93	5.32
G3	23.01	7.04	13.73	5.62
G4	17.47	6.00	9.76	4.07
G5	16.98	4.20	11.85	4.32

Key: PN= Picture Naming, SPON= Spontaneous.

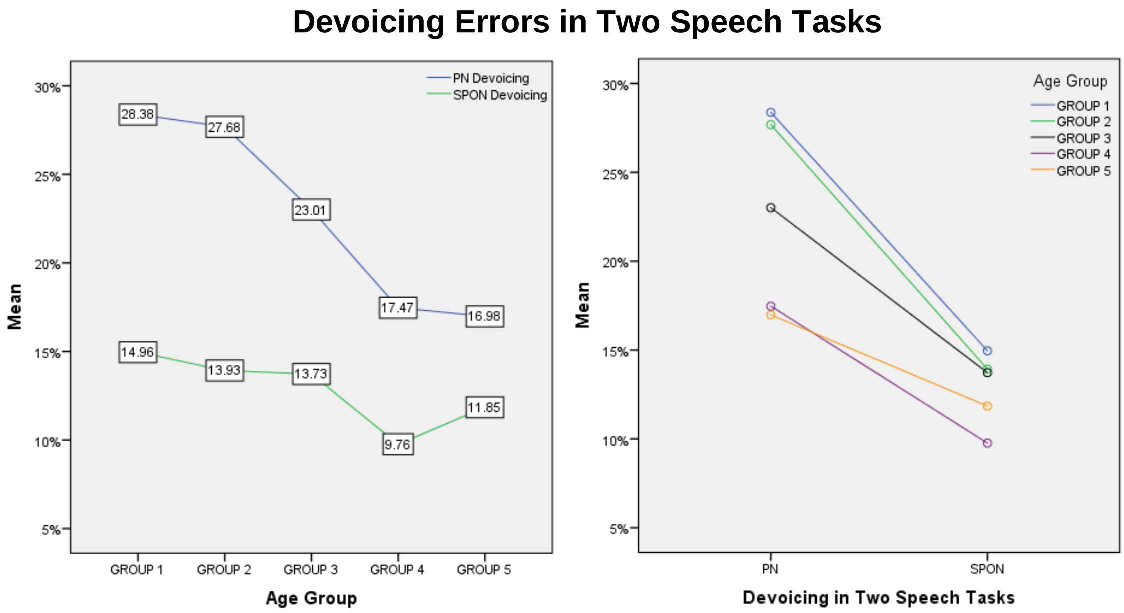


Figure 6.13. The percentage of devoicing errors in two speech tasks: as a function of age group (left) and speech task (right). Key: PN= Picture Naming, SPON= Spontaneous.

Also, by comparing the mean values across gender (Table 6.22 and Figure 6.14), it is notable that young females in groups 1, 2, and 3 in both speech tasks and females in group 5 in SPON sample produce more devoicing errors than their male peers. However, older males in groups 4 and 5 produce more devoicing errors in PN sample than their female peers. Moreover, young males in groups 1 and 2 show slightly greater individual differences (higher SD value) than their female peers in SPON sample. In contrast, young females in groups 1 and 2 show greater individual differences in PN sample.

Table 6.22.

The Occurrence of Devoicing Errors in Two Speech Tasks: Gender Comparison.

Age Group	Gender	PN Devoicing Errors		SPON Devoicing Errors	
		Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	Females	30.53	12.65	13.91	6.76
	Males	26.21	6.95	16	7.63
G2	Females	25.81	9.16	14.68	5.43
	Males	29.55	7.1	13.17	5.6
G3	Females	23.23	6.22	13.95	6.89
	Males	22.78	8.37	13.49	4.68
G4	Females	13.37	3.65	7.9	2.99
	Males	21.56	5.06	11.62	4.38
G5	Females	16.79	5.65	12.61	4.06
	Males	17.46	2.58	11.08	4.81

Key: PN= Picture Naming, SPON= Spontaneous.

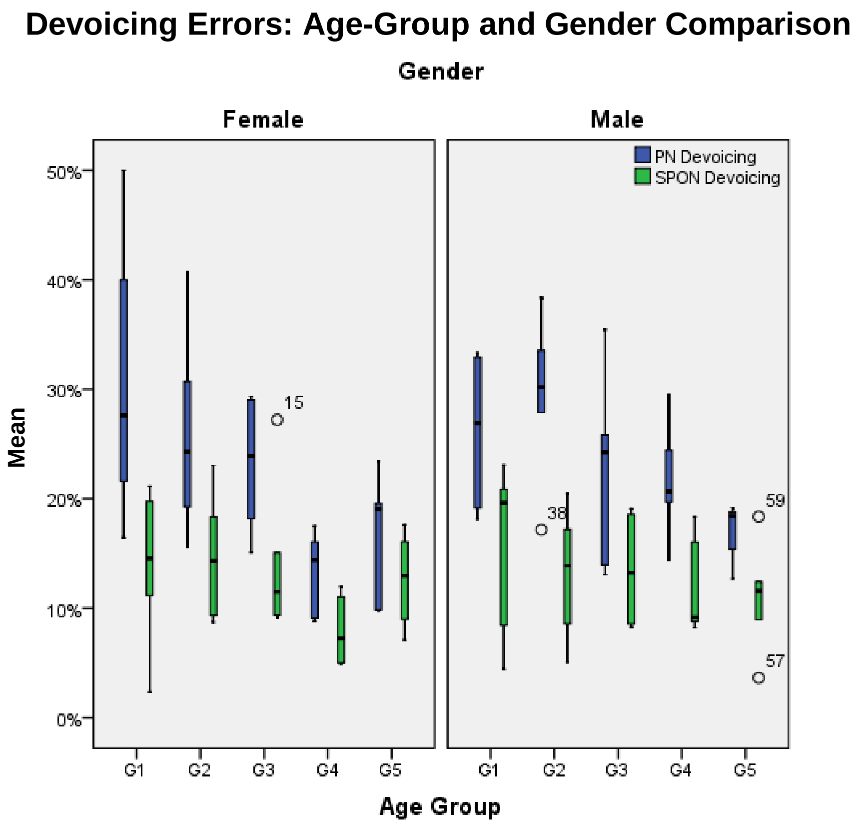


Figure 6.14. The occurrence of devoicing errors in two speech Tasks: gender comparison. Key: PN= Picture Naming, SPON= Spontaneous.

The devoicing data is normally distributed in all age groups and in both speech tasks (see Appendix-AK for more details). As a result, a 2x5x2 Mixed ANOVA was applied with two between-subjects factors: gender with two levels (female; male) and age-group with five levels and a single within-subjects factor being speech task with two levels: picture naming (PN); spontaneous (SPON). The dependant variable was proportion of devoicing errors. Mauchly's Test of Sphericity was significant: $p < .001$ (see Appendix-AL for more details), therefore, the Greenhouse-Geisser correction was applied to the degrees of freedom and consequently a significant main effect of Speech-Task was found, i.e. across all age-groups, the means of PN-devoicing and SPON-devoicing are significantly different: $F(1, 50) = 177.286$, $p < .001$, partial $\eta^2 = .780$. Additionally, the speech-task by age-group interaction was significant: $F(4, 50) = .5.033$, $p = .002$, partial $\eta^2 = .287$. However, the speech-task by gender interaction was not significant: $F(1, 50) = .496$, $p = .458$, partial $\eta^2 = .01$. Similarly, the three-way interaction between speech-task, age-group, and gender was not significant: $F(4, 50) = 1.977$, $p = .112$, partial $\eta^2 = .137$.

Because the speech-task by age-group interaction was significant, a within-subjects repeated measures ANOVA for each age group was completed. Mauchly's Test of Sphericity was significant: $p < .001$ (see Appendix-AL for more details), Therefore, the Greenhouse-Geisser correction was applied to the degrees of freedom. As a result, the means of PN-devoicing and SPON-devoicing were found to be significantly different at all age groups, i.e. $p< .05$ (Table 6.23).

Table 6.23.

*Devoicing Errors within-Subjects ANOVA: Speech-Task*Age-Group Interaction*

AG	df ST*age -group	df Error (ST*age-group)	F	Sig.	Partial Eta Squared	Observed Power
G1	1	11	29.798	.000*	.730	.999
G2	1	11	47.388	.000*	.812	1.000
G3	1	11	48.009	.000*	.814	1.000
G4	1	11	37.119	.000*	.771	1.000
G5	1	11	23.415	.001*	.680	.992

*. The mean difference is significant at the .05 level. Key: AG= Age-Group, ST= Speech-Task

Additionally, the Test of Between-Subjects effect showed that the effect of Age-Group was significant: $F(4, 50) = 4.79$, $p = .002$, partial $\eta^2 = .277$. On the other hand, that the effect of the Gender of was not significant: $F(1, 50) = .436$, $p = .512$, partial $\eta^2 = .009$. Moreover, the Age-Group by Gender interaction was not significant $F(4, 50) = .756$, $p = .559$, partial $\eta^2 = .057$. Finally, a Tukey Post Hoc test was applied to make pair-wise comparisons between the groups. Pairwise comparisons reached significance between age groups that have an age gap of at least 18 months. All results are listed in the Table 6.24 (see Appendix-AM for more details).

Table 6.24.

Devoicing Errors Post Hoc Test between Age-Groups.

Age group	G1		G2		G3		G4		G5	
	MD	SEM	MD	SEM	MD	SEM	MD	SEM	MD	SEM
G1	NA		-.86	2.35	-3.29	2.35	-8.05*	2.35	-7.25*	2.35
G2	.86	2.35	NA		-2.43	2.35	-7.18*	2.35	-6.39	2.35
G3	3.29	2.35	2.43	2.35	NA		-4.75	2.35	-3.95	2.35
G4	8,05*	2.35	7.18*	2.35	4.75	2.35	NA		.79	2.35
G5	7.25*	2.35	6.39	2.35	3.95	2.35	-.79	2.35	NA	

*. The mean difference is significant at the .05 level.
Key: MD = Mean Difference, SEM = Standard Error of the Mean, NA = Not Applicable

Finally, Table 6.25 and Figure 6.15 below provide age, speech task and positional comparison in relation to devoicing errors. Although there is a general tendency for devoicing to decrease with age, the highest levels of errors occur in the PN sample collapsing across syllable/word position. Interestingly, devoicing errors in SIWI and SFWW positions show a similar and gradual decrease over time that is accelerated in the PN sample: nearly double its frequency of occurrence can be found in the SPON sample. In comparison, devoicing errors in SIWW and SFWF show a less drastic difference between PN and SPON samples. Finally, it is apparent from Figure 6.16 below that devoicing errors in SPON sample are not substantially affected by the age of the participants in SIWW and SFWF positions.

Table 6.25.

Positional Differences in the Occurrence of Devoicing Errors in Two Speech Tasks.

	Mean of Devoicing Errors (%)							
S/WP	**SIWI**		**SIWW**		**SFWW**		**SFWF**	
ST	PN	SPON	PN	SPON	PN	SPON	PN	SPON
G1	33.14	15.00	22.26	11.42	33.42	17.68	24.01	11.77
G2	31.20	14.21	24.03	12.52	29.66	15.68	23.50	12.22
G3	24.65	13.60	19.42	10.16	24.57	11.81	18.80	11.32
G4	18.11	8.62	13.46	8.94	17.30	8.00	13.78	9.21
G5	13.84	10.69	15.65	10.14	13.08	9.54	16.70	11.09

Key: S/WP= Syllable/Word Position, ST= Speech Task, SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, PN= Picture Naming, SPON= Spontaneous.

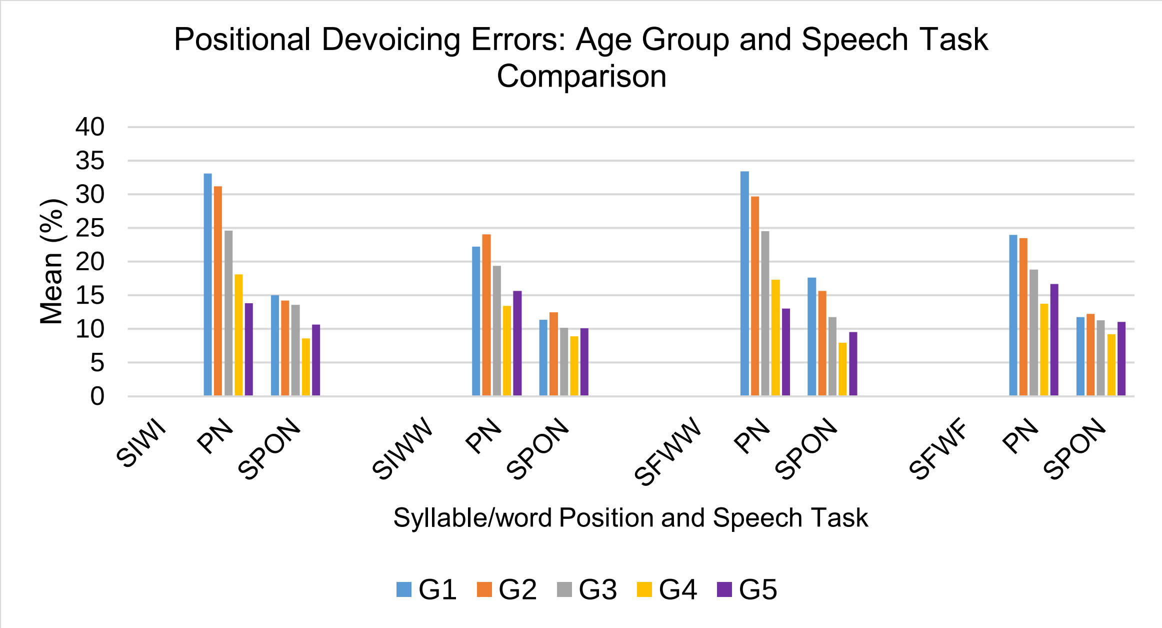


Figure 6.15. Positional differences in devoicing errors: Age-group and speech task comparison. Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, PN= Picture Naming, SPON= Spontaneous.

To statistically compare the difference between the occurrences of devoicing errors in different syllable/word position, Friedman test was completed as the positional devoicing data is not normally distributed in SFWW Groups 1, 3, 4 and 5 or in SIWI Group-4 (see Appendix-AN). The test was run on each group separately and again between all four syllable/word positions collapsing across age groups (Table 6.26).

Table 6.26.

Positional Devoicing Errors: Mean Rank, N, Chi-Sq, df, and p Value for Friedman Test.

	G1	**G2**	**G3**	**G4**	**G5**	**All Groups**
			Mean Rank			
SIWI	2.50	2.67	3.33	2.58	2.83	2.78
SIWW	2.42	1.96	1.67	2.42	2.33	2.16
SFWW	2.75	2.92	2.67	2.00	1.83	2.43
SFWF	2.33	2.46	2.33	3.00	3.00	2.63
			Friedman Test			
N	12	12	12	12	12	60
Chi-Square	.700	3.605	10.400	3.700	6.000	7.828
df	3	3	3	3	3	3
***p* value**	.873	.307	.015*	.296	.112	.050*

*. The mean difference is significant at the .05 level.
Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

From Table 6.26, it can be concluded that syllable/word position has a significant effect on the occurrence of devoicing errors in Group-3 and in all the participants as a whole. On the other hand, syllable/word position has no significant effect of the occurrence of devoicing errors in Groups 1, 2, 4, and 5. In Group-3 (average age 3;00 years) devoicing errors occurred the most in SIWI then in SFWW and then in SFWF whilst consonants in SIWW appear to be least likely to incur devoicing errors. However, across all age groups, consonants in SIWI are most likely to incur most of the devoicing errors followed by consonants in SFWF and SFWW whilst consonants in SIWW remain to be least likely to incur devoicing errors.

Table 6.27, lists the results of a series of Wilcoxon Singed Rank Test conducted to compare consonants mean ranks of devoicing at word boundaries (SIWI vs. SFWF), in onset positions (SIWI vs. SIWW), in medial positions (SIWW vs. SFWW), and in coda positions (SFWW vs. SFWF) (see Appendix-AO for more details). Since each dependent variable is only tested twice, the Bonferroni corrected/adjusted *p* value was calculated using the following equation:

$$\alpha = \frac{.05}{2} = .025$$

Finally, the test results were compared to the new and adjusted *p* value *α* = .025 as the higher boundary for significance. Consequently, it can be concluded that there are no significant differences in the occurrence of devoicing errors between consonants at word boundaries (SIWI vs. SFWF), onset positions (SIWI vs. SIWW), medial positions (SIWW vs. SFWW), or in coda positions (SFWW vs. SFWF).

Table 6.27.

Difference in the Occurrence of Positional Devoicing Errors between Several Syllable/word positions: Wilcoxon Signed Ranks Test.

	Wilcoxon Signed Ranks Test	
	Z	Sig. (two-Tailed)
SIWI vs. SFWF	-1.204[a]	.229
SIWI vs. SIWW	-1.840[a]	.066
SIWW vs. SFWW	-1.182[b]	.237
SFWW vs. SFWF	-.180[a]	.857

a. Based on positive ranks.
b. Based on negative ranks.
*. The mean rank is significant at the .025 level.
Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

In summary, devoicing errors occurred more in the PN than in the SPON sample with a Group1-to Group5 range of 28.3-16.9% and 14.9-9.7% consecutively. This difference was confirmed to be significantly different via parametric statistical analysis. Also, the effect of the age group was also significant with a tendency for the devoicing errors to decrease over time. In contrast, devoicing errors were equally present in both genders. Moreover, the interaction of the speech-task with the age-group was significant. Consequently, a post Hoc analysis revealed that the mean difference of devoicing errors between the two speech samples was only significant between age groups that were at least 18 months apart. Finally, syllable/word position had clear significant effect on the occurrence of devoicing errors in group-3 and across all age groups. The same effect was not present in age groups 1, 2, 4, and 5. Finally, although the occurrence of devoicing errors appears to favour consonants at different syllable/word positions in the following order: SIWI>SFWF>SFWW>SIWW, yet these positional differences were not statistically significant.

6.4. Errors in Manner of Articulation

The manner of articulation refers to how the airstream from the lungs flows and shaped by the speech organs such as the tongue, lips, and palate. Consequently, consonants are often put together in groups that share the same manner of articulation: e.g. Fricatives, Stops, Nasals… etc. In this section, four different types of errors involving the manner of articulation of consonants were investigated: Fricative-stopping, Deaffrication, Lateralization, and Liquid gliding/vocalization.

6.4.1. Fricative Stopping

In the current study, fricative stopping is defined as the realisation of fricative consonants as a stop. One common example in this corpus is the realisation of /ð/ as [d] in the word: /ˈhaˑðɪ/ (this) → [ˈhaˑdɪ]. Table 6.28 provides descriptive statistics: Mean and standard deviation values for the occurrence of fricative stopping in both speech tasks: PN and SPON. It appears that all participants produce more fricative stopping errors in the PN sample than in SPON sample (Figure 6.16).

Table 6.28.

The Percentage of Fricative-Stopping Errors in Two Speech Tasks.

	PN Fricative-Stopping Errors		**SPON Fricative-Stopping Errors**	
Age Group	Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	29.43	13.23	20.68	12.66
G2	27.36	9.95	16.15	7.96
G3	20.36	11.78	14.28	7.07
G4	15.29	13.08	11.26	11.66
G5	10.06	6.36	7.23	4.74

Key: PN= Picture Naming, SPON= Spontaneous.

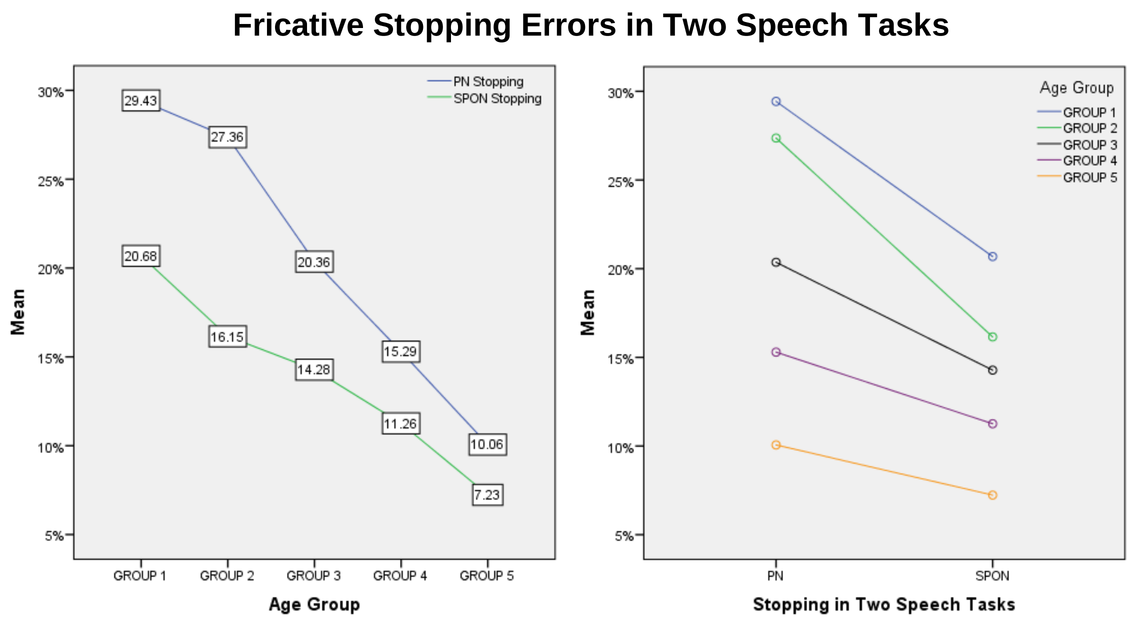


Figure 6.16. The percentage of fricative stopping errors in two speech tasks: as a function of age group (left) and speech task (right). Key: PN= Picture Naming, SPON= Spontaneous.

Also, by comparing the mean values across gender, it is notable that males are consistently producing more fricative stopping errors in SPON sample. However, in the PN sample, females produced slightly more fricative stopping errors than their male peers in age-groups 1, 3, and 5 while males in age groups 2 and 4 made many more fricative stopping errors than their female peers. Moreover, male participants generally have a higher SD value, suggesting greater individual differences amongst male participants than the female participants except for age-groups 3 and 5 where the females had greater individual differences in the PN task only (Table 6.29 and Figure 6.17).

Table 6.29.

The Occurrence of Fricative Stopping Errors in Two Speech Tasks: Gender Comparison.

Age Group	Gender	PN Fricative Stopping		SPON Fricative Stopping	
		Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	Females	30.72	12.73	17.75	10.69
	Males	28.15	14.80	23.62	14.76
G2	Females	21.26	7.54	12.54	6.18
	Males	33.47	8.44	19.76	8.36
G3	Females	22.12	13.13	11.76	6.53
	Males	18.60	11.20	16.79	7.22
G4	Females	9.29	8.91	6.77	8.36
	Males	21.30	14.51	15.74	13.45
G5	Females	11.83	7.48	6.28	4.27
	Males	8.29	5.04	8.19	5.38

Key: PN= Picture Naming, SPON= Spontaneous.

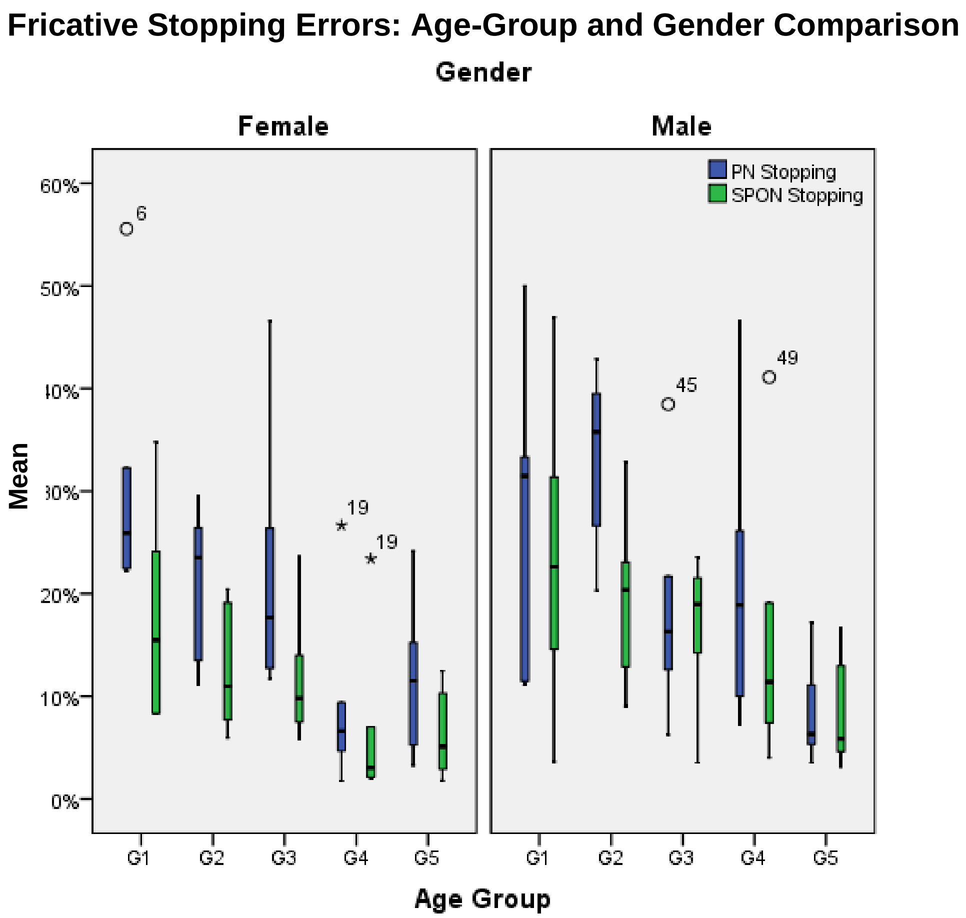


Figure 6.17. The occurrence of fricative stopping errors in two speech tasks: gender comparison. Key: PN= Picture Naming, SPON= Spontaneous.

The fricative-stopping data is mostly normally distributed except for Group-4 in both speech tasks (see Appendix-AP for more details). As a result, a 2x5x2 Mixed ANOVA with two between-subjects factors was applied: gender with two levels (female; male) and age-group with five levels and a single within-subjects factor being speech task with two levels: picture naming (PN); spontaneous (SPON). The dependant variable was proportion of fricative stopping errors. Mauchly's Test of Sphericity was significant: $p < .001$ (see Appendix-AQ for more details), therefore, the Greenhouse-Geisser correction was applied to the degrees of freedom and consequently a significant main effect of Speech-Task was found, i.e. the means of PN-Stopping and SPON-Stopping are significantly different: $F(1, 50) = 37.931$, $p < .001$, partial $\eta^2 = .431$. However, the speech-task by age-group interaction was not significant: $F(4, 50) = 2.055$, $p = .101$, partial $\eta^2 = .141$. Also, the speech-task by gender interaction was not significant: $F(1, 50) = 1.820$, $p = .183$, partial $\eta^2 =$

.035. Similarly, the three-way interaction between speech-task, age-group, and gender was not significant: $F(4, 50) = 1.824$, $p = .139$, partial $\eta^2 = .127$.

Additionally, the Test of Between-Subjects effect showed that the effect of Age-Group was significant: $F(4, 50) = 6.154$, $p < .001$, partial $\eta^2 = .330$. However, the effect of the Gender of was not significant: $F(1, 50) = 3.419$, $p = .07$, partial $\eta^2 = .064$. Also, the Age-Group by Gender interaction was not significant $F(4, 50) = 1.019$, $p = .406$, partial $\eta^2 = .075$. Finally, a Tukey Post Hoc test was applied to make pair-wise comparisons between Age-Groups. Pairwise comparisons reached significance between several age groups that have an age gap of 18 months or more, all results are listed in the Table 6.30 (see Appendix-AR for more details).

Table 6.30.

Fricative-Stopping Errors Post-Hoc Test between Age-Groups.

Age group	G1		G2		G3		G4		G5	
	MD	SEM	MD	SEM	MD	SEM	MD	SEM	MD	SEM
G1	NA		-3.29	3.72	-7.73	3.72	-11.78*	3.72	-16.41**	3.72
G2	3.29	3.72	NA		-4.44	3.72	-8.48	3.72	-13.11**	3.72
G3	7.73	3.72	4.44	3.72	NA		-4.04	3.72	-8.67	3.72
G4	11.78*	3.72	8.48	3.72	4.04	3.72	NA		-4.62	3.72
G5	16.41**	3.72	13.11**	3.72	8.67	3.72	4.62	3.72	NA	

MD = Mean Difference, SEM = Standard Error of the Mean, NA = Not Applicable
*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.

Finally, Table 6.31 and Figure 6.18 below provide age, speech task and positional comparison in relation to fricative stopping. Although there is a general tendency for stopping to decrease with age, the slope is much sharper in SIWI and SFWW where the highest levels of stopping occur at the Group-1 and drop significantly at Group-2 in both speech tasks. These findings suggest that fricatives in SIWW and SFWF positions incur more stopping errors than fricatives in SIWI and SFWW positions in both speech tasks.

Table 6.31.

Positional Differences in the Occurrence of Fricative Stopping Errors in Two Speech Tasks.

	Mean of Fricative Stopping Errors (%)							
S/WP	**SIWI**		**SIWW**		**SFWW**		**SFWF**	
ST	PN	SPON	PN	SPON	PN	SPON	PN	SPON
G1	33.89	25.97	22.65	16.27	33.18	34.15	24.09	13.78
G2	26.38	15.54	24.92	18.74	25.47	18.28	25.12	15.18
G3	19.24	9.50	17.86	17.45	18.54	10.82	18.09	15.43
G4	14.89	12.17	13.43	9.45	15.38	12.84	11.75	8.92
G5	11.31	7.34	5.92	6.50	10.94	8.49	4.30	4.94

Key: S/WP= Syllable/Word Position, ST= Speech Task, SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, PN= Picture Naming, SPON= Spontaneous.

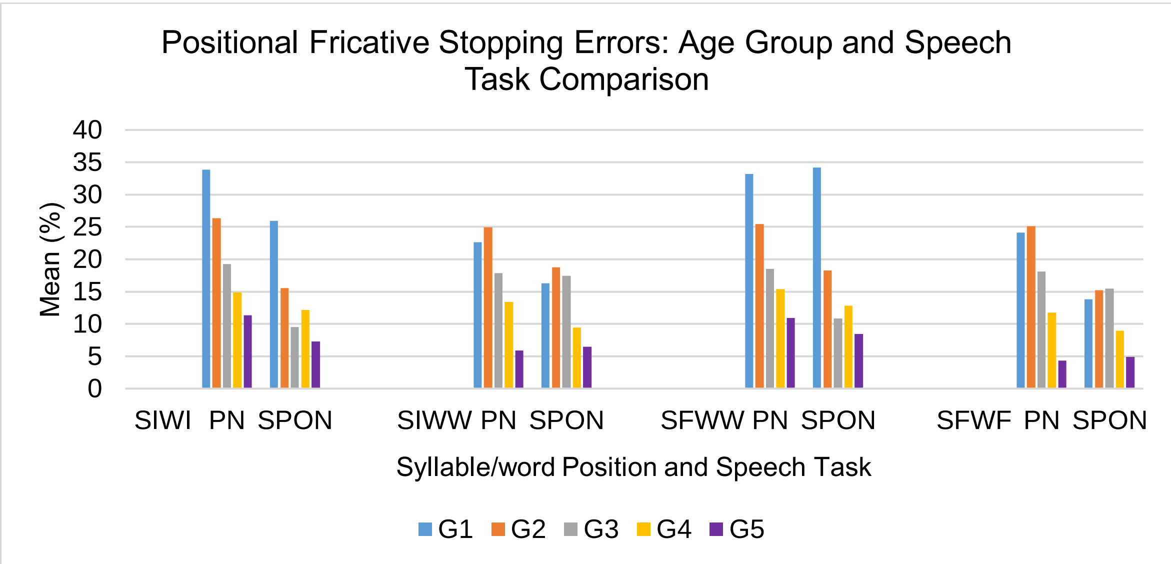


Figure 6.18. Positional differences in the occurrence of fricative stopping errors: Age-Group and Speech-Task comparison. Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, PN= Picture Naming, SPON= Spontaneous.

To statistically compare the difference between the occurrences of fricative stopping errors in different syllable/word position, Friedman test was completed as the positional fricative stopping data is not normally distributed in several age-groups per syllable/word position (see Appendix-AS). The test has been run on each age-group separately and again between all participants as a whole (Table 6.32).

Table 6.32.

Positional Fricative-Stopping Errors: Mean Rank, N, Chi-Squ, df, and p Value for Friedman Test.

	G1	**G2**	**G3**	**G4**	**G5**	**All groups**
				Mean Rank		
SIWI	2.67	2.17	1.63	2.42	2.67	2.31
SIWW	2.13	2.83	3.33	2.58	2.33	2.64
SFWW	3.54	2.83	2.38	2.75	3.58	3.02
SFWF	1.67	2.17	2.67	2.25	1.42	2.03
				Friedman Test		
N	12	12	12	12	12	60
Chi-Square	14.143	3.200	10.916	1.000	17.300	19.560
df	3	3	3	3	3	3
***p* value**	.003**	.362	.012*	.801	.001**	.000**

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

From Table 6.32, it can be concluded that syllable/word position has an effect on the occurrence of fricative stopping errors. In general, medial consonants in SIWW or SFWW positions have the highest mean rank of fricative stopping in comparison to consonants at word boundaries in SIWI or SFWF positions. Table 6.33 lists the results of a series of Wilcoxon Singed Rank Test conducted to compare consonants mean ranks of fricative stopping at word boundaries (SIWI vs. SFWF), in onset positions (SIWI vs. SIWW), in medial positions (SIWW vs. SFWW), and in coda positions (SFWW vs. SFWF) (see Appendix-AT for more details). Since each dependent variable is only tested twice, the Bonferroni corrected/adjusted *p* value was calculated using the following equation:

$$\alpha = \frac{.05}{2} = .025$$

Accordingly, the test results were compared to the new and adjusted *p* value *α* = .025 as the higher boundary for significance. Consequently, it can be concluded that there are no significant differences in the occurrence of fricative stopping between consonants in: word boundaries (SIWI vs. SFWF), in onset positions (SIWI vs. SIWW), in word-medial positions (SIWW vs. SFWW), or in coda positions (SFWW vs. SFWF).

Table 6.33.

Difference in the Occurrence of Positional Fricative Stopping Errors between Several Syllable/word positions: Wilcoxon Signed Ranks Test.

	Wilcoxon Signed Ranks Test	
	Z	Sig. (two-Tailed)
SIWI vs. SFWF	-1.340[a]	.180
SIWI vs. SIWW	-.158[a]	.874
SIWW vs. SFWW	-1.200[b]	.230
SFWW vs. SFWF	-2.098[a]	.036

a. Based on positive ranks.
b. Based on negative ranks.
*. The mean rank is significant at the .025 level.
Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

In summary, more fricative stopping errors occurred in the PN sample (ranged between 29.4% in Group-1 and 10.06% in Group-5) in comparison to the SPON sample (ranged between 20.6% in Group-1 and 7.2% in Group-5). The difference in the occurrence rate of fricative stopping errors between the two speech tasks was confirmed to be statistically significant p<.001. Similarly, the age-group of the participants, but not the gender, had a significant effect on fricative stopping errors with a clear tendency for errors to decrease with age. Moreover, in a post Hoc analysis the difference between the means of fricative stopping errors in the two speech samples was only significant between age groups that have an age gap of 18 months or more. Finally, syllable/word position was found to have a significant effect on the occurrence of fricative stopping errors in age groups 1, 3, and 5 and in all age groups combined. Nonetheless, no significant difference was detected when fricative stopping errors were compared between consonants at word boundaries or in onset, word-medial, and coda positions.

6.4.2. Deaffrication Errors:

In the current study, de-affrication is defined as the realisation of an affricate consonant by non-affricated consonant, typically by losing the fricative or the stop element, e.g. the realisation of /ʤ/ as [d] in /ʤaːj/ (coming) → [daːj] or as [θ] → [θaːj]. Table 6.34 provides descriptive statistics: Mean and standard deviation values for the occurrence of deaffrication in both speech samples: PN and SPON. It appears that the youngest participants in Group-1 produced more deaffrication errors in the PN sample than in SPON sample (Figures 6.19). However, in all other age-groups, the occurrence of deaffrication errors appear to be very similar in both speech tasks.

Table 6.34.

The Percentage of Deaffrication Errors in Two Speech Tasks.

	PN Deaffrication Errors		**SPON Deaffrication Errors**	
Age Group	Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	93.91	9.75	69.90	29.31
G2	47.75	31.43	60.29	36.18
G3	50.86	35.27	58.27	32.18
G4	49.39	34.03	51.37	40.78
G5	21.67	22.53	26.86	12.94

Key: PN= Picture Naming, SPON= Spontaneous.

Deaffrication Errors: Age-Group and Speech Task Comparison

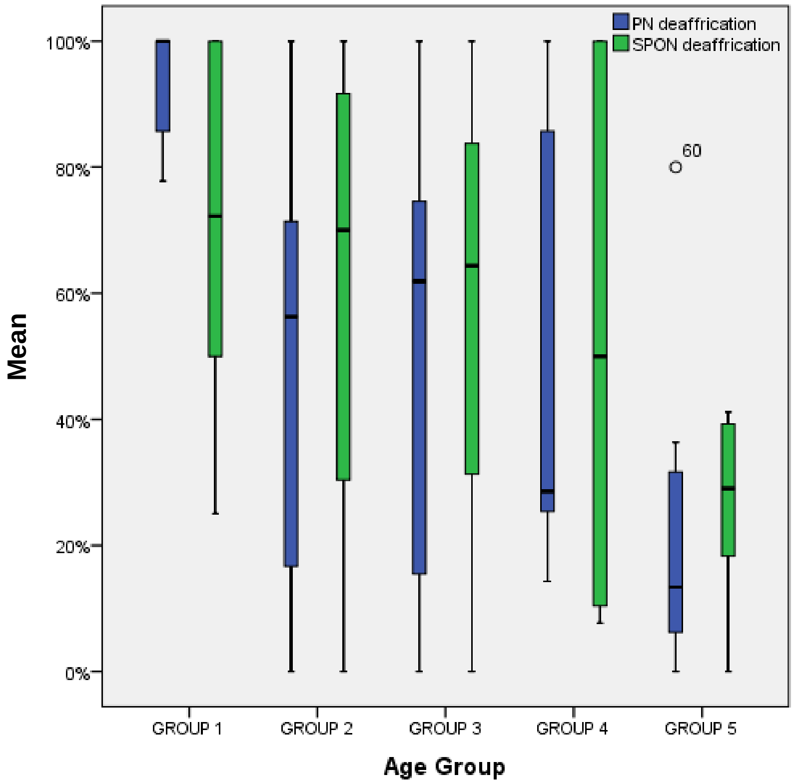


Figure 6.19. Deaffrication errors in two speech tasks. Key: PN= Picture Naming, SPON= Spontaneous.

In the both speech tasks, two participants in PN sample and five participants in SPON sample in Group-1 failed/did not have the opportunity to attempt any targets which contained affricates. Therefore, this was considered as missing data. Moreover, the deaffrication data was found not to be normally distributed in three age-groups: Groups 1, 4 and 5 in PN sample and in Group-4 in SPON sample (see Appendix-AU for more details). Also, Leven's Test of Equality of Error Variances was significant in SPON sample (see Appendix-AV for more details). As a result, non-parametric tests were used to compare deaffrication errors for Between-Subjects and Within-Subjects factors independently. Unfortunately, exploring the interactions between IVs and DV was not attainable due to the abnormal distribution of the data.

- *Kurskal-Wallis One-Way Between-Subjects factor: Age-group*

Test results show that Age-Groups has a significant effect on the occurrence of deaffrication errors in PN sample: $\chi^2(4, N = 58) = 21.610$, $p < .000$ (Figures 6.19).

Similarly, Age-Group has a significant effect on the occurrence of deaffrication errors in SPON sample: $\chi^2(4, N = 55) = 9.602$, $p = .048$ (Figure 6.20). Table 6.35 show *N* and Mean Rank value in each age-group in both speech samples.

Table 6.35.

Deaffrication Errors in Two Speech Tasks: Kurskal-Wallis Test.

Age Group	PN Deaffrication Errors		SPON Deaffrication Errors	
	N	Mean Rank	*N*	Mean Rank
G1	10	49.05	7	38.07
G2	12	27.50	12	31.46
G3	12	28.46	12	30.67
G4	12	29.83	12	27.17
G5	12	15.92	12	16.83
Total N	58		55	

Key: PN= Picture Naming, SPON= Spontaneous, *N*= Number of Participants.

- *Mann-Whitney Test Between-Subjects Factor: Gender*

In Figure 6.20, Table 6.36 and Table 6.37 deaffrication errors were compared in both genders in each age-group separately and then amongst all participants as a whole in both speech tasks. From the results it can be concluded that the gender of the participants has no effect on the occurrence of deaffrication errors in either speech task in all participants as a whole and within each age-group: $p > 0.05$.

Deaffrication Errors: Age-Group, Speech Task and Gender Comparison

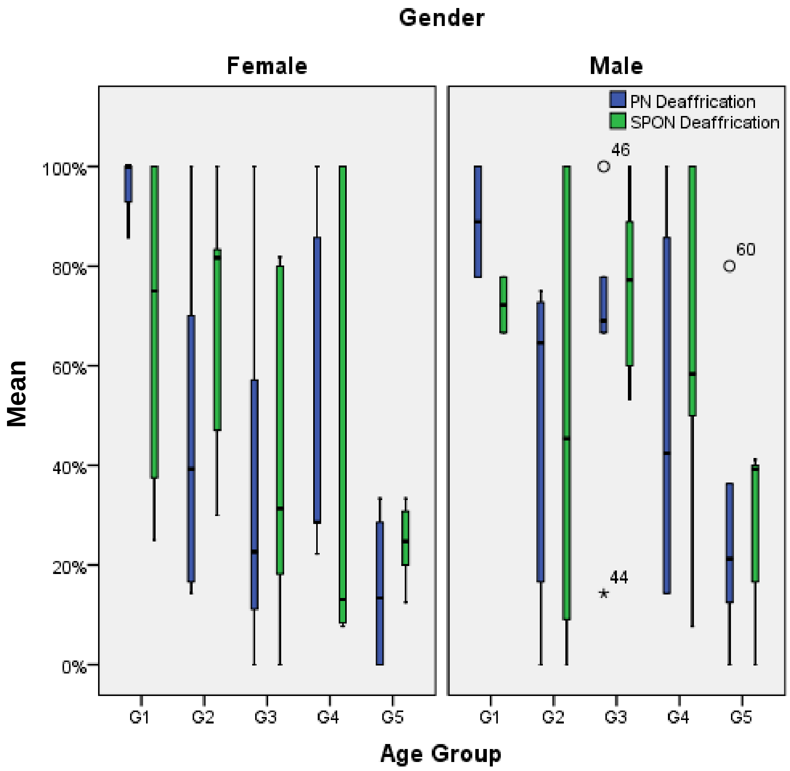


Figure 6.20. The occurrence of deaffrication errors in two speech tasks: gender comparison. Key: PN= Picture Naming, SPON= Spontaneous.

Table 6.36.

Deaffrication Errors in Picture Naming Sample: Gender Comparison.

	G1	G2	G3	G4	G5	All Groups
			Females			
Mean Rank	6.92	6.25	4.92	6.75	5.67	28.93
N	6	6	6	6	6	30
			Males			
Mean Rank	3.38	6.75	8.08	6.25	7.33	30.11
N	4	6	6	6	6	28
Mann-Whitney U	3.500	16.500	8.500	16.500	13.000	403.000
Z	-2.050	-.241	-1.527	-.246	-.812	-.266
Sig. (two-Tailed)	.067*	.818*	.132*	.818*	.485*	.790

*. Exact Sig.

Table 6.37.

Deaffrication Errors in Spontaneous Sample: Gender Comparison.

	G1	G2	G3	G4	G5	All Groups
			Females			
Mean Rank	3.75	7.17	4.50	5.75	5.33	25.61
N	4	6	6	6	6	28
			Males			
Mean Rank	4.33	5.83	8.50	7.25	7.67	30.48
N	3	6	6	6	6	27
Mann-Whitney U	5.000	14.000	6.000	13.500	11.000	311.000
Z	-.367	-.646	-1.925	-.736	-1.123	-1.133
Sig. (two-Tailed)	.857*	.589*	.065*	.485*	.310*	.257

*. Exact Sig.

- *Wilcoxon Signed Ranks for Within-Subjects Factor: Speech Task*

In here, the occurrence of deaffrication errors is compared in two speech tasks. Based on the results in Table 6.38 below, it can be concluded that the Speech-

Task has no effect on the occurrence of deaffrication errors, i.e. deaffrication errors occur equally in both PN and SPON samples.

Table 6.38.

Speech Task Differences in Deaffrication Errors: Wilcoxon Signed Ranks Test.

	Wilcoxon Signed Ranks Test SPON – PN deaffrication		
	N - ties	Z	Sig. (two-Tailed)
All Groups	48	-.636[a]	.525
G1	4	-1.826[a]	.068
G2	11	-1.156[b]	.248
G3	12	-.589[b]	.556
G4	10	-.051[b]	.959
G5	11	-.978[b]	.328

a. Based on positive ranks.
b. Based on negative ranks.
Key: PN= Picture Naming, SPON= Spontaneous.

Table 6.39 and Figure 6.21 below provide age, speech task and positional comparison in relation to deaffrication errors. Although there is a general tendency for de-affrication to decrease with age, the highest levels of de-affrication occur at the Group-1 and drop significantly at Group-2 in all positions in PN sample and only in SFWF in SPON sample. Moreover, another significant drop in the frequency of occurrence is obvious at age 4;00 years (i.e. Group-5) where it reaches its lowest recorded levels in this study in both speech tasks. Therefore, the results suggest that there are very little changes in the occurrence of deaffrication errors between the age 2;06 and 3;06 years.

Table 6.39.

Positional Differences in the Occurrence of Deaffrication Errors in Two Speech Tasks.

	Mean of Deaffrication Errors (%)							
S/WP	**SIWI**		**SIWW**		**SFWW**		**SFWF**	
ST	PN	SPON	PN	SPON	PN	SPON	PN	SPON
G1	80.81	70.34	93.00	73.33	80.77	67.24	93.00	73.81
G2	61.36	60.48	55.01	59.88	67.90	65.58	48.16	45.67
G3	50.48	58.57	61.80	65.85	58.66	61.61	57.87	55.00
G4	58.59	53.44	53.94	53.25	62.58	55.56	47.07	48.30
G5	37.52	24.75	30.71	28.93	41.01	24.74	23.72	22.09

Key: S/WP= Syllable/Word Position, ST= Speech Task, SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, PN= Picture Naming, SPON= Spontaneous.

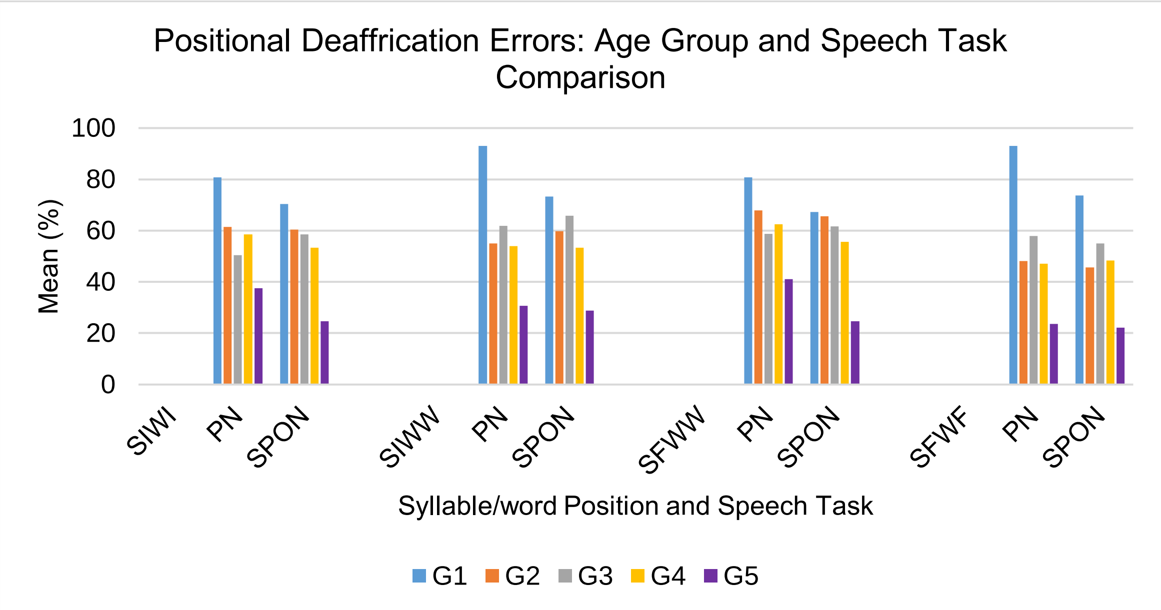


Figure 6.21. Positional differences in the occurrence of deaffrication errors: Age Group and Speech Task comparison. Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, PN= Picture Naming, SPON= Spontaneous.

To statistically compare the difference between the occurrences of deaffrication errors in different syllable/word position, Friedman test was completed as the positional deaffrication data is not normally distributed in several age-groups per syllable/word position (see Appendix-AW). The test was run on each group separately and again between all four syllable/word positions collapsing across all age groups (Table 6.40). Finally, it can be concluded that syllable/word position has no effect of the occurrence of deaffrication errors in any age-groups or across participants as a whole.

Table 6.40.

Positional Deaffrication Errors: Mean Rank, N, Chi-Squ, df, and p Value for Friedman Test.

	G1	**G2**	**G3**	**G4**	**G5**	**All Groups**
			Mean Rank			
SIWI	2.08	2.25	2.22	2.67	2.09	2.29
SIWW	3.00	2.94	2.83	2.42	3.05	2.82
SFWW	1.67	2.81	2.56	2.71	2.55	2.52
SFWF	3.25	2.00	2.39	2.21	2.32	2.37
			Friedman Test			
N	6	8	9	12	11	46
Chi-Square	7.260	3.254	1.523	1.659	3.425	5.371
df	3	3	3	3	3	3
***p* value**	.064	.354	.677	.646	.331	.147

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

In summary, deaffrication errors had the highest rate of occurrence of all phonological errors investigates in the current study: Group1-to-Group-5 range 93.9-21.6% in PN sample and 69.9-26.8% in SPON sample. Non-parametric analysis of deaffrication errors (data not normally distributed) revealed that none of the independent variables (speech task, age group, gender, or syllable/word position) had a significant effect on the occurrence of deaffrication errors in NA speaking-children between 1;10 and 4;02 years.

6.4.3. Lateralization Errors

In the current study, Lateralization is defined as the replacement of any non-lateral consonant by a lateral one. This will typically include but is not restricted to the realisation of the trill /r/ or the tap /ɾ/ as a lateral [l]. For example, the realisation of /ɾ/ as [l] in /kɪˈmɪθɾə/ (pear) → [kɪ.ˈmɪθ.lə] or /r/ as [l] in /ˈmɑr.rɑ/ (very) → [ˈmal.la]. Table 6.41 provides descriptive statistics: Mean and standard deviation values for the occurrence of Lateralization errors in both speech samples: PN and SPON. In general, it appears that Lateralization is not a common phonological error in Najdi Arabic as its occurrence does not exceed 5% in either speech task. Nonetheless, there is a general tendency for Lateralization to decrease with age. Moreover, it appears that all participants produce more Lateralization errors in the PN sample than in SPON sample (Figure 6.22).

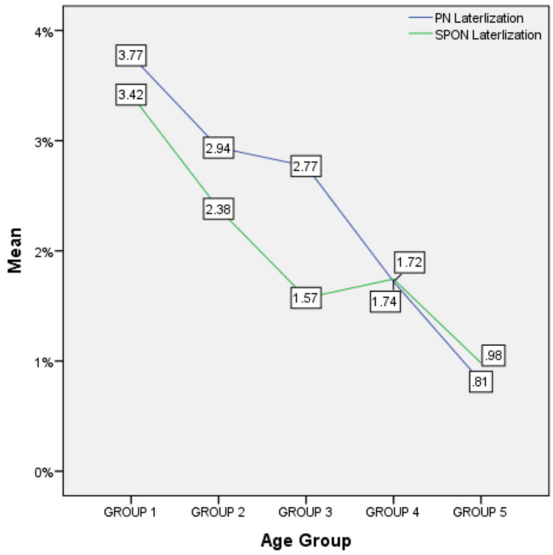
Table 6.41.

The Percentage of Lateralization Errors in Two Speech tasks.

	PN Lateralization Errors		**SPON Lateralization Errors**	
Age Group	Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	3.77	3.48	3.42	3.34
G2	2.94	2.55	2.38	3.12
G3	2.77	3.04	1.57	1.21
G4	1.72	2.22	1.74	1.99
G5	.81	.71	.98	.59

Key: PN= Picture Naming, SPON= Spontaneous.

Lateralization Errors in Two Speech Tasks



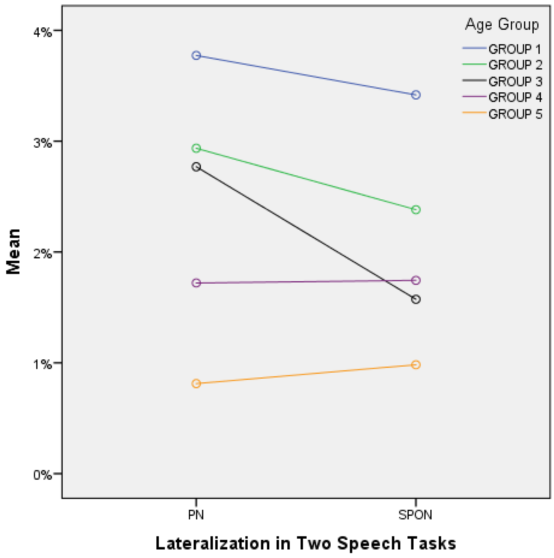


Figure 6.22. The percentage of lateralization errors in two speech tasks: as a function of age group (left) and speech task (right). Key: PN= Picture Naming, SPON= Spontaneous.

When comparing the mean values across gender (Table 6.42), it is notable that the male participants are consistently producing more Lateralization errors in both speech-tasks (except for males in Group-1 in the PN sample). Moreover, the male participants also have a higher SD value than their female peers (except for Group-2 in SPON sample) suggesting an overall greater individual differences amongst the male participants (Figure 6.23).

Table 6.42.

The Occurrence of Lateralization Errors in Two Speech Tasks: Gender Comparison.

Age Group	Gender	**PN Lateralization Errors** Mean (%)	**PN Lateralization Errors** Standard Deviation	**SPON Lateralization Errors** Mean (%)	**SPON Lateralization Errors** Standard Deviation
G1	Females	4.79	2.95	3.34	2.44
	Males	2.76	3.94	3.49	4.32
G2	Females	2.13	2.22	2.35	4.22
	Males	3.75	2.80	2.41	1.89
G3	Females	1.47	1.48	.85	.58
	Males	4.07	3.75	2.30	1.27
G4	Females	1.27	1.94	1.37	1.83
	Males	2.18	2.56	2.12	2.25
G5	Females	.71	.52	.67	.53
	Males	.91	.91	1.29	.52

Key: PN= Picture Naming, SPON= Spontaneous.

Lateralization Errors: Age-Group, Speech Task, and Gender Comparison

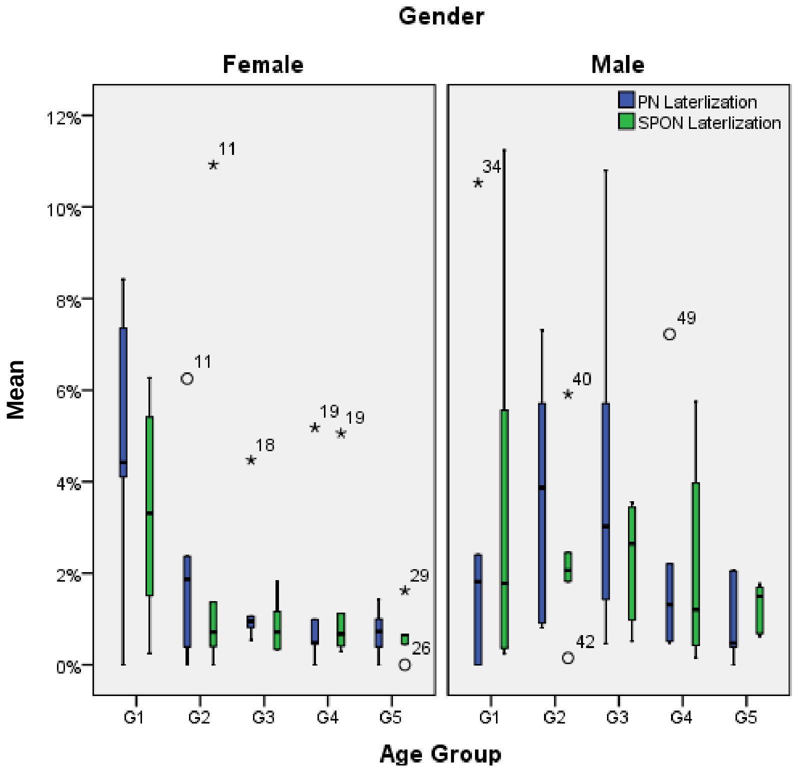


Figure 6.23. The occurrence of lateralization errors in two speech tasks: gender comparison. Key: PN= Picture Naming, SPON= Spontaneous.

The Lateralization data is mostly normally distributed except for two age-groups in each sample: Groups 3 and 4 in PN and Groups 2 and 4 in SPON sample (see Appendix-AX). As a result, a 2x5x2 Mixed ANOVA with two between-subjects factors: gender with two levels (female; male) and age-group with five levels and a single within-subjects factor being speech task with two levels: picture naming (PN); spontaneous (SPON) was applied. The dependant variable was the proportion of Lateralization errors. Mauchly's Test of Sphericity was significant: $p < .001$ (Appendix-AY).Therefore, the Greenhouse-Geisser correction was applied to the degrees of freedom and it was found that the main effect of Speech-Task was not significant: $F(1, 50) = 2.338$, $p = .133$, partial $\eta^2 = .045$. Moreover, the speech-task interaction with Age-Group, Gender and Age-Group*Gender were not significant either (Table 6.43).

Table 6.43.

*Lateralization Errors: Speech-Task Interaction with Age-Group, Gender and Age-Group*Gender.*

Lateralization: Speech-Task Interactions list	**df**	**F**	**Sig.**	**Partial Eta Squared**
Lateralization * Age-Group	4	.928	.455	.069
Lateralization * Gender	1	.014	.907	.000
Lateralization * Age-Group * Gender	4	1.739	.156	.122
Error(Lateralization)	50			

Additionally, the Test of Between-Subjects effect showed that the effect of Age-Group was not significant: $F(4, 50) = 2.379$, $p = .064$, partial $\eta^2 = .16$ and that the effect of the Gender was not significant either: $F(1, 50) =1.171$, $p = .284$, partial $\eta^2 = .023$. Also, the Age-Group by Gender interaction was not significant $F(4, 50) = .665$, $p = .619$, partial $\eta^2 = .05$.

Finally, Table 6.44 and Figure 6.24 below provide age, speech task and positional comparison in relation to positional Lateralization. It is notable that the highest levels of positional lateralization errors occur at SIWW position followed by SFWF position in both speech tasks. On the other hand, Lateralization errors occur least in SIWI and SFWW positions in both speech tasks. Also, the youngest participants

(Group-1) consistently have the highest frequency of occurrence of Lateralization in all syllable/word positions and in both speech tasks. However, these levels drop significantly in Group-2 (age 2;06 years) in SIWI, SIWW, and SFWW positions in both speech tasks. Similar drop occurs in SFWF position 12 and 18 months later in SPON and PN samples consecutively. In conclusion, it can be concluded that Lateralization errors occur more frequently in SIWW and SFWF positions and least in SIWI and SFWW positions.

Table 6.44.

Positional Differences in the Occurrence of Lateralization Errors in Two Speech Tasks.

	Mean of Lateralization Errors (%)							
S/WP	**SIWI**		**SIWW**		**SFWW**		**SFWF**	
ST	PN	SPON	PN	SPON	PN	SPON	PN	SPON
G1	2.18	1.78	5.35	6.16	2.83	2.18	4.58	4.28
G2	1.37	0.89	4.40	4.34	1.25	1.08	4.53	3.62
G3	0.98	0.77	4.24	2.69	1.38	0.87	4.25	2.18
G4	0.98	0.91	2.80	3.05	1.27	0.78	2.79	2.94
G5	0.53	0.47	1.09	1.46	0.62	0.48	1.06	1.37

Key: S/WP= Syllable/Word Position, ST= Speech Task, SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, PN= Picture Naming, SPON= Spontaneous.

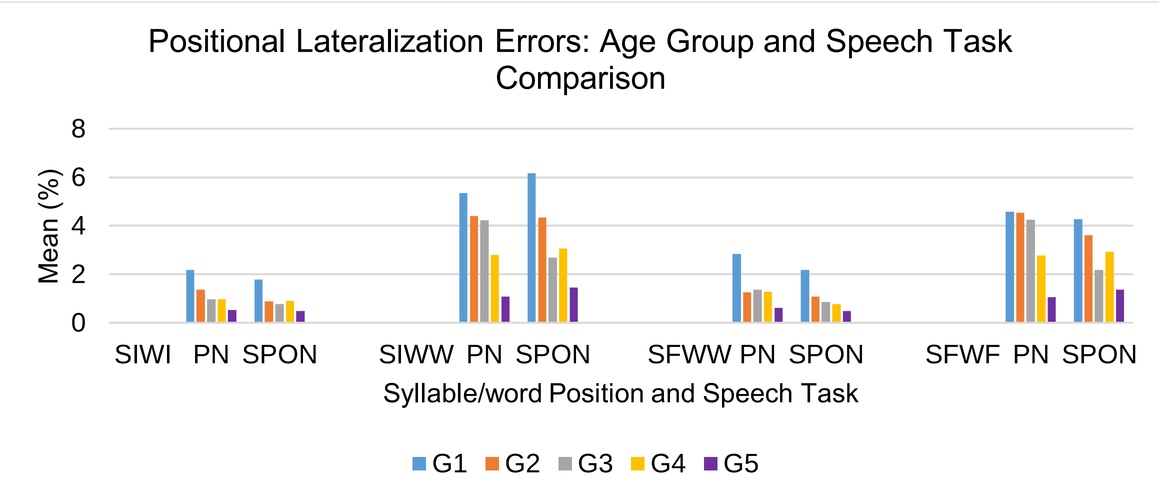


Figure 6.24. Positional differences in the occurrence of Lateralization errors: Age Group and Speech Task comparison. Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, PN= Picture Naming, SPON= Spontaneous.

To statistically compare the difference between the occurrences of Lateralization errors in different syllable/word position, Friedman test was completed as the positional Lateralization data is not normally distributed (see Appendix-AZ). The test has been run on each group separately and again between all four syllable/word positions collapsing across age groups (Table 6.45).

Table 6.45.

Positional Lateralization Errors: Mean Rank, N, Chi-Squ, df, and p Value for Friedman Test.

	G1	**G2**	**G3**	**G4**	**G5**	**All Groups**
				Mean Rank		
SIWI	1.63	1.50	1.75	2.00	1.83	1.74
SIWW	3.42	3.33	3.42	3.00	3.29	3.29
SFWW	1.79	2.25	2.17	1.58	2.04	1.97
SFWF	3.17	2.92	2.67	3.42	2.83	3.00
				Friedman Test		
N	12	12	12	12	12	60
Chi-Square	18.529	15.444	11.483	16.241	10.282	65.109
df	3	3	3	3	3	3
***p* value**	.000**	.001**	.009**	.001**	.016*	.000**

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

From Table 6.45 it is obvious that more Lateralization errors occurs in SIWW and SFWF positions and least in SFWW and SIWI positions. To compare mean ranks of Lateralization errors at word boundaries (SIWI vs. SFWF), in onset positions (SIWI vs. SIWW), in medial positions (SIWW vs. SFWW), and in coda positions (SFWW vs. SFWF) a series of Wilcoxon Singed Rank Tests were completed. Since each dependent variable is only tested twice, the Bonferroni corrected/adjusted *p* value was calculated using the following equation:

$$\alpha = \frac{.05}{2} = .025$$

Accordingly, the test results were compared to the new and adjusted *p* value *α* = .025 as the higher boundary for significance. The results suggest that there are significant differences in the occurrence of Lateralization between consonants at: word boundaries; i.e. SIWI and SFWF (z = 2.667, N = 12, p = .008), in onset positions; i.e. SIWI and SIWW (z = 2.747, N = 11, p = .006), in word-medial position; i.e. SIWW and SFWW (z = 2.589, N = 12, p = .010), and in coda positions; i.e. SFWW and SFWF (z =2.589, N = 12, p = .010). Finally, it can be concluded that consonants in SFWF position incur more Lateralization errors than those in SIWI positions. Similarly, consonants in SIWW position incur more Lateralization errors than those in SIWI position. Also, consonants in SFWW position incur more Lateralization errors than those in SIWW position and finally, consonants in SFWF position incur more Lateralization errors than those in SFWW position (see Appendix-BA for more detail).

In summary, in the current study the occurrence rate of lateralization errors was very low: Group1-to-Group-5 range 3.7-.8% in PN sample and 3.4-.9% in SPON sample. Parametric analysis of lateralization errors revealed that the speech-task, age group, and the gender of the participants did not have a significant effect on its occurrence rate. In contrast, non-parametric analysis revealed that syllable/word position had a strong significant effect on the occurrence of lateralization errors. In other words, the occurrence of lateralization errors favoured consonants at different syllable/word positions in the following order: SFWF>SFWW>SIWW>SIWI.

6.4.4. Liquid Gliding/Vocalization Errors

In the current study, gliding/vocalization of liquids is defined as the realisation of any liquid consonant by a glide or a vowel. For example, the realisation of /ɾ/ as [j] in /ɾʊzː/ (rice) → [jʊzː] or the realisation of /l/ as [w] in /maʕ.ˈlɛːʃ/ (it’s ok) → [maʕ.ˈwɛːʃ]. Table 6.46 provides descriptive statistics: Mean and standard deviation values for the occurrence of gliding/vocalization errors in both speech samples: PN and SPON. The difference between speech tasks is not consistent across all age groups. For example, Groups 1, 3 and 5 produce more errors in SPON sample whilst Groups 2 and 4 produce more errors in the PN sample (Figure 6.25).

Table 6.46.

The Percentage of Liquid Gliding/Vocalization Errors in Two Speech Tasks.

	PN Gliding/Vocalization Errors		**SPON Gliding/Vocalization Errors**	
Age Group	Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	3.74	7.74	7.24	8.19
G2	3.16	5.22	3.14	3.94
G3	1.87	2.52	2.24	2.19
G4	1.95	2.46	1.17	2.49
G5	.26	.90	1.21	1.40

Key: PN= Picture Naming, SPON= Spontaneous.

Liquid Gliding/Vocalization Errors in Two Speech Tasks

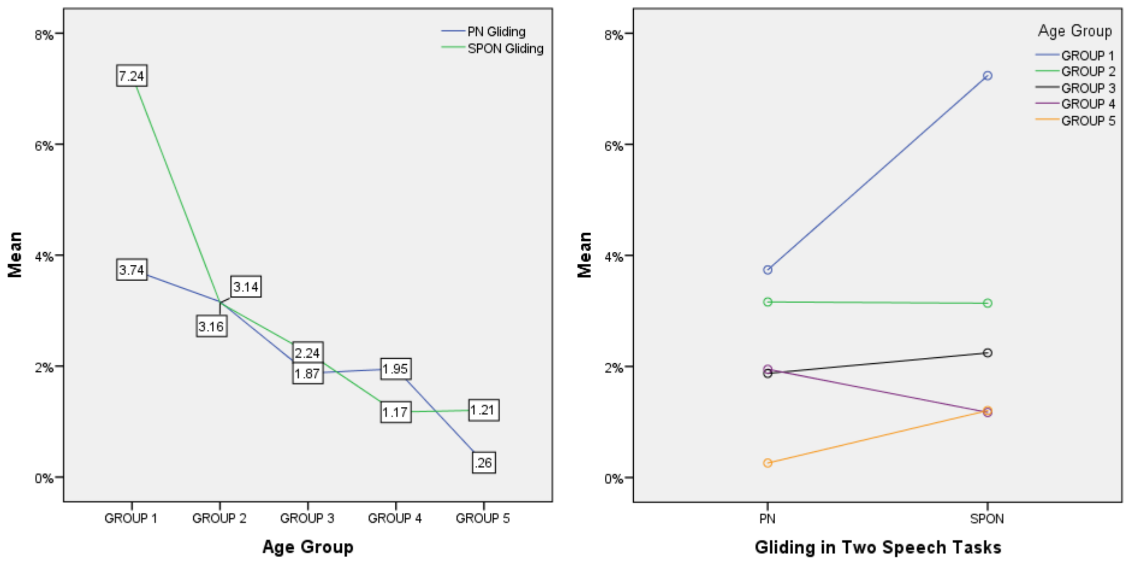


Figure 6.25. The percentage of liquid gliding/vocalization errors in two speech tasks: as a function of age group (left) and speech task (right). Key: PN= Picture Naming, SPON= Spontaneous.

Also, by comparing the mean values across gender (Table 6.47), it is notable that both male and female participants produced more gliding/vocalization errors in the SPON sample. Also, the highest level of variation between participants can be seen in Group-1 males in PN sample (SD = 10.21) and Group-1 females in the

SPON sample (SD = 10.79). Moreover, in the PN sample, male participants in general produced more gliding/vocalization errors than their female peers. However, male and female participants do not show an overall clear pattern of gender related differences (Figure 6.26). Moreover, individual differences within gender do decrease over time to reach their lowest values in Group-5 in both speech samples.

Table 6.47.

The Occurrence of Liquid Gliding/Vocalization Errors in Two Speech Tasks: Gender Comparison.

AG	**Gender**	**PN Gliding/ Vocalization Errors**		**SPON Gliding/ Vocalization Errors**	
		Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	Females	3.31	5.23	7.38	10.79
	Males	4.17	10.21	7.10	5.56
G2	Females	3.16	6.68	2.75	4.67
	Males	3.17	3.90	3.52	3.47
G3	Females	1.23	3.03	2.15	1.79
	Males	2.51	1.97	2.34	2.70
G4	Females	1.53	1.71	.15	.37
	Males	2.37	3.15	2.19	3.32
G5	Females	.52	1.28	.61	.69
	Males	.00	.00	1.80	1.74

Key: AG= Age Group, PN= Picture Naming, SPON= Spontaneous.

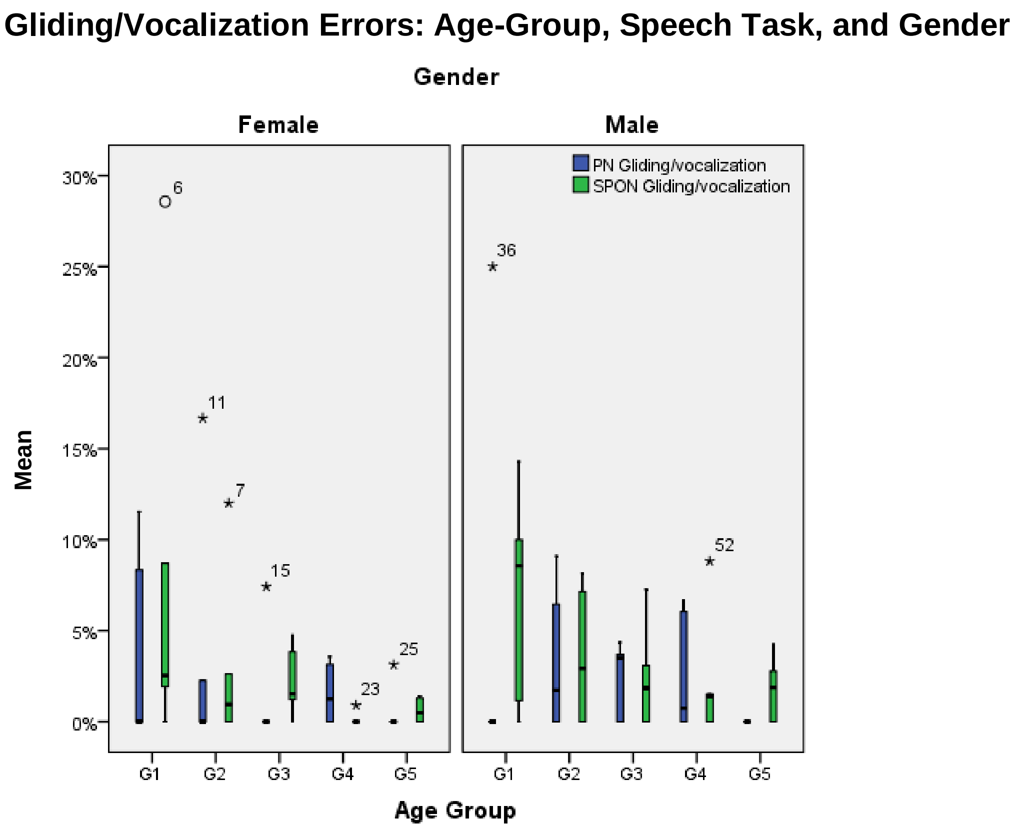


Figure 6.26. The occurrence of liquid gliding/vocalization errors in two speech tasks: gender comparison. Key: PN= Picture Naming, SPON= Spontaneous.

The liquid gliding/vocalization data is mostly not normally distributed (see Appendix-BB for more details) thus it was initially analysed using non-parametric test (Appendix-BC: a., b., c., and d.). However, the results are reported below using parametric testing to gain information about the interactions between the independent variables as the findings are identical to the outcomes of the non-parametric test. Accordingly, a 2x5x2 Mixed ANOVA with two between-subjects factors: gender with two levels (female; male) and age-group with five levels and a single within-subjects factor being speech task with two levels: picture naming (PN); spontaneous (SPON) was applied. The dependant variable was proportion liquid gliding/vocalization errors. Mauchly's Test of Sphericity was significant: $p < .001$ (Appendix-BD), therefore the Greenhouse-Geisser correction was applied to the degrees of freedom and it was found that the main effect of Speech-Task was not significant: $F(1, 50) = 1.051$, $p = .310$, partial $\eta^2 = .021$. Moreover, the speech-task interaction with Age-Group, Gender, and Age-Group*Gender was not significant either (Table 6.48).

Table 6.48.

*Liquid Gliding/Vocalization Errors: Speech-Task Interaction with Age-Group, Gender and Age-Group*Gender.*

Liquid Gliding/Vocalization: Speech-Task Interactions list	**df**	**F**	**Sig.**	**Partial Eta Squared**
Liquid Gliding/Vocalization*Age-Group	4	.869	.489	.065
Liquid Gliding/Vocalization*Gender	1	.035	.853	.001
Liquid Gliding/Vocalization*Age-Group* Gender	4	.143	.965	.011
Error(Gliding)	50			

Additionally, the Test of Between-Subjects effect showed that the effect of Age-Group was significant: $F(4, 50) = 3.356$, $p = .016$, partial $\eta^2 = .212$. Moreover, the effect of the Gender was not significant: $F(1, 50) = .503$, $p = .481$, partial $\eta^2 = .010$ and the Age-Group by Gender interaction was not significant $F(4, 50) = .058$, $p = .994$, partial $\eta^2 = .005$. However, using Kruskal-Wallis non-parametric test (Appendix-BC-b) to compare the same variables showed that Age-Group in fact has a significant effect on gliding/vocalization errors yet only in SPON sample: $\chi^2(4, N = 60) = 11.030$, $p = .026$. Finally, a Tukey Post Hoc test was applied to compare Gliding errors mean difference in the two speech samples: PN vs. SPON at different Age-Groups. Significant differences were found between age groups that are at least 24 months apart, all results are listed in the Table 6.49 (see Appendix-BE for more details).

Table 6.49.

Liquid Gliding/Vocalization Errors Post-Hoc Test between Age-Groups.

AG	G1		G2		G3		G4		G5	
	MD	SEM	MD	SEM	MD	SEM	MD	SEM	MD	SEM
G1	NA		-2.33	1.41	-3.42	1.41	-3.92	1.41	-4.75*	1.41
G2	2.33	1.41	NA		-1/09	1.41	-1.58	1.41	-2.41	1.41
G3	3.42	1.41	1.09	1.41	NA		-.49	1.41	-1.32	1.41
G4	3.92	1.41	1.58	1.41	.49	1.41	NA		-.82	1.41
G5	4.75*	1.41	2.41	1.41	1.32	1.41	.82	1.41	NA	

*. The mean difference is significant at the .05 level.
Key: AG= Age Group, MD = Mean Difference, SEM = Standard Error of the Mean, NA = Not Applicable

Table 6.50 and Figure 6.27 provide age, speech task and positional comparison in relation to liquid gliding/vocalization. Although there is a general tendency for liquid gliding/vocalization to decrease with age, it is clear that all syllable/word positions have a similar sloping shape with Group-1 having the highest frequency of errors, at least double its occurrence in Group-2. Moreover, SFWW position is the only exception to this where PN has a fluctuating trend that differs from the rest. In general, liquid gliding/vocalization errors occur mostly in medial positions (SIWW and SFWW) and least at word boundaries (SIWI and SFWF) in both speech samples.

Table 6.50.

Positional Differences in the Occurrence of Liquid Gliding/Vocalization Errors in Two Speech Tasks.

	Mean Liquid Gliding/Vocalization Errors (%)							
S/WP	**SIWI**		**SIWW**		**SFWW**		**SFWF**	
ST	PN	SPON	PN	SPON	PN	SPON	PN	SPON
G1	4.50	5.18	6.74	10.07	3.64	11.94	5.85	5.34
G2	1.56	2.99	3.71	3.01	3.91	4.59	3.00	2.05
G3	1.37	1.62	2.04	1.79	0.99	1.52	1.99	1.66
G4	0.29	1.37	1.42	0.83	0.21	1.12	1.69	0.95
G5	0.30	1.19	0.49	0.81	2.06	1.02	0.40	0.93

Key: S/WP= Syllable/Word Position, ST= Speech Task, SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, PN= Picture Naming, SPON= Spontaneous.

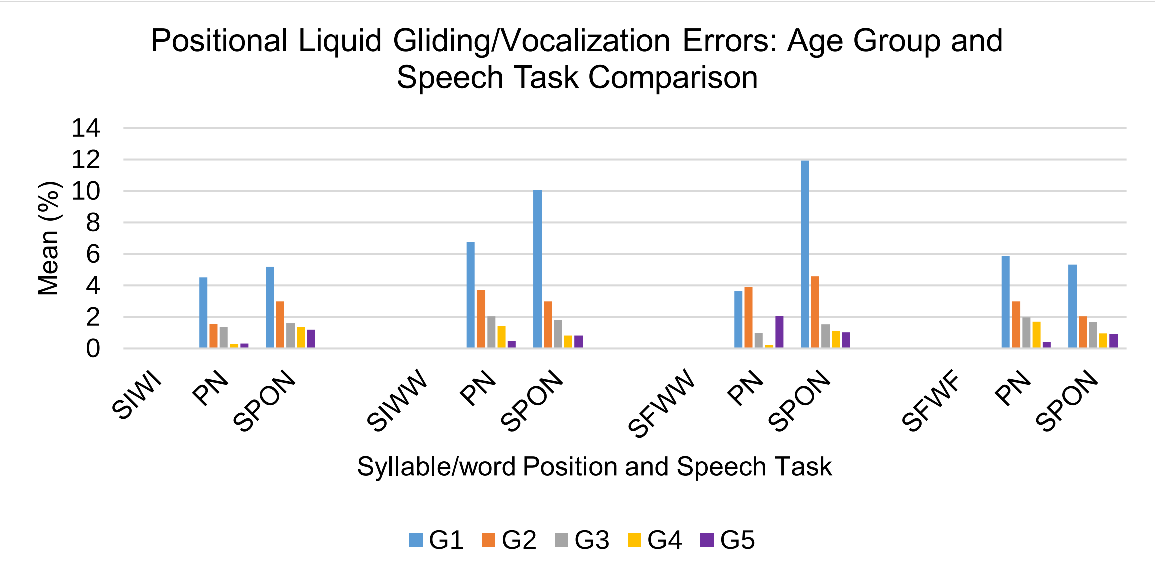


Figure 6.27. Positional differences in the occurrence of liquid gliding/vocalization errors in two speech Tasks. Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, PN= Picture Naming, SPON= Spontaneous.

To statistically compare the difference between the occurrences of liquid gliding/vocalization errors in different syllable/word position, Friedman test was completed as the positional liquid gliding/vocalization data is not normally distributed in almost all age-groups per syllable/word position (see Appendix-BF). The test was run on each age group separately and again between all four syllable/word positions collapsing across all age groups (Table 6.51). Finally, it can be concluded that syllable/word position has no effect of the occurrence of liquid gliding/vocalization errors in any age-groups and in all the participants as a whole.

Table 6.51.

Positional Liquid gliding/vocalization Errors: Mean Rank, N, Chi-Squ, df, and p Value for Friedman Test.

	G1	**G2**	**G3**	**G4**	**G5**	**All Groups**
			Mean Rank			
SIWI	2.38	2.63	2.50	2.75	2.63	2.58
SIWW	2.71	2.25	2.67	2.38	2.46	2.49
SFWW	2.42	2.71	2.33	2.50	2.38	2.47
SFWF	2.50	2.42	2.50	2.38	2.54	2.47
			Friedman Test			
N	12	12	12	12	12	60
Chi-Square	.606	1.480	.558	1.080	.441	.430
df	3	3	3	3	3	3
***p* value**	.895	.687	.906	.782	.932	.934

Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

In summary, liquid gliding/vocalization errors in both speech tasks had a low occurrence rate, i.e. <8%. Although it appears in the descriptive statistics that more errors occurred in the SPON sample, both parametric and non-parametric statistical analysis revealed that the speech task had no effect on the occurrence of liquid gliding/vocalization errors. On the other hand, the age-group of the participants, but not the gender, had a significant effect on liquid gliding/vocalization errors with a clear tendency for errors to decrease over time. Moreover, in a post Hoc test, the mean difference of errors between the two speech tasks was only significant between age groups that had an age gap of 24 months or more. Finally, non-parametric statistical analysis showed that syllable/word position had no effect on the occurrence of liquid gliding/vocalization errors in any age group and in all groups combined.

6.5. De-emphasis errors

In the current study, the phonological process of de-emphasis is defined as the realisation of an emphatic consonant as its non-emphatic equivalent. Below, there is an example of a de-emphasis error for each of the emphatic consonants included in the analysis:

Error	**IPA Target**	**IPA Actual**	**Meaning**
t/tˤ	/tˤɑːħ/	[taːħ]	“fell”
s/sˤ	/ʕɑsˤ.ˈfuːr/	[ʔas.ˈpuːl]	“bird”
l/lˤ	/xɑ.ˈlˤɑːsˤ/	[ha.ˈlaːs]	“enough”
ð/ðˤ	/ˈbɛː.ðˤə/	[ˈbɛː.ðə]	“an egg”
d/dˤ	/ˈʔax.dˤɑr/	[ˈʔax.dal]	“green”

Moreover, the frequency of occurrence of partial-de-emphasis errors was also investigated and reported in detail in this section (Figure 6.28). This extra analysis is conducted to demonstrate evidence of early perceived awareness of the emphatic quality of the consonant irrespective of the child’s inability to produce it correctly in their speech especially at a very young age. Partial de-emphasis was phonetically transcribed in the corpus as a retracted rather than a pharyngealized consonant: e.g. /t̠/, /d̠/, /s̠/, /l̠/ and /ð̠/. In Figure 6.28., there is a clear decline of both complete and partial de-emphasis errors as the correct production of emphatic consonants increases with age.

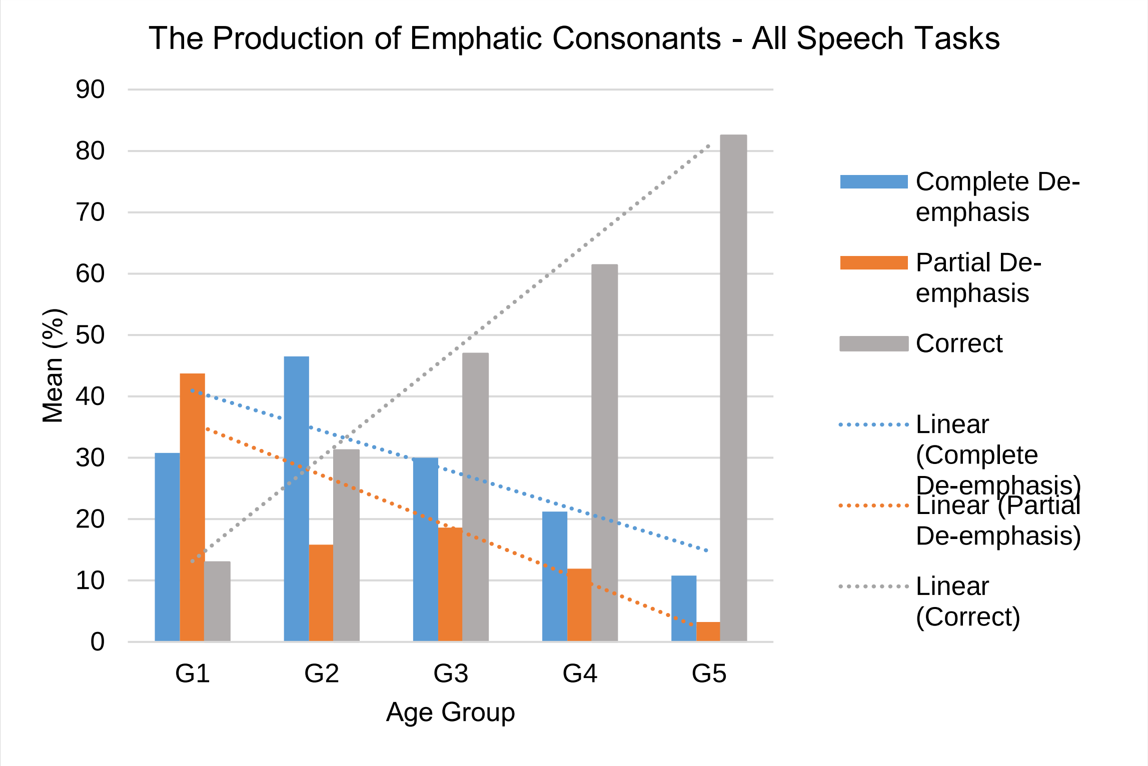


Figure 6.28. Correct, complete and partial de-emphasis production of emphatic consonants: age-group comparison.

Furthermore, qualitative comparison on individual emphatic consonant with regards to the occurrence of complete and partial de-emphasis errors was also conducted. In Figures 6.29 and 6.30, it is obvious that /tˤ/ has the highest token frequency (previously reported in figure 5.10). Also, /tˤ/ has the lowest average percent of complete de-emphasis errors and highest average percent of partial de-emphasis errors of all emphatic consonants. In contrast, all other emphatic consonants show more complete de-emphasis errors than partial de-emphasis errors.

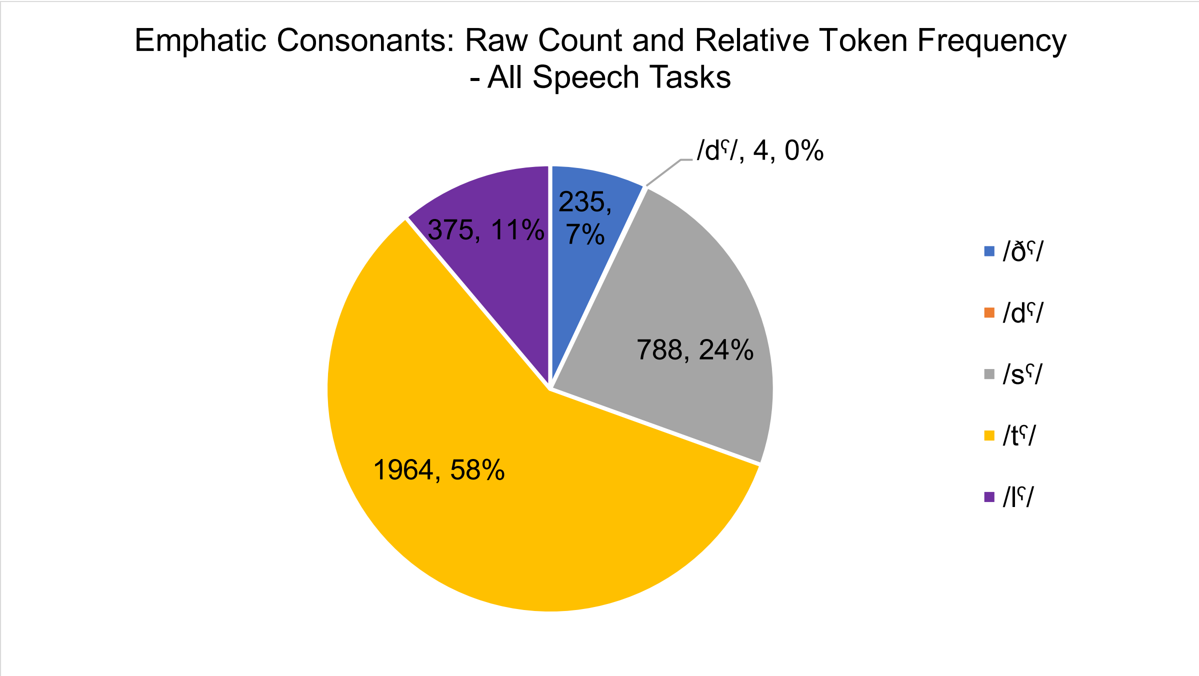


Figure 6.29. IPA target raw count and relative token frequency of emphatic consonants.

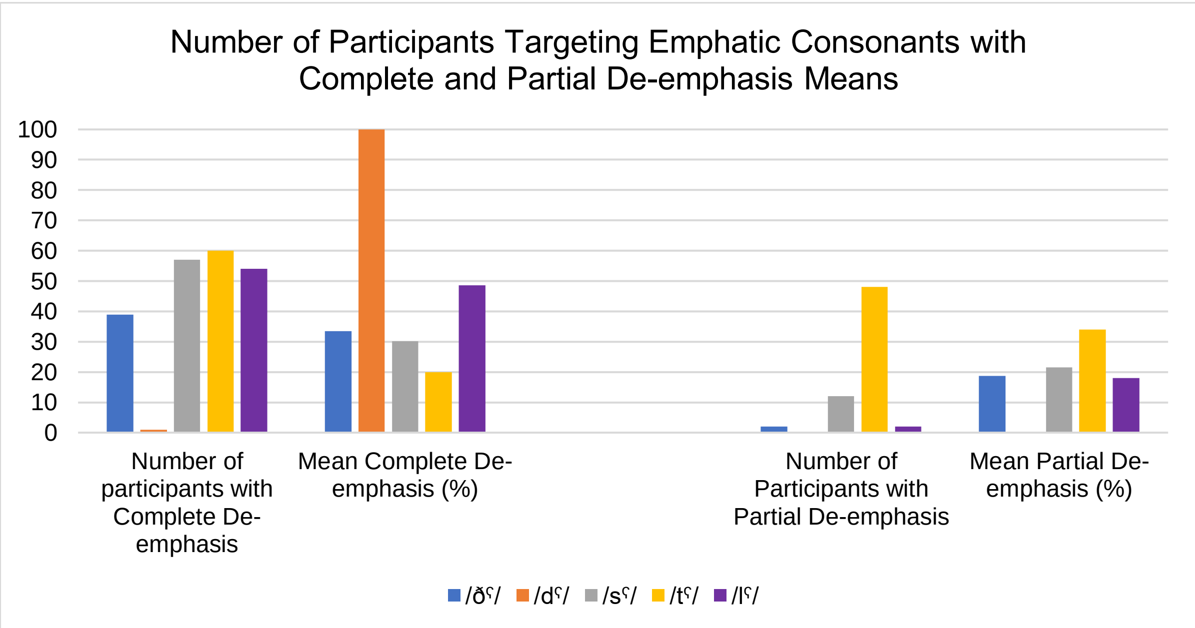


Figure 6.30. Number of participants targeting emphatic consonants and the Means of complete and partial de-emphasis errors.

Next, the quantitative analysis is presented on the main effect of age-group and gender on the overall the occurrence of *complete de-emphasis* errors. Figure 6.32 shows an overall tendency of decreased complete de-emphasis errors over time. As expected, Group-5 has the smallest percentage of errors. Nonetheless, there is an apparent fluctuation in highest percentage of errors amongst age groups in addition to great variation between subjects within each age-group.

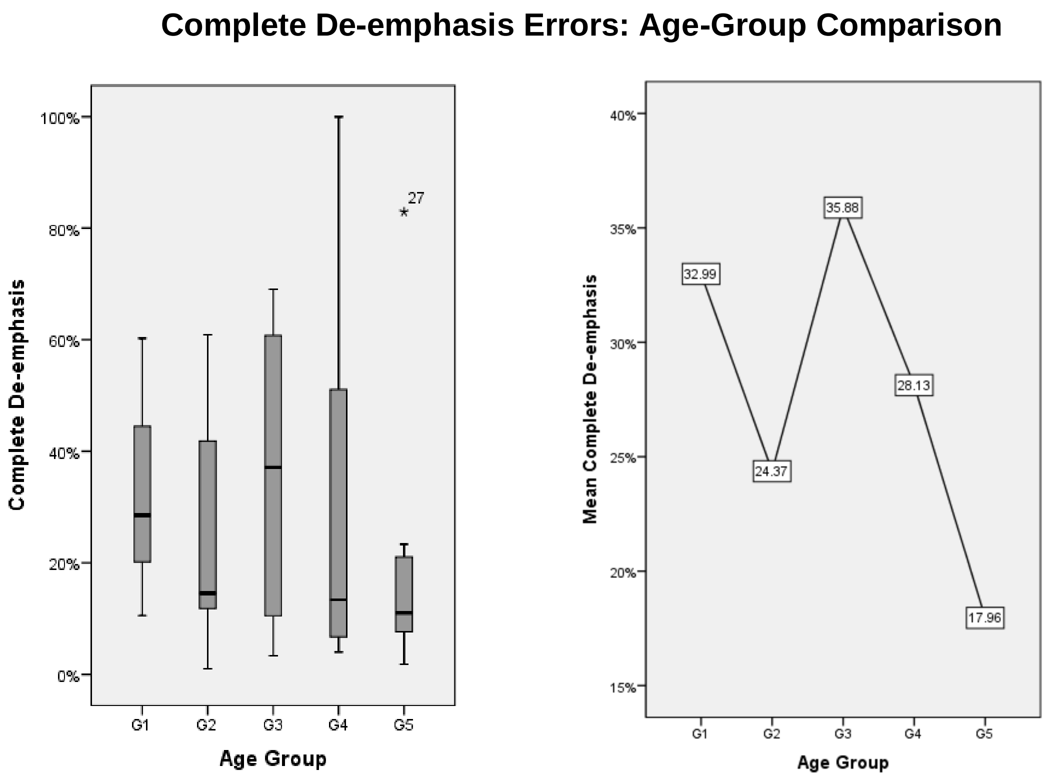


Figure 6.31. Complete de-emphasis errors across all age-groups (speech tasks combined).

Table 6.52 provides descriptive statistics: Mean and standard deviation values for the occurrence of complete de-emphasis in each age-group as a whole and again between female and male participants. Although the Group-1 mean and standard deviation in both genders are very similar, the difference is more evident in other age-groups. Figure 6.32 exhibits the greater variation and individual differences amongst the female participants when compared to their male peers. At the same time, male participants in Groups 2, 3, 4 and 5 notably produce fewer complete de-emphasis errors when compared to their female peers within the same age groups.

Table 6.52.

The Percentage of Complete De-Emphasis Errors- All Speech Tasks – Gender Comparison.

	Females		**Males**		**All Participants**	
AG	*Mean* (%)	Standard Deviation	*Mean* (%)	Standard Deviation	*Mean* (%)	Standard Deviation
G1	30.36	18.22	35.61	16.30	32.99	16.71
G2	31.25	24.07	17.49	14.47	24.37	20.25
G3	46.83	24.24	24.94	24.16	35.88	25.75
G4	46.26	36.23	10.00	4.35	28.13	31.04
G5	24.36	29.06	11.56	9.05	17.96	21.58

Key: AG= Age group

Complete De-emphasis Errors: Gender Comparison

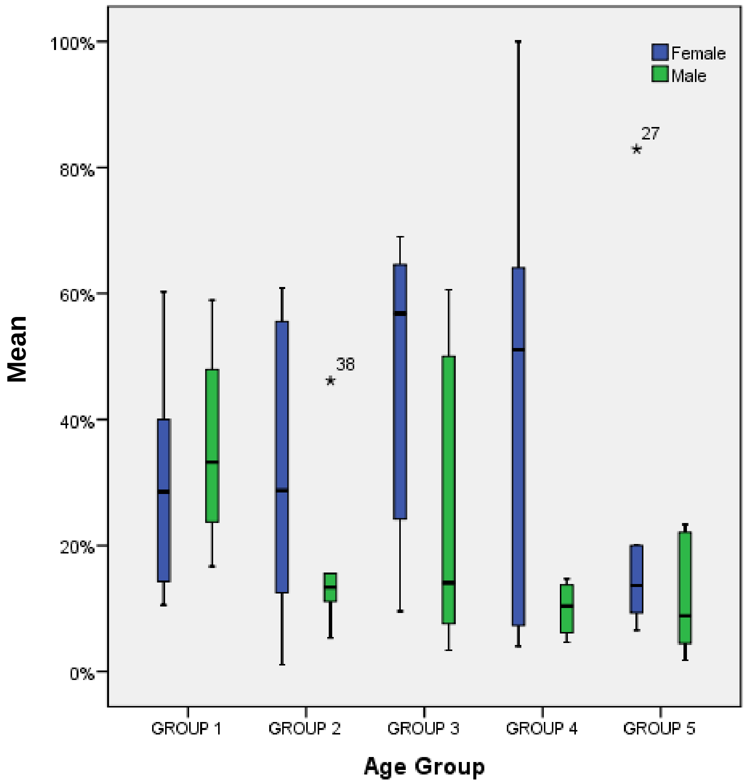


Figure 6.32. The percentage of complete de-emphasis errors across all speech tasks: gender comparison.

The complete de-emphasis data was not normally distributed in 4 age-groups therefore it was converted using LOG arithmetic function to successfully obtain normative distribution before a 2x5x1 Two-Way ANOVA was completed with two between-subjects factors: gender with two levels (female; male) and age-group with five levels. The dependent variable was the proportion of complete de-emphasis errors (see appendix-BG for details). The analysis revealed that the main effect of the participant's Age-Group was not significant ($F(4, 50) = 1.805$, $p = .143$, partial $\eta^2 = .126$). In contrast, the main effect of Gender was significant ($F(1, 50) = 4.953$, $p = .031$, partial $\eta^2 = .090$) however with a low observed power = .588. Finally, the Age-Group by Gender interaction was not significant ($F(4, 50) = .978$, $p = .428$, partial $\eta^2 = .073$).

Furthermore, the effect of speech task on the occurrence of complete de-emphasis errors was also investigated. Table 6.53 and Figure 6.33 provide descriptive statistics: Mean and standard deviation values for the occurrence of complete de-emphasis in both speech samples: PN and SPON.

Table 6.53.

The Percentage of Complete De-Emphasis Errors in Two Speech Tasks.

	PN De-Emphasis Errors		**SPON De-Emphasis Errors**	
Age Group	Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	35.92	20.47	28.39	18.13
G2	19.71	17.48	22.79	20.06
G3	27.30	18.99	36.36	27.53
G4	33.33	31.73	24.07	30.26
G5	17.39	21.57	17.31	22.11

Key: PN= Picture Naming, SPON= Spontaneous.

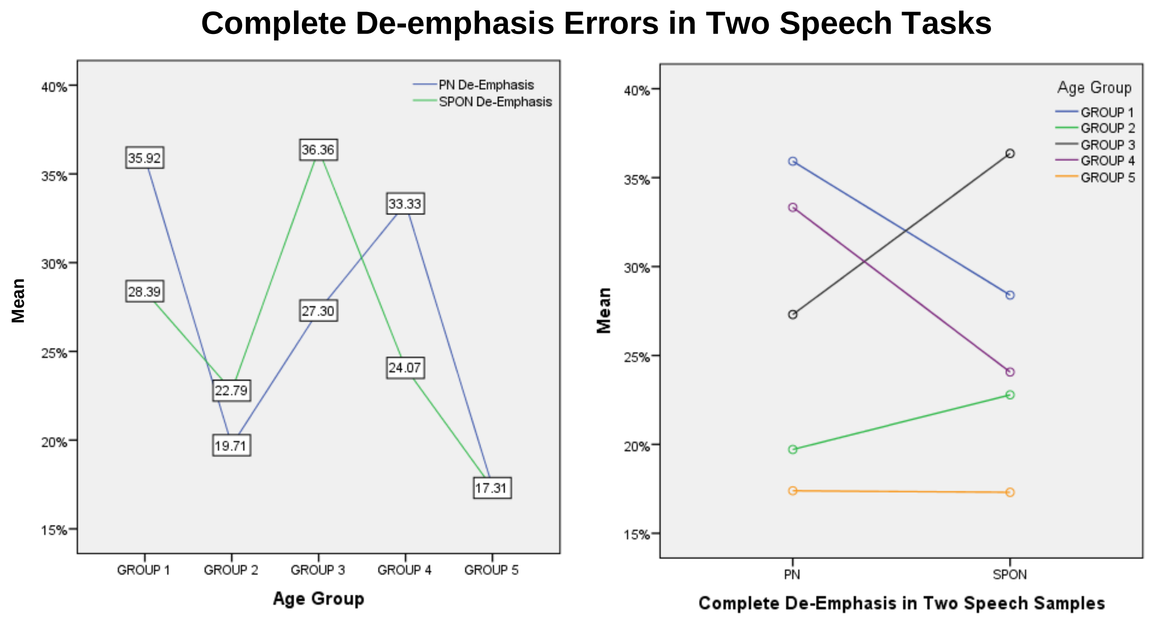


Figure 6.33. The percentage of complete de-emphasis errors in two speech tasks: as a function of age group (left) and speech samples (right). Key: PN= Picture Naming, SPON= Spontaneous.

The complete de-emphasis data is normally distributed in some but not all age-groups in either speech task. Consequently, PN and SPON de-emphasis data was successfully converted using square root arithmetic function to establish a normal distribution in all age groups (see Appendix-BH for more details). As a result, a 2x5x2 Mixed ANOVA was applied with two between-subjects factors: gender with two levels (female; male) and age-group with five levels and a single within-subjects factor being speech task with two levels: picture naming (PN); spontaneous (SPON). The dependant variable was proportion of complete de-emphasis errors. Mauchly's Test of Sphericity was significant: $p < .001$ and Levene's Test of Equality of Error Variances was insignificant in both speech samples (see Appendix-BI a. and b. for more details). Therefore, the Greenhouse-Geisser correction was applied to the degrees of freedom and the main effect of Speech-Task was found not significant, i.e. at different age groups, the means of PN-de-emphasis and SPON-de-emphasis are not significantly different: $F(1, 50) = .096$, $p = .758$, partial $\eta^2 = .002$. Moreover, the speech-task by age-group interaction was not significant: $F(4, 50) = 1.774$, $p = .149$, partial $\eta^2 = .124$. Also, the speech-task by gender interaction was not significant: $F(1, 50) = .278$, $p = .600$, partial $\eta^2 = .006$. Similarly, the three-way interaction between speech-task, age-group, and gender was not significant: $F(4, 50) = 1.108$, $p = .363$, partial $\eta^2 = .081$.

Additionally, the Test of Between-Subjects Effect showed that the effect of Age-Group was not significant: $F(4, 50) = 1.610$, $p = .186$, partial $\eta^2 = .114$. However, the effect of the Gender was significant: $F(1, 50) = 5.649$, $p = .021$, partial $\eta^2 = .102$ with low observed power = .645 (Table 6.54 and Figure 6.34 below). Finally, the Age-Group by Gender interaction was not significant $F(4, 50) = 1.452$, $p = .231$, partial $\eta^2 = .104$.

Table 6.54.

The Occurrence of Complete De-Emphasis Errors in Two Speech Tasks: Gender Comparison

		PN Complete De-Emphasis Errors		**SPON Complete De-Emphasis Errors**	
Age Group	**Gender**	Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	Females	30.04	20.96	26.33	18.11
	Males	41.80	19.99	30.46	19.63
G2	Females	23.33	22.51	27.31	22.95
	Males	16.09	11.57	18.27	17.61
G3	Females	28.03	9.63	49.89	27.89
	Males	26.57	26.45	22.83	21.21
G4	Females	52.73	35.48	39.52	37.18
	Males	13.94	7.34	8.62	7.67
G5	Females	27.53	26.63	23.02	29.08
	Males	7.25	8.24	11.59	12.29

Key: PN= Picture Naming, SPON= Spontaneous.

Complete De-emphasis Errors: Age-Group, Speech Task, and Gender

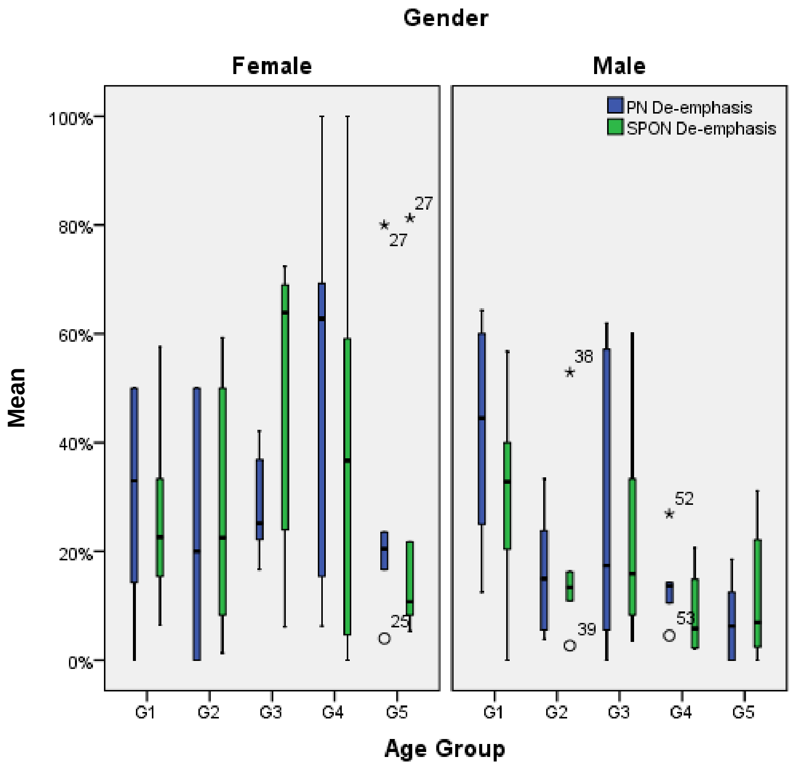


Figure 6.34. The occurrence of complete de-emphasis errors in two speech tasks: gender comparison. Key: PN= Picture Naming, SPON= Spontaneous.

Moreover, the effect of syllable/word position on the occurrence of complete de-emphasis errors was also investigated. Because the speech task was found not to be significant in the sections above, the data from both speech tasks was combined in this analysis. The positional complete de-emphasis data is normally distributed in some but not all age-groups (see Appendix-BJ). Consequently, data were transformed using multiple arithmetic functions with no success in achieving normal distribution in all age groups and all syllable/word positions. As a result, Friedman test was completed to statistically compare the occurrence of complete de-emphasis errors in different syllable/word positions. The test was run on each group separately and again with all age groups combined (Table 6.55). When age groups were collapsed, the results suggest that syllable/word positions does affect the occurrence of complete de-emphasis errors: $\chi^2(3, N = 52) = 20.367$, $p < .001$ with highest mean rank in SFWF position = 3.13. Similarly, the effect syllable/word position can be seen only in the youngest participants (i.e. Group-1): $\chi^2(3, N = 8) = 9.304$, $p < .026$ however with highest mean rank in SIWW position = 2.63. In older age-groups, i.e. Groups 2, 3, 4 and 5, *p* value is insignificant yet complete de-emphasis in SFWF position consistently has the highest mean rank (Figure 6.35).

Table 6.55.

Positional Complete De-emphasis Errors: Mean Rank, N, Chi-Squ, df, and p Value for Friedman Test

	G1	G2	G3	G4	G5	All Groups
			Mean Rank			
SIWI	1.44	1.94	2.46	2.41	1.79	2.05
SIWW	2.63	2.89	2.46	2.32	2.25	2.48
SFWW	2.56	1.94	2.00	2.23	2.96	2.35
SFWF	2.38	3.22	3.08	3.05	3.00	3.13
			Friedman Test			
N	8	9	12	11	12	52
Chi-Square	9.304	7.207	4.794	2.830	7.763	20.367
df	3	3	3	3	3	3
***p* value**	.026*	.066	.187	.419	.051	.000**

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

To compare the difference in positional complete De-emphasis errors at word boundaries (SIWI vs. SFWF), in onset positions (SIWI vs. SIWW), in medial positions (SIWW vs. SFWW), and in coda positions (SFWW vs. SFWF) a series of Wilcoxon Singed Rank Tests were completed. Since each dependent variable is only tested twice, the Bonferroni corrected/adjusted *p* value was calculated using the following equation:

$$\alpha = \frac{.05}{2} = .025$$

Accordingly, the test results were compared to the new and adjusted *p* value α = .025 as the higher boundary for significance. The results suggest that there are significant differences in the occurrence of complete De-emphasis between consonants at: word boundaries; i.e. SIWI and SFWF (z = -3.846[a], N = 46, p <

.001), in onset positions; i.e. SIWI and SIWW (z = -2.484[a], N = 54, p = .013), and in coda positions; i.e. SFWW and SFWF (z =-3.217[a], N = 47, p = .001) where z [a] values based on negative ranks. In contrast, there was no significant difference in the occurrence of complete De-emphasis errors of consonants in word-medial positions, i.e. SIWW and SFWW (z = -1.296[b], N = 54, p = .195) where z [b] value is based on positive ranks. As a result, it can be concluded that consonants in SFWF position incur more complete De-emphasis errors than those in SIWI positions. Similarly, consonants in SIWW position incur more complete De-emphasis errors than those in SIWI position. Also, consonants in SFWF position incur more complete De-emphasis errors than those in SFWW position (Figure 6.35). However, medial consonants in SIWW and SFWW appear to incur the same level of De-emphasis errors (see Appendix-BK for more detail).

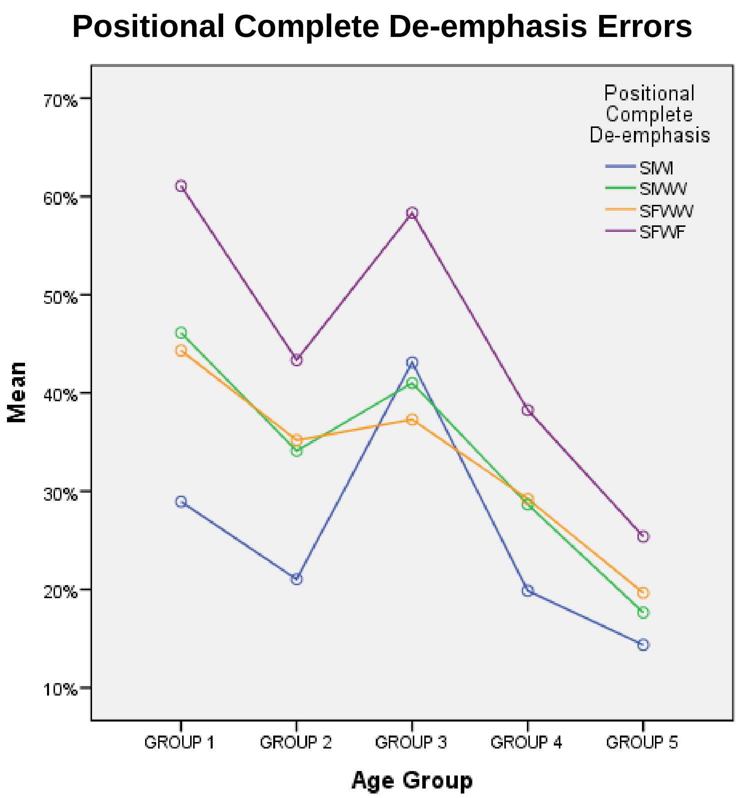


Figure 6.35. The occurrence of positional complete de-emphasis errors: age-group comparison. Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

Finally, the association between the token frequency of emphatic consonants and the occurrence of positional complete de-emphasis errors was investigated. Table 6.56 and Figure 6.36 provide age-group and positional differences in the occurrence of positional complete de-emphasis of all emphatic consonants combined.

Table 6.56.

Positional Differences in Emphatic Consonants Raw Count and the Occurrence of Complete De-emphasis Errors: Age Group Comparison.

	SIWI		SIWW		SFWW		SFWF	
AG	TRC	DE (%)	TRC	DE (%)	TRC	DE (%)	TRC	DE (%)
G1	78	29.48	188	47.87	106	40.56	30	70
G2	134	30.59	231	51.51	154	51.29	56	73.21
G3	145	20.00	298	31.20	173	31.79	63	41.26
G4	161	14.28	257	21.01	209	17.22	92	20.65
G5	168	13.69	376	10.10	263	16.34	91	15.38

Key: AG= Age Group, TRC= Target Raw Count, DE (%) = Percentage of de-emphasis errors in IPA actual

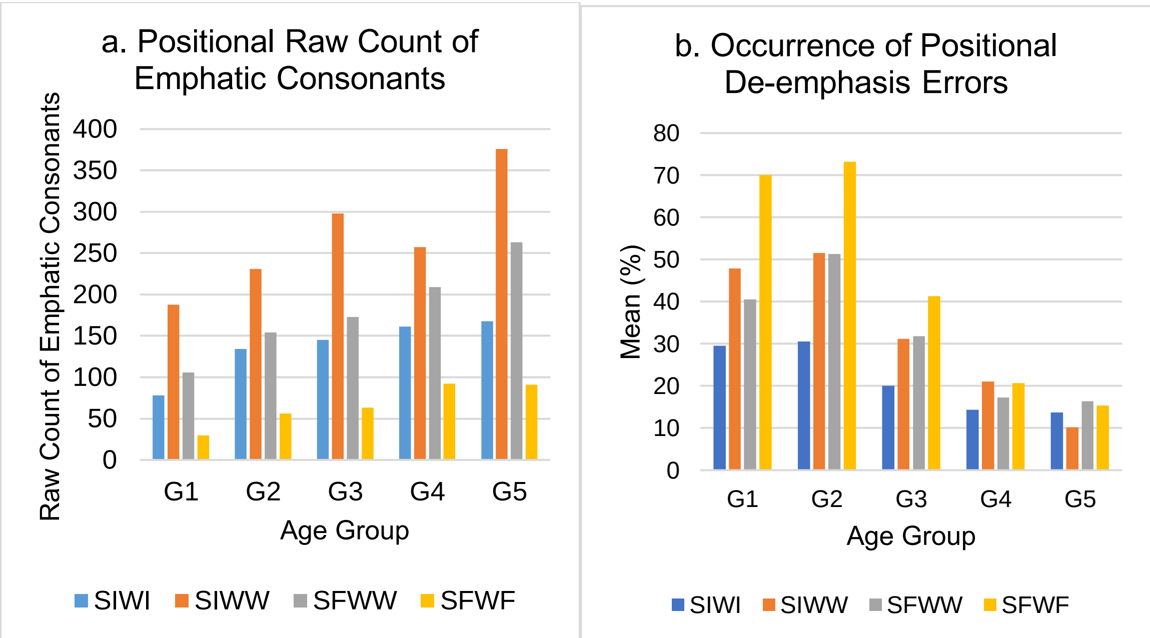


Figure 6.36. The positional frequency of emphatic consonants and de-emphasis errors: a. Emphatic consonants' positional raw count, b. the occurrence of positional complete de-emphasis. Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

However, in Figure 6.30 it was obvious that the emphatic consonants vary significantly in their positional token frequency. Therefore, it was necessary to split emphatic consonants in two groups:

- *Highly-Frequent Emphatic Consonants*: Emphatic consonants with high token frequency and occurring in all syllable/word positions: /tˤ/ and /sˤ/ together compromising a little over 84% of the overall the token frequency of emphatic consonants in the copra.
- *Less-Frequent Emphatic Consonants*: Emphatic consonants with low token frequency: /dˤ/ and /ðˤ/, or emphatics that limited in specific syllable/word positions: /lˤ/.

Most of the data of highly and less frequent emphatic consonants is not normally distributed (Appendix-BL a. and b.). As a result, Spearman's rho correlation test was completed for highly and less frequent emphatics in all four syllable/word positions (Table 6.57).

Table 6.57.

Correlation between IPA Target Raw Count and the Occurrence of Positional Complete De-emphasis Errors in IPA Actual.

	Highly Frequent Emphatic Consonants: /tˤ/ and /sˤ/			**Less Frequent Emphatic Consonants: /dˤ/, /ðˤ/ and /lˤ/**		
	r	Sig. (1-tailed)	*N*	*r*	Sig. (1-tailed)	*N*
SIWI	-.234	.036*	60	-.001	.498	14
SIWW	-.304	.009**	60	-.160	.124	54
SFWW	-.119	.188	57	.166	.141	44
SFWF	-.255	.034*	52	-.143	.247	25

*. Correlation is significant at the 0.05 level (1-tailed)
**. Correlation is significant at the 0.01 level (1-tailed)
Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final

From the table above, it is apparent that highly-frequent emphatic consonants have a moderate negative correlation between its positional raw count in IPA target and the occurrence of complete de-emphasis errors in SIWI, SIWW and SFWF positions (Figures 6.37, 6.38 and 6.39) but no correlation was found in SFWW position. Furthermore, there was no correlation between IPA-target positional raw count and the occurrence of complete de-emphasis errors in the less-frequent emphatic consonants in any syllable/word positions.

IPA Target Raw Count and De-emphasis Errors in IPA Actual of SIWI /tˤ/ and /sˤ/

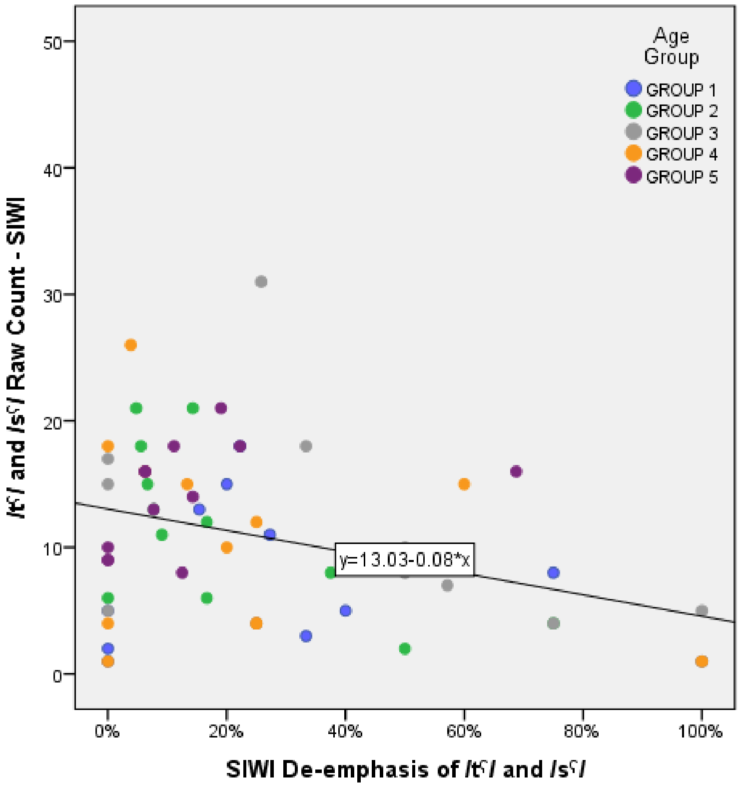


Figure 6.37. Correlation between SIWI IPA-target raw count and SIWI complete de-emphasis of /tˤ/ and /sˤ/ Key: SIWI= Syllable-Initial Word-Initial.

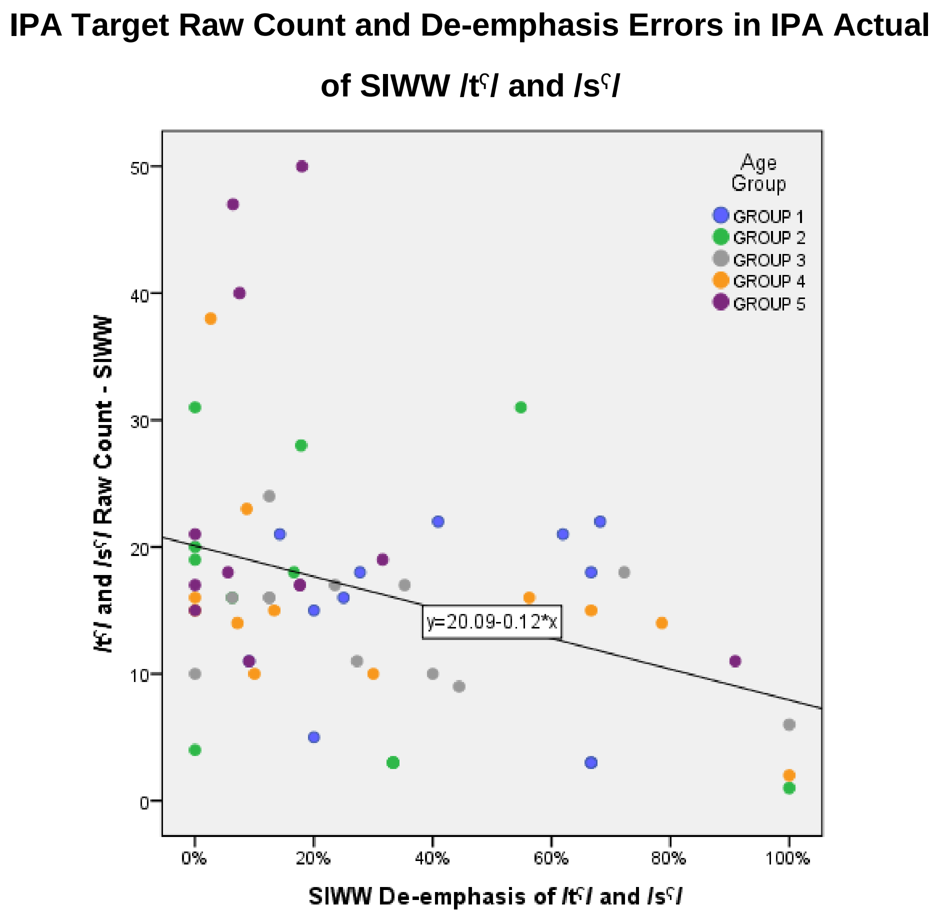


Figure 6.38. Correlation between SIWW IPA-target raw count and SIWW complete de-emphasis of /tˤ/ and /sˤ/. Key: SIWW= Syllable-Initial Within-Word.

IPA Target Raw Count and De-emphasis Errors in IPA Actual of SFWF /tˤ/ and /sˤ/

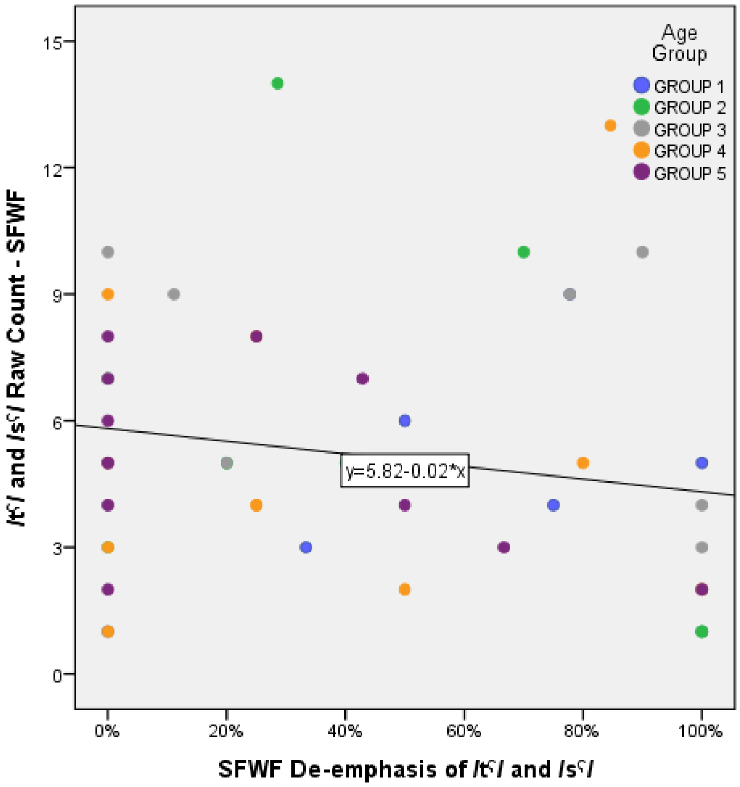


Figure 6.39. Correlation between SFWF IPA-target raw count and SFWF complete de-emphasis of /tˤ/ and /sˤ/. Key: SFWF= Syllable-Final Word-Final.

In summary, Najdi Arabic has five emphatic consonants: /tˤ/, /sˤ/, /lˤ/, /ðˤ/, and /dˤ/. In the current study, only complete de-emphasis errors underwent detailed statistical analysis. Even though the data was not normally distributed, parametric analysis was possible after data conversion. As a result, the speech-task and the age group were found to have no significant effects on the occurrence of de-emphasis errors. In contrast, the gender of the participants was found to have a significant effect with moderate effect size and insufficient power <.8 on de-emphasis errors in favour of the males. The moderate effect size indicates that the gender of the participant of a randomly selected data point might be predicted solely based on its de-emphasis error rate. Nonetheless, the low observed power of the test indicates that there is only a 58% chance that the difference in de-emphasis errors between the two genders is true. In other words, in the current study emphatic consonants were more challenging for the female participants. Similarly, syllable/word position also had a significant effect on the occurrence of de-emphasis errors but only in Group-1 and in all the participants when age groups were combined. Further analysis revealed that the occurrence of de-emphasis errors favoured consonants at different syllable/word positions in the following order: SFWF>SFWW=SIWW>SIWI. Finally, correlation analysis revealed that only highly-frequent emphatic consonants: /tˤ/ and /sˤ/ have a moderate negative correlation between its positional raw count in IPA target and the occurrence of complete de-emphasis errors in three syllable/word positions: SIWI, SIWW, and SFWF but not in SFWW position.

6.6. Deletion Errors:

In the current study, deletion is defined as the absence of an element in IPA Target from the IPA Actual. This element can either be a syllable, a consonant, or a vowel. For the purpose of this study, only syllable and consonant deletions will be reported in two main sections: Singleton Consonant Deletion (SCD from here after) and Weak Syllable Deletion (WSD from here after).

6.6.1 Singleton Consonant Deletion:

In this section, the results of SCD are presented. Consonants deleted in any word syllable/word position are included in this analysis. For example, /ˈda.ɾad͡ʒ/ "stairs" → [ˈda.ɾa] the absolute coda was deleted and in /ˌɣas.ˈsaː.lə/ 'washing machine' → [ˌɣa.ˈsaː.lə] the medial coda was deleted which may also be considered as shortening of a geminate rather than a deletion. However, Phon software considers any absence of an IPA symbol as a deletion (explained in detail in the methodology chapter figure 4.6) and therefore such deletions were included in this analysis. As a continuation of the previous methods, the results of non-positional followed by positional SCD are presented. Table 6.58 below provides descriptive statistics: Mean and standard deviation values for the occurrence of SCD in both speech samples: PN and SPON. It appears that all participants produce more SCD errors in the PN sample than in SPON sample mostly obvious in the youngest age-group: Group-1 (Figure 6.40).

Table 6.58.

The Percentage of Singleton Consonant Deletion Errors in Two Speech Tasks.

Age Group	PN SCD Errors		SPON SCD Errors	
	Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	6.78	5.57	2.44	1.54
G2	3.43	1.49	2.93	1.30
G3	2.84	1.44	2.30	1.02
G4	1.73	1.23	1.66	.71
G5	2.11	1.22	1.83	.72

Key: SCD= Singleton Consonant Deletion, PN= Picture Naming, SPON= Spontaneous.

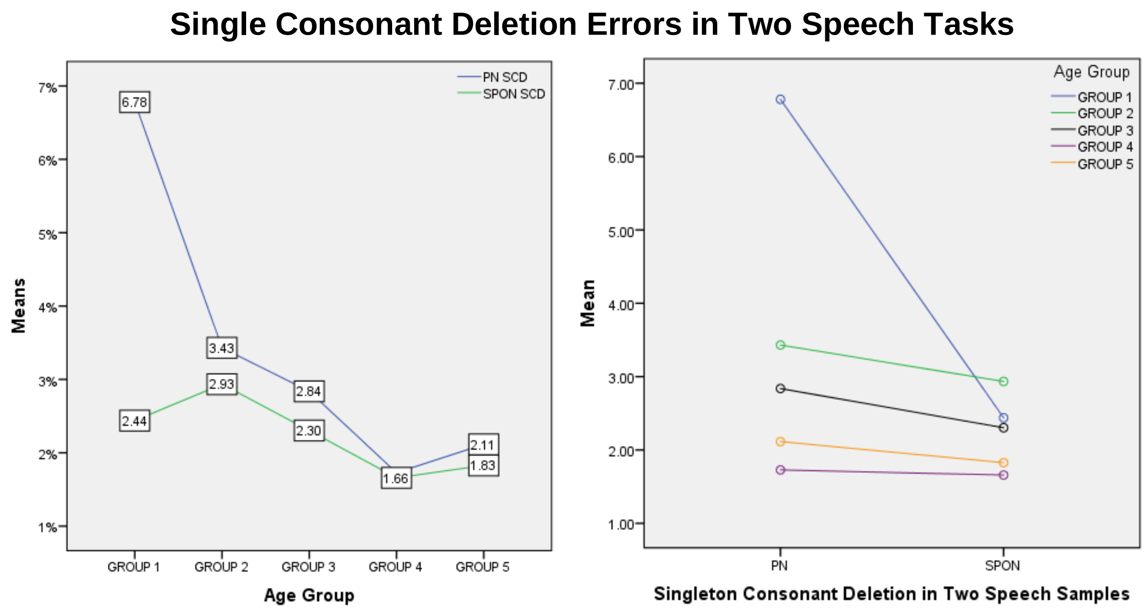


Figure 6.40. The percentage of singleton consonant deletion errors in two speech tasks: as a function of age group (left) and speech task (right). Key: SCD= Singleton Consonant Deletion, PN= Picture Naming, SPON= Spontaneous.

Also, by comparing the mean values across gender, there appears to be minor gender differences in SCD errors in both speech tasks. However, in PN sample, males in Group-1 have double the SD value when compared to their female peers suggesting greater individual differences amongst the young male participants (Table 6.59 and Figure 6.41).

Table 6.59.

The Occurrence of Singleton Consonant Deletion Errors in Two Speech Tasks: Gender Comparison.

		PN SCD		SPON SCD	
Age Group	**Gender**	Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	Females	6.69	3.53	2.72	1.15
	Males	6.87	7.46	2.15	1.93
G2	Females	3.41	1.72	2.37	1.06
	Males	3.45	1.38	3.50	1.36
G3	Females	2.91	1.91	1.97	1.07
	Males	2.76	.95	2.64	.94
G4	Females	1.20	.84	1.36	.77
	Males	2.26	1.39	1.95	.56
G5	Females	1.49	.65	1.80	.96
	Males	2.73	1.39	1.86	.47

Key: SCD= Singleton Consonant Deletion, PN= Picture Naming, SPON= Spontaneous.

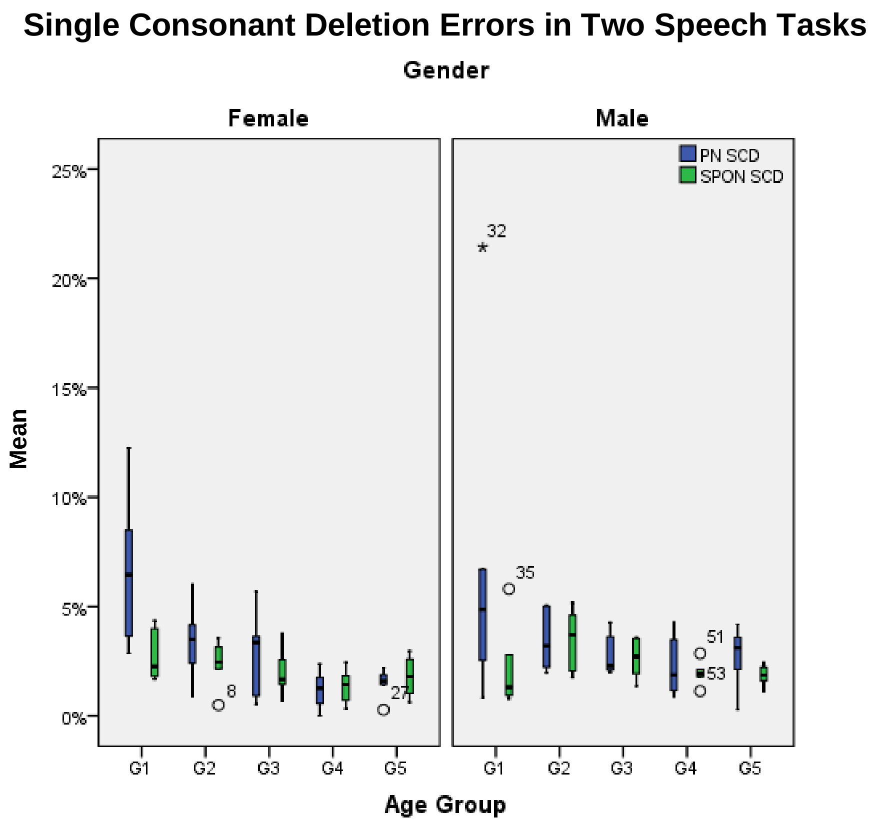


Figure 6.41. The occurrence of Singleton Consonant Deletion errors in two speech tasks: gender comparison. Key: SCD= Singleton Consonant Deletion, PN= Picture Naming, SPON= Spontaneous.

The SCD data is mostly normally distributed except Group-1 in PN sample (see Appendix-BM for more details). As a result, a 2x5x2 Mixed ANOVA was applied with two between-subjects factors: gender with two levels (female; male) and age-group with five levels, and a single within-subjects factor being speech task with two levels: picture naming (PN); spontaneous (SPON). The dependant variable was the proportion of SCD errors. Mauchly's Test of Sphericity was significant: $p < .001$ (see Appendix-BN), therefore the Greenhouse-Geisser correction was applied to the degrees of freedom and a significant main effect of Speech-Task was found, i.e. at different age groups, the means of PN-SCD and SPON-SCD are significantly different: $F(1, 50) = 8.991$, $p = .004$, partial $\eta^2 = .152$. Moreover, the speech-task by age-group interaction was also significant: $F(4, 50) = 4.418$, $p = .004$, partial $\eta^2 = .261$. However, the speech-task by gender interaction was not significant: $F(1, 50) = .016$, $p = .900$, partial $\eta^2 = .000$. Similarly, the three-way interaction between speech-task, age-group, and gender was not significant: $F(4, 50) = .342$, $p = .848$, partial $\eta^2 = .027$.

Additionally, the Test of Between-Subjects effect showed that the effect of Age-Group was significant: $F(4, 50) = 6.359$, $p < .000$, partial $\eta^2 = .337$. However, the effect of the Gender of was not significant: $F(1, 50) = 1.062$, $p = .308$, partial $\eta^2 = .021$ and the Age-Group by Gender interaction was not significant $F(4, 50) = .190$, $p = .943$, partial $\eta^2 = .015$. Finally, a Tukey Post Hoc test was applied to compare SCD means between age-groups. Significant differences were found between Group-1 and Groups 3, 4 and 5. No significant difference was found between any other age-groups (Table 6.60).

Table 6.60.

Singleton Consonant Deletion Errors Post Hoc Test between Age-Groups.

AG	G1		G2		G3		G4		G5	
	MD	SEM	MD	SEM	MD	SEM	MD	SEM	MD	SEM
G1	NA		-1.42	.65	-2.03*	.65	-2.91**	.65	-2.63**	.65
G2	1.42	.65	NA		-6.21	.65	-1.48	.65	-1.21	.65
G3	2.03*	.65	.61	.65	NA		-.87	.65	-.59	.65
G4	2.91**	.65	1.48	.65	.87	.65	NA		.27	.65
G5	2.63**	.65	1.21	.65	.59	.65	-.27	.65	NA	

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: AG= Age Group, MD = Mean Difference, SEM = Standard Error of the Mean, NA = Not Applicable

Next, positional SCD was compared in two speech samples: PN vs. SPON. Table 6.61 and Figures 6.42 compare the occurrence of SCD errors in each syllable/word position in PN and SPON samples. As apparent in the figure below, singletons consonants in coda position are more likely to be deleted than singleton consonants in onset positions in general. Moreover, singleton consonants in medial coda position, i.e. SFWW in PN sample are the most deleted with range of 5-16%. In comparison, singleton consonants in absolute onset position, i.e. SIWI are least deleted (1.3% or less in all age groups). The results of positional SCD errors showing that coda consonants are far more likely to be deleted than consonants in onset position are in line with the UG suggesting that CV syllable shape is universally unmarked whilst coda consonants are more challenging.

Table 6.61.

Positional Differences in the Occurrence of Singleton Consonant Deletion Errors in Two Speech Tasks.

	Mean of Singleton Consonant Deletion Errors (%)							
S/WP	**SIWI**		**SIWW**		**SFWW**		**SFWF**	
ST	PN	SPON	PN	SPON	PN	SPON	PN	SPON
G1	1.30	0.75	3.21	0.80	13.79	10.71	14.00	4.63
G2	0.22	0.57	2.11	1.01	10.77	15.56	3.87	5.95
G3	0.34	0.84	1.68	0.63	8.01	7.82	3.80	5.12
G4	0.18	0.23	1.17	0.55	4.77	5.43	1.97	4.09
G5	0.32	0.30	1.14	0.52	4.98	4.73	3.83	5.07

Key: S/WP= Syllable/Word Position, ST= Speech Task, SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, PN= Picture Naming, SPON= Spontaneous.

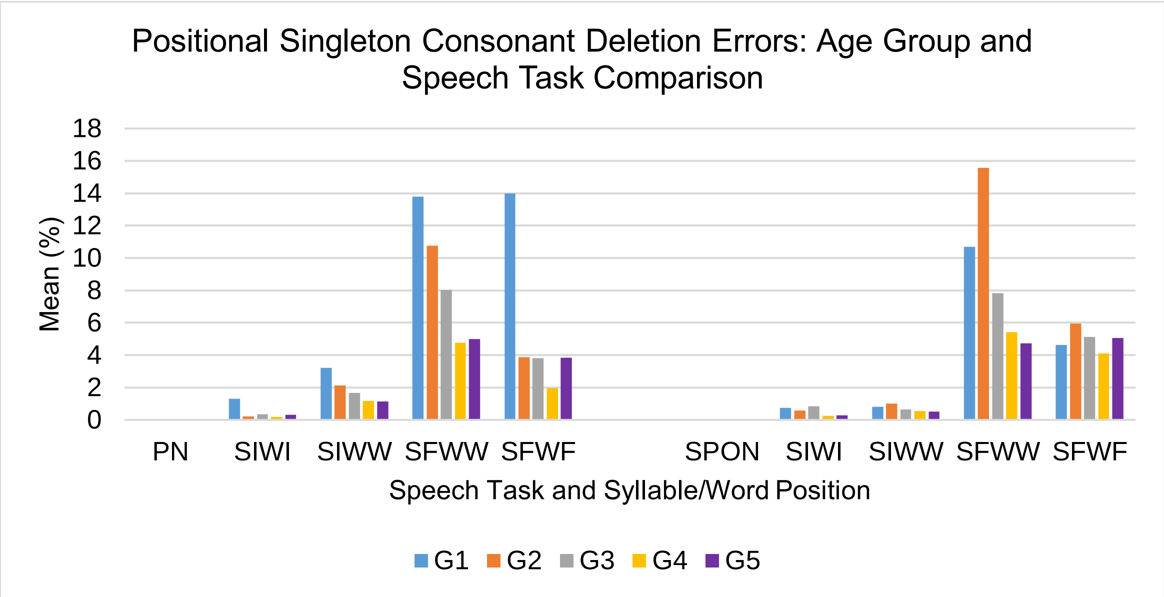


Figure 6.42. Positional differences in singleton consonant deletion errors: Age Group and Speech Task comparison. Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, PN= Picture Naming, SPON= Spontaneous.

The positional SCD data is not normally distributed in all age groups and syllable/word positions therefore, the data was successfully transformed using LOG arithmetic function to obtain normal distribution in all age-groups and syllable/word positions (see Appendix-BO for more details). As a result, a Two-

Way Mixed ANOVA of Within-Subjects Contrasts was completed. Both Mauchly's Test of Sphericity and Levene's Test of Equality of Error Variances were not significant: p >.05 (see Appendix-BP for details). The results showed that the main effect of Syllable/word position is significant, i.e. the means of SIWI-SCD, SIWW-SCD, SFWW-SCD and SFWF-SCD are significantly different: $F(3,69) = 170.591$, $p < .001$, partial $\eta^2 = .881$. Moreover, the syllable/word position by age-group interaction was also significant: $F(12, 69) = 1.328$, $p = .223$, partial $\eta^2 = .188$. However, the syllable/word position by gender interaction was not significant: $F(3,69) = 1.403$, $p = .249$, partial $\eta^2 = .057$ and the three-way interaction between syllable/word position, age-group, and gender also was not significant either: $F(3, 69) = .645$, $p = .797$, partial $\eta^2 = .101$.

Moreover, the Test of Between-Subjects effect showed that the effect of Age-Group was significant: $F(4, 23) = 4.812$, $p = .006$, partial $\eta^2 = .456$. However, the effect of the Gender of was not significant: $F(1, 23) = 3.439$, $p = .077$, partial $\eta^2 = .130$. Similarly, the Age-Group by Gender interaction was not significant $F(4, 23) = .320$, $p = .861$, partial $\eta^2 = .053$.

Finally, the deletion of singleton consonants was then compared between the two onset positions, the two medial positions, and the two coda positions. The results show that there is no difference in the occurrence of SCD between the two onset positions: SIWI and SIWW $F(1, 23) = 2.673$, $p = .116$, partial $\eta^2 = .104$. However, there was a significant difference between SCD in the two medial positions: SIWW and SFWW $F(1, 23) = 256.329$, $p < .001$, partial $\eta^2 = .918$. Similarly, there was a significant difference between SCD in the two coda positions: SFWW and SFWF $F(1, 23) = 12.166$, $p = .002$, partial $\eta^2 = .346$. Finally, the interactions of syllable/word position with Age-group, Gender, and Age-Group*Gender were all not significant except for Syllable/word position*Age-Group interaction between the two coda positions: SFWW and SFWF: $F(4, 23) = 4.079$, $p = .012$, partial $\eta^2 = .415$ (see Appendix-BQ for more details). Consequently, a within-subjects repeated measures ANOVA was completed for each age group comparing the SCD means in SFWW and SFWF. Mauchly's Test of Sphericity was significant: $p < .001$ (see Appendix-BR for more details), therefore the Greenhouse-Geisser correction was applied to the degrees of freedom and it was found that the means of SCD-SFWW and SCD-SFWF are significantly different ($p < .05$) only in Groups 2 and 3 (Table 6.62).

Table 6.62.

*Positional Singleton Consonant Deletion Errors: SFWW vs. SFWF*Age interaction in Each Age-Group Within-Subjects Comparison.*

Age Group	df ST*age -group	df Error(ST*age -group)	F	Sig.	Partial Eta Squared	Observed Power
G1	1	11	4.639	.054	.297	.502
G2	1	11	8.681	.013*	.441	.765
G3	1	11	8.676	.013*	.441	.765
G4	1	11	1.791	.208	.140	.231
G5	1	11	.207	.658	.018	.070

*. The mean difference is significant at the .05 level. Key: ST= Speech task, SFWW = Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final

In summary, SCD errors occurred more in the PN than in the SPON sample with Group1-to-Group-5 range of 6.7-2.1% and 2.4-1.8% consecutively. This difference was confirmed to be significant via parametric statistical analysis. Also, the effect of the age group, but not the gender, was significant with a tendency for the SCD errors to decrease over time. Moreover, the interaction of the speech-task with the age-group was significant. In other words, the mean difference of SCD errors between the two speech tasks is significantly different at different age groups. However, in a post Hoc analysis this difference was only significant between Group-1 and Groups 3, 4 and 5.

Furthermore, syllable/word position had clear significant effect on the occurrence rate of SCD errors. Similarly, the age group of the participants, but not the gender, also had a significant effect on positional SCD with significant interaction too. Multiple statistical analyses were carried out comparing SCD in onset, word-medial, and coda positions. The results showed that there was no difference in SCD errors between the two onset positions: SIWI and SIWW. However, significant difference was detected between consonants in word medial positions: SIWW vs. SFWW and consonants in coda positions: SFWW vs SFWF. In other words, the occurrence of SCD errors favoured consonants at different syllable/word positions in the following order: SFWW>SFWF> SIWW=SIWI. Finally, due to the positive interaction of positional SCD with age group only between coda consonants, the data was further analysed via repeated measures ANOVA to reveal that the means of SCD in SFWW and SFWF are significantly different only in Groups 2 and 3.

6.6.2. Weak Syllable Deletion

Typically, young children delete syllables that are weak or unstressed as a simplification method for producing long and complex multisyllabic words. For example, /ˈqʊb.ba.ʕə/ "hat" → [ˈqʊb.ba] and /tɪl.ˌfɪz.ˈjɔːn/ "television" → [ˌfɪz.ˈjɔːn]. In the current study the percentage of words with WSD is compared across all age groups and speech tasks. Previously in section 5.2.2. the PN sample had a greater ratio of multi-syllables when compared to the SPON sample. Accordingly, it would be logical to expect a higher percentage of WSD in the PN sample. As shown in Figure 6.32, WSD in PN are represented by a sharp negative slope indicating a strong inverse correlation with age. On the other hand, WSD in the SPON sample show smaller and more gradual changes over time which is also inversely correlated with age.

Table 6.63 provides descriptive statistics: Mean and standard deviation values for the occurrence of WSD in both speech tasks: PN and SPON. It appears that all participants produce more WSD errors in the PN sample than in SPON sample (Figure 6.43). The difference between the mean in the two speech tasks diminishes at Group-5 (average age 4;00 years) and yet WSD remains slightly higher in PN sample.

Table 6.63.

The Percentage of Weak Syllable Deletion Errors in Two Speech Tasks.

Age Group	PN WSD Errors		SPON WSD Errors	
	Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	21.12	9.79	9.09	3.68
G2	22.37	16.47	10.64	4.79
G3	12.91	9.46	6.88	2.89
G4	7.28	5.50	4.78	2.02
G5	4.98	4.18	4.59	2.70

Key: WSD= Weak Syllable Deletion, PN= Picture Naming, SPON= Spontaneous.

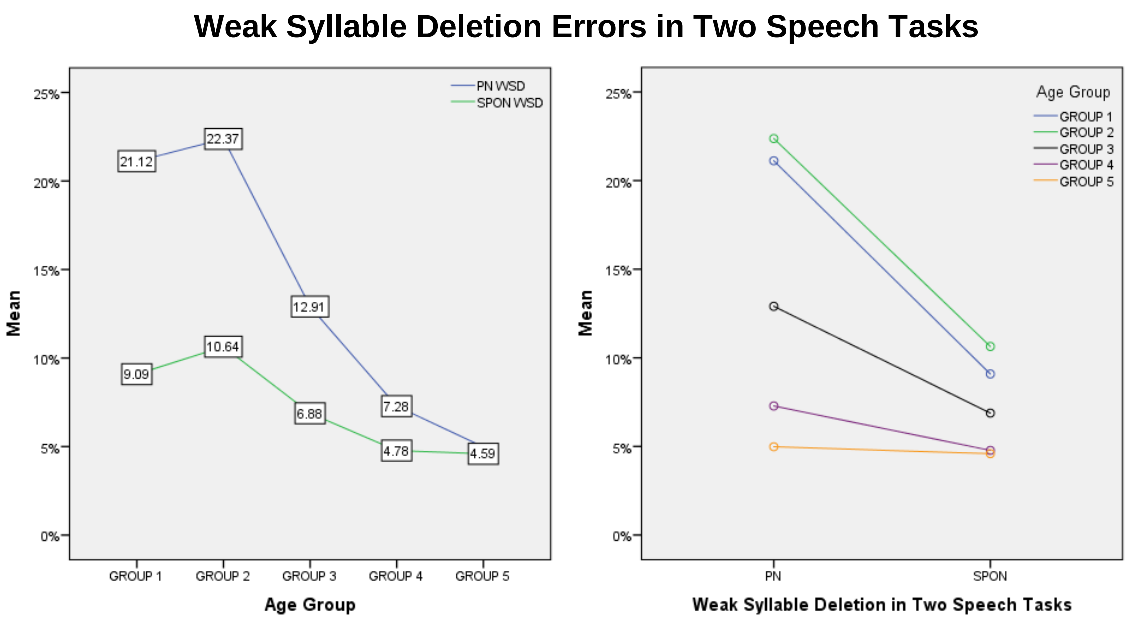


Figure 6.43. The percentage of weak syllable deletion errors in two speech tasks: as a function of age group (left) and speech task (right). Key: WSD= Weak Syllable Deletion PN= Picture Naming, SPON= Spontaneous.

Also, by comparing the mean values across gender, it is notable that females in Group-1 (average age 2;00 years) are producing slightly more WSD errors than their male peers in PN sample only. However, in Group-1 SPON sample and in all other age-groups in both speech tasks (average age 2;06 years and above), male participants are consistently producing more WSD errors than their female peers. Moreover, male participants appear to have a higher SD value than their female peers (except Group 4 in PN sample and Groups 2 and 3 in SPON sample) suggesting greater individual differences amongst the male participants. In general, individual differences between same-gender participants appear to become smaller overtime in both speech tasks (Table 6.64 and Figure 6.44).

Table 6.64.

The Occurrence of Weak Syllable Deletion Errors in Two Speech Tasks: Gender Comparison.

Age Group	**Gender**	**PN WSD**		**SPON WSD**	
		Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	Females	23.09	9.06	8.92	3.85
	Males	19.15	10.93	9.26	3.86
G2	Females	16.30	7.29	9.42	5.45
	Males	28.45	21.33	11.86	4.16
G3	Females	9.66	5.22	6.40	3.10
	Males	16.15	12.01	7.36	2.87
G4	Females	6.29	6.12	4.18	1.73
	Males	8.27	5.17	5.38	2.26
G5	Females	2.43	1.83	3.67	2.02
	Males	7.53	4.41	5.52	3.15

Key: WSD= Weak Syllable Deletion, PN= Picture Naming, SPON= Spontaneous.

Weak Syllable Deletion Errors: Age-Group, Speech Task, and Gender Comparison

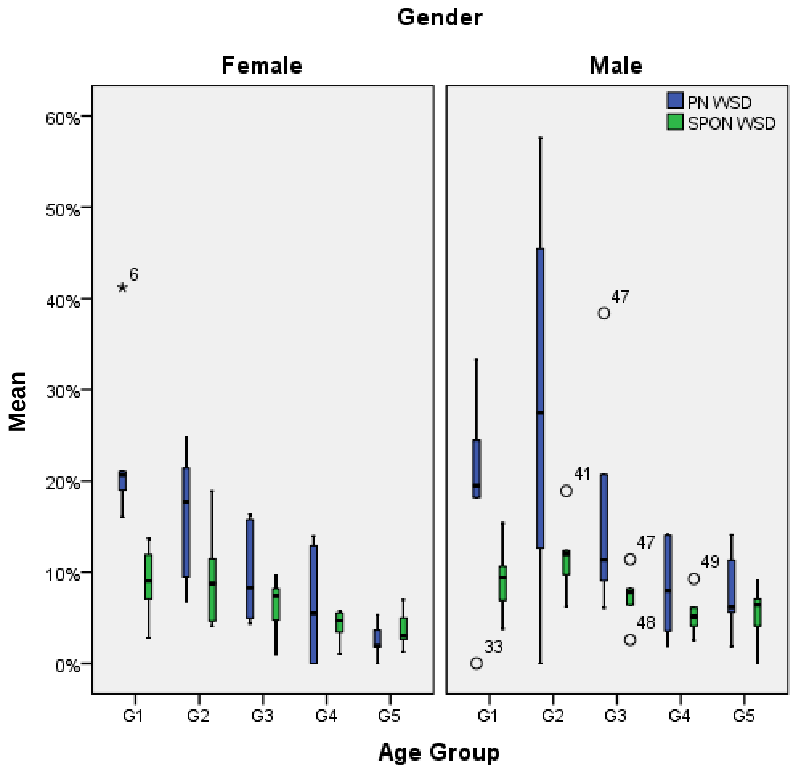


Figure 6.44. The occurrence of Weak syllable deletion errors in two speech tasks: gender comparison. Key: WSD= Weak Syllable Deletion, PN= Picture Naming, SPON= Spontaneous.

The WSD data is mostly normally distributed except Group-3 in PN sample (see Appendix-BS for more details). As a result, a 2x5x2 Mixed ANOVA was applied with two between-subjects factors: gender with two levels (female; male) and age-group with five levels and a single within-subjects factor being speech task with two levels: picture naming (PN); spontaneous (SPON). The dependant variable was the proportion of WSD errors. Mauchly's Test of Sphericity was significant: $p < .001$ (see Appendix-BT-a), therefore the Greenhouse-Geisser correction was applied to the degrees of freedom and consequently a significant main effect of Speech-Task was found, i.e. at different age groups, the means of PN-WSD and SPON-WSD are significantly different: $F(1, 50) = 30.197$, $p < .001$, partial $\eta^2 = .377$. Moreover, the Speech-Task by Age-Group interaction was also significant: $F(4, 50) = 3.938$, $p = .007$, partial $\eta^2 = .240$. However, the Speech-Task by Gender interaction was not significant: $F(1, 50) = 1.593$, $p = .213$, partial $\eta^2 = .031$. Similarly, the three-way interaction between Speech-Task, Age-Group, and Gender was not significant: $F(4, 50) = .968$, $p = .433$, partial $\eta^2 = .072$. Because WSD*Age-Group interaction was significant, a within-subjects repeated measures ANOVA was completed for each age group comparing the means of PN-WSD and SPON-WSD. Mauchly's Test of Sphericity was significant: $p < .001$ (see Appendix-BT-b). Therefore, the Greenhouse-Geisser correction was applied to the degrees of freedom and the means of PN-WSD and SPON-WSD were found to be significantly different ($p < .05$) only in Groups 1, 2, and 3 (Table 6.65). In other words, by the age of 3;06 years, the speech-task has no effect on the occurrence of WSD errors.

Table 6.65.

*Weak-Syllable Deletion: PN vs SPON*Age interaction in Each Age-Group Within-Subjects Comparison.*

Age Group	df ST*age-group	df Error(ST* age-group)	F	Sig.	Partial Eta Squared	Observed Power
G1	1	11	11.240	.002*	.610	.965
G2	1	11	7.437	.020*	.403	.700
G3	1	11	6.587	.026*	.375	.648
G4	1	11	2.945	.114	.211	.347
G5	1	11	.135	.720	.012	.063

*. The mean difference is significant at the .05 level.
Key: ST= Speech Task, PN= Picture Naming, SPON= Spontaneous.

Moreover, the Test of Between-Subjects effect showed that the effect of Age-Group was significant: $F(4, 50) = 10.026$, $p < .001$, partial $\eta^2 = .445$. However, the effect of the Gender of was not significant: $F(1, 50) = 3.709$, $p = .060$, partial $\eta^2 = .069$ and the Age-Group by Gender interaction was not significant either $F(4, 50) = 1.001$, $p = .416$, partial $\eta^2 = .074$. Finally, a Tukey Post Hoc test was applied to make pair-wise comparisons between the groups (Table 6.64). Pairwise comparisons reached significance between Group-1 and Groups 4 and 5 and between Group-2 and Groups 4 and 5 (Table 6.66). No significant difference was found between any other age-groups (see Appendix-BU for more details).

Table 6.66.

Weak Syllable Deletion Errors Post-Hoc Test between Age-Groups.

AG	G1		G2		G3		G4		G5	
	MD	**SEM**	**MD**	**SEM**	**MD**	**SEM**	**MD**	**SEM**	**MD**	**SEM**
G1	NA		1.40	2.34	-5.21	2.34	-9.07*	2.34	-10.31*	2.34
G2	-1.40	2.34	NA		-6.61	2.34	-10.47*	2.34	-11.72*	2.34
G3	5.21	2.34	6.61	2.34	NA		-3.86	2.34	-5.10	2.34
G4	9.07*	2.34	10.47*	2.34	3.86	2.34	NA		1.24	2.34
G5	10.31*	2.34	11.72*	2.34	5.10	2.34	1.24	2.34	NA	

*. The mean difference is significant at the .01 level. Key: AG= Age Group, MD = Mean Difference, SEM = Standard Error of the Mean, NA = Not Applicable

Next, positional WSD is compared in each word position: Initial, Medial, and Final. Earlier in chapter 5, it has been explained that the nature PN task inflated the proportion of multi-syllabic words. As a result, the analysis of positional WSD will only be reported in the SPON sample. Table 6.67 below compares the occurrence of positional WSD errors in the SPON sample. Medial syllables will only occur in words that have three syllables or more. These words are obviously more challenging for young participants than mono and bi-syllabic words. This is clearly reflected in Figure 6.45 where medial syllables are deleted more than 50% of the time in all age groups. Unstressed/weak initial syllables are also deleted in high percentage across all age groups; at least 40% of the time. However, final syllables are least likely to be deleted, as they are rarely unstressed as they often play a vital role in inflectional morphology in Arabic.

Table 6.67.

Positional Difference in the Occurrence of Weak-Syllable Deletion Errors in the SPON sample.

AG	Word Position					
	Initial WSD Errors		**Medial WSD Errors**		**Final WSD Errors**	
	Mean (%)	Standard Deviation	Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	41.04	25.00	52.16	24.15	6.81	7.69
G2	42.66	10.24	52.69	8.99	4.66	6.10
G3	42.33	11.40	54.58	9.50	3.09	3.89
G4	44.20	14.72	52.35	14.01	3.45	4.27
G5	42.44	13.78	52.48	14.92	5.08	6.17

Key: AG= Age Group, WSD= Weak Syllable Deletion.

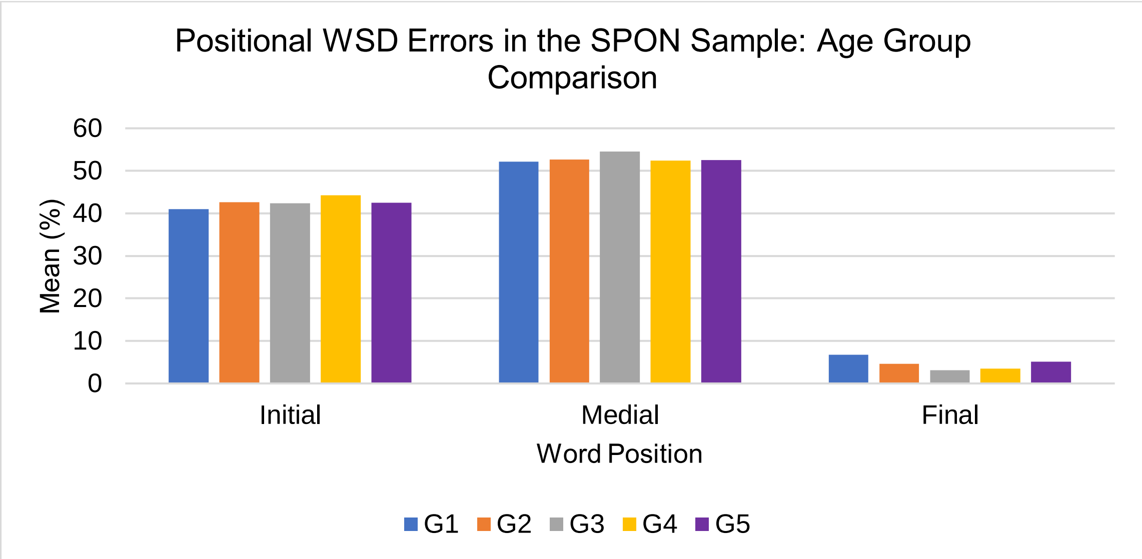


Figure 6.45. Positional differences in weak-syllable deletion errors in the spontaneous sample. Key: WSD= Weak Syllable Deletion, SPON = Spontaneous Sample.

The word-initial WSD data is normally distributed in all age groups, word-medial WSD is normally distributed in 4 age-groups (except for Group-1) and word-final WSD is abnormally distributed in four age-groups (except Group-2), see Appendix-BV for more details. Multiple data transformations have been carried out aiming for a normal distribution in all age-groups in all three word positions, however unsuccessfully. Consequently, non-parametric Friedman Test was completed followed by a series of Wilcoxon Signed Rank tests. However, to obtain more information about DV and IV interactions, a 2x5x3 Mixed ANOVA with two between-subjects factors: gender with two levels (female; male) and age-group with five levels and a single within-subjects factor being word-position with three levels: initial, medial, and final was also applied. The dependant variable was proportion of positional WSD errors.

The Friedman's Test result indicate that WSD confidence varied significantly between the three word positions: initial, medial, and final: $\chi^2(2, N = 59) = 86.606$, $p < .001$ (see Appendix-BW a. and b. for more details). Additionally, multiple Wilcoxon Ranks Tests were completed to compare initial-WSD to WSD in both medial and final positions and also to compare medial-WSD to final-WSD (see Appendix-BW-c. for more details). Since each dependent variable is tested twice, the Bonferroni corrected/adjusted *p* value was calculated using the following equation:

$$\alpha = \frac{.05}{2} = .025$$

The Wilcoxon Singed Rank Test result was significant in all three comparisons. In other words, weak syllables were significantly more likely to be deleted in word-medial position when compared to weak syllables in weak syllables in initial and final word positions. Similarly, weak syllables in word-initial positions were significantly more likely to be deleted than weak syllables in word-final position (Table 6.68).

Table 6.68.

The Difference in Positional WSD Errors: Wilcoxon Signed Rank Test.

	Wilcoxon Signed Ranks Test	
	Z	Sig. (two-Tailed)
Medial WSD – Initial WSD	-2.863[a]	.004*
Final WSD – Medial WSD	-6.673[b]	.000*
Final WSD – Initial WSD	-6.567[b]	.000*

*. The mean rank is significant at the .025 level.
Key: a. Based on negative ranks, b. Based on positive ranks. WSD= Weak-Syllable Deletion.

The Mixed ANOVA analysis gave similar results. Mauchly's Test of Sphericity was significant: $p < .001$ (Appendix-BX) , therefore the Greenhouse-Geisser correction was applied to the degrees of freedom and consequently a significant main effect of word-position was found, i.e. at different age groups, the means of initial-WSD, medial-WSD and final-WSD are significantly different: $F(1.194,58.488) = 135.628$, $p < .001$, partial $\eta^2 = .735$ (Figure 6.46) . However, the positional WSD by Age-Group interaction was not significant: $F(4.775, 58.488) = .095$, $p = .991$, partial $\eta^2 = .008$. Similarly, the positional WSD by Gender interaction was not significant: $F(1.194,58.488) = .181$, $p = .716$, partial $\eta^2 = .004$. Also, the three-way interaction between positional WSD, Age-Group, and Gender was not significant: $F(4.775, 58.488) = .323$, $p = .890$, partial $\eta^2 = .026$.

Positional WSD Errors in the Spontaneous Sample

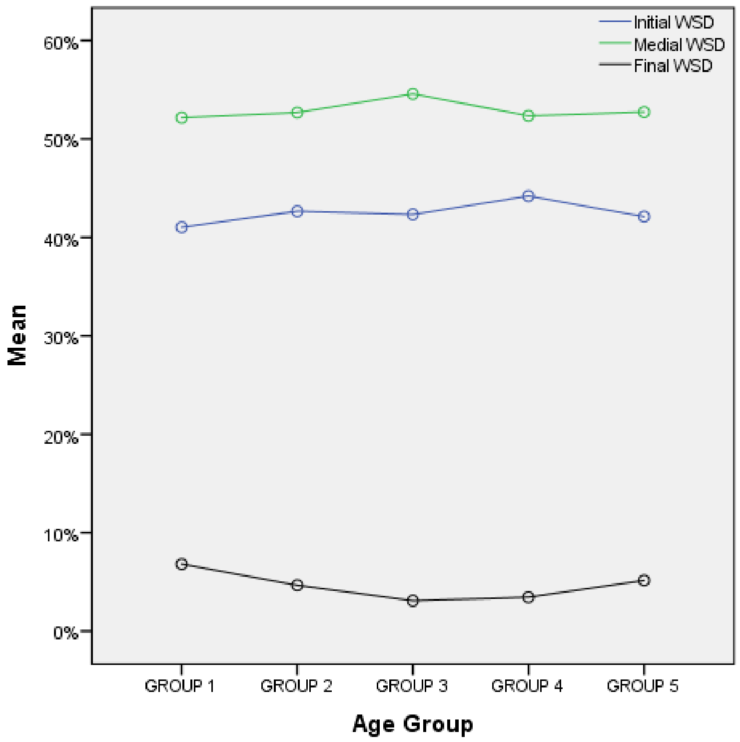


Figure 6.46. Positional weak-syllable deletion errors in the spontaneous sample. Key: WSD= Weak-Syllable Deletion.

Additionally, a Test of Within-Subjects Contrasts was also completed, i.e. comparing word-initial WSD vs. word-medial WSD and word-medial WSD vs. word final WSD. The results show that there was a significant difference in the occurrence of WSD between word-initial and word-medial positions: $F(1, 49) = 6.292$, $p = .015$, partial $\eta^2 = .114$. Similarly, there was a significant difference between WSD in word-medial and word-final positions: $F(1, 49) = 457.066$, $p < .001$, partial $\eta^2 = .903$. Moreover, the interactions of initial vs. medial WSD and medial vs. final WSD with Age-group, Gender, and Age-Group*Gender were all not significant: $p > .05$ (see Appendix-BY for more details).

Finally, the Test of Between-Subjects effect showed that the effect of Age-Group was not significant: $F(4, 49) = 1.893$, $p = .127$, partial $\eta^2 = .134$ (Figure 6.48). However, the effect of the Gender was significant: $F(1, 49) = 4.350$, $p = .042$, partial $\eta^2 = .082$ however with a low observed power = .534. Moreover, the Age-Group by Gender interaction was not significant $F(4, 49) = .907$, $p = .467$, partial $\eta^2 = .069$ (Figures 6.47 and 6.48).

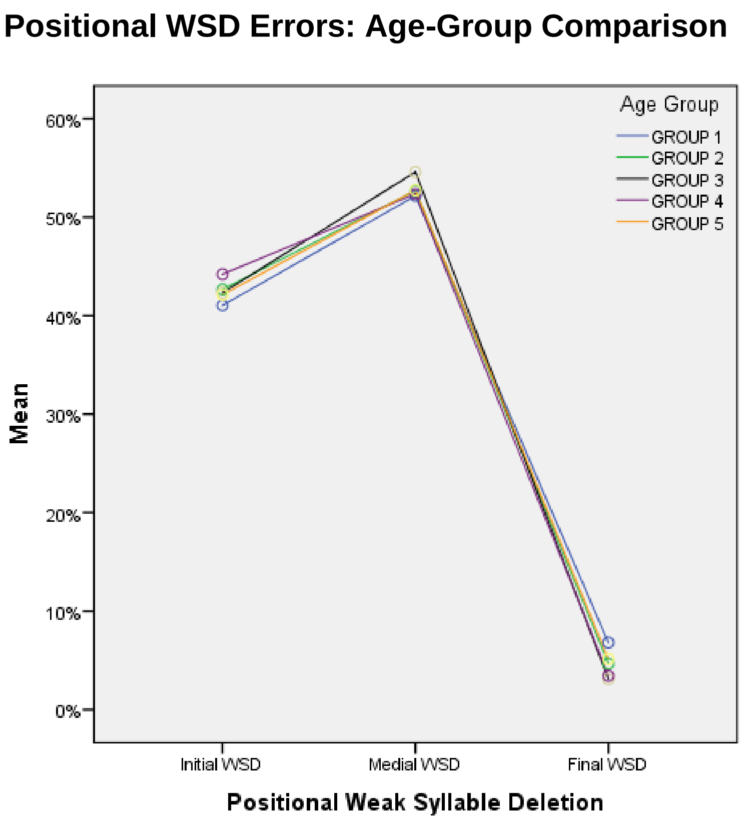


Figure 6.47. Positional WSD errors: Age-Group comparison. Key: WSD= Weak-Syllable Deletion.

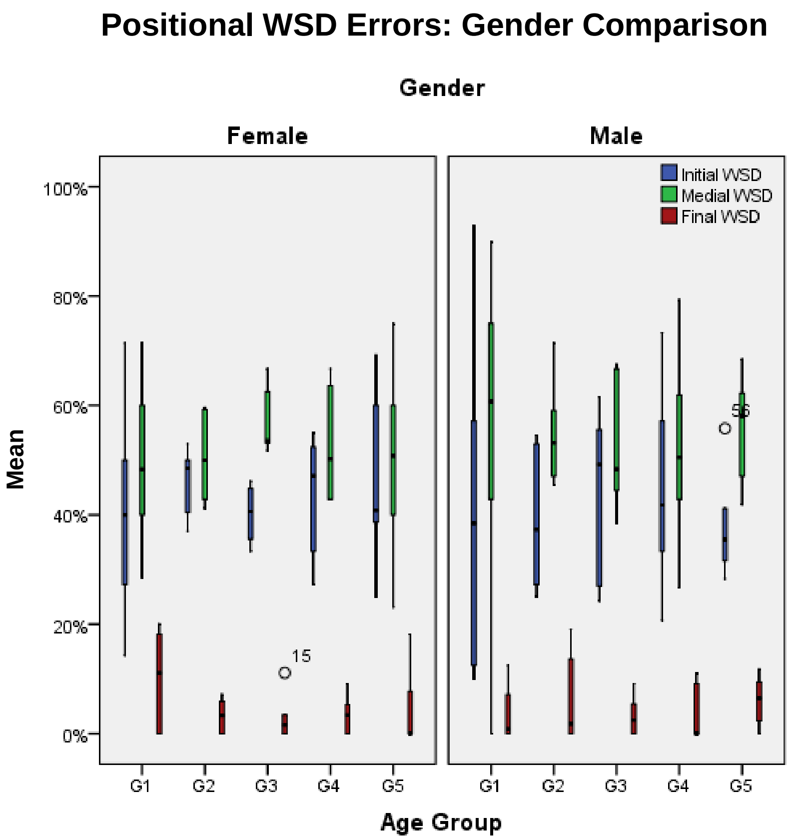


Figure 6.48. Positional WSD errors: Age-Group, and Gender comparison. Key: WSD= Weak-Syllable Deletion.

In summary, WSD errors occurred twice as frequently in the youngest three age groups in the PN sample in comparison to the SPON sample with Group1-to-Group-5 range 21.1-4.9% and 9-4.5% consecutively. Accordingly, the effect of speech task on WSD errors was confirmed via statistical analysis in favour of the SPON sample. Moreover, the effect of the age group, but not the gender, was also significant with a tendency for the WSD errors to decrease over time. Similarly, the interaction of the speech-task with the age-group was significant however, the means of PN-WSD and SPON-WSD were only significantly different in age groups 1, 2, and 3. In other words, the difference between PN and SPON WSD errors is only significant up the age of 3;06 years, after which NA speaking children appear to make the same amount of WSD errors in both speech tasks. Moreover, a post Hoc analysis revealed that WSD mean difference between the two speech tasks was significantly different between Group-1 and Groups 4 and 5 and also between Group-2 and Groups 4 and 5.

Finally, positional WSD was only investigated in the SPON sample to avoid bias caused by the PN stimulus design. Statistical analysis revealed that word-position had a clear significant effect on the occurrence of WSD errors. Word-medial followed by word-initial syllables were deleted the most. In contrast, syllables in word-final position were the least likely to be deleted (>10%) in all age groups. Moreover, the effect of age group on the rate of positional WSD errors was not significant yet the gender of the participants was to the advantage of the females with moderate effect size and insufficient power <.8. The moderate effect size indicates that the gender of the participant of a randomly selected data point might be predicted solely based on its positional WSD error rate. Nonetheless, the low observed power of the test indicates that there is only a 53% chance that the gender difference in positional WSD errors is true.

6.5. Errors in the Production of Consonant Clusters:

In this section, all possible outcomes of consonant cluster production are reported, namely: Cluster Reduction (CR), Cluster Epenthesis (CE), Other, Migration, Broken, and Deletion. CR errors are reported when one of the two consonantal elements of the Arabic cluster is deleted. CE errors are indicated when a vowel is inserted between the two elements of the consonantal cluster to provide an outcome that does not resemble Standard or Najdi Arabic productions of the same target by adult speakers. “Other” errors are indicated when both elements of the consonant cluster remain present in the child’s production within the same syllable with one or both elements undergoing changes in place, manner and/or voicing allowing other phonological process to take place; i.e. assimilation and harmony. In “migration” errors, one element of the consonant cluster migrates from its position to form another cluster within the same target word. For example, instead of saying /kalb/ ‘dog’ a child produces [klab]. “Broken” errors present themselves when both elements of the cluster are correctly produced yet with a prolonged pause in between. For example, for the target /ˈʃmaːɣ/ (a traditional Saudi-men clothing item) a child will say [ʃː ˈmaːɣ] instead. Broken errors have been considered an error in the analysis due to its effect on reducing articulation complexity associated with the timely production of consonant clusters. Finally, “deletion” errors are indicated when both elements of the consonant cluster are omitted. Deletion of consonant clusters is very rare in the sample and only occurred in the youngest age group (Group-1) in the PN sample with frequency of 6.9%. No other occurrences of consonant cluster deletion in other age groups or in the SPON. Figures 6.49 and 6.50 below illustrate all possible consonant cluster production outcomes with their frequency of occurrence in PN and SPON samples consecutively.

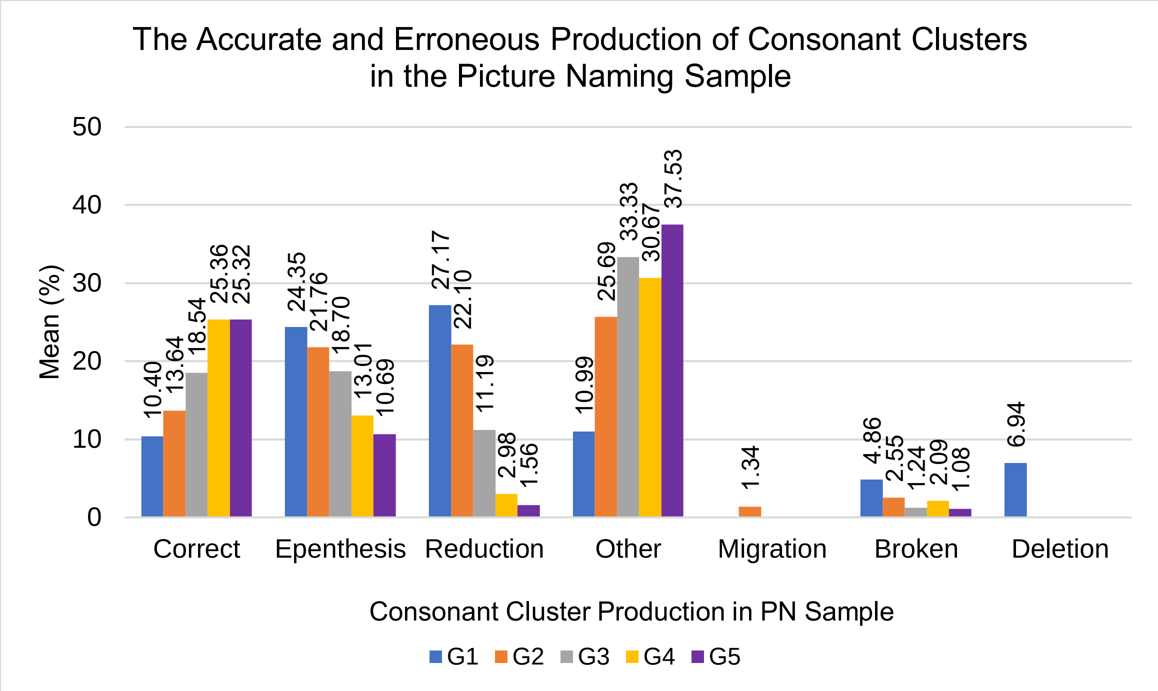


Figure 6.49. The accurate and erroneous production of consonant cluster in the picture naming task. Key: PN = Picture Naming

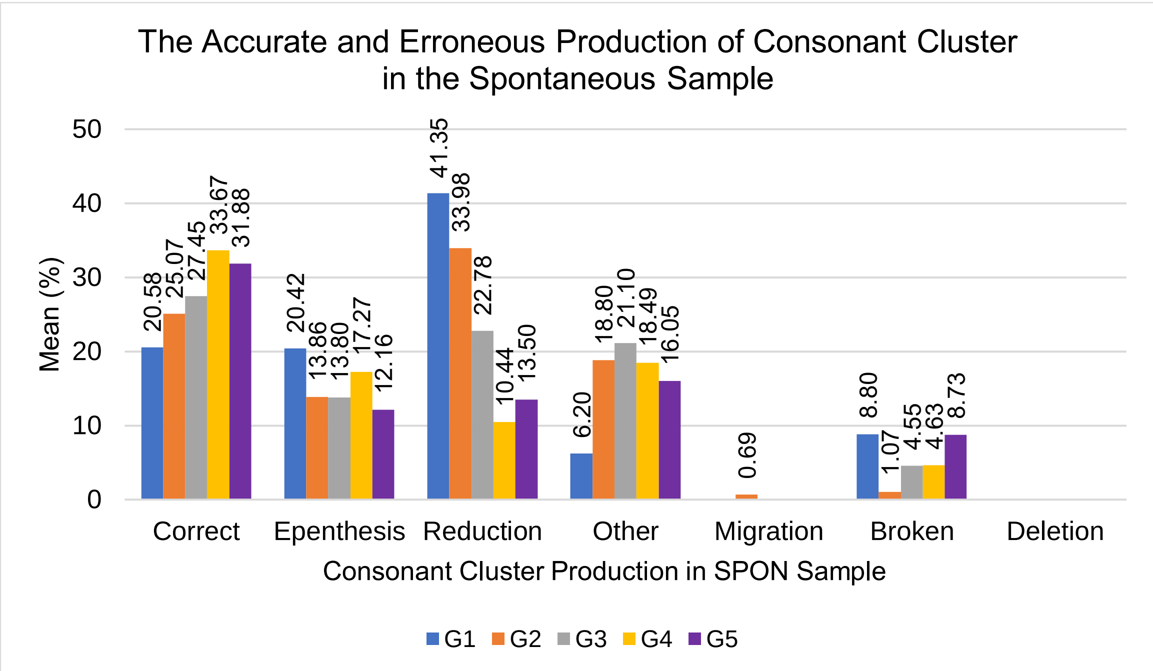


Figure 6.50. The accurate and erroneous production of consonant cluster in SPON task. Key: SPON = Spontaneous.

As apparent in the figures above, CR is the most common error type in Group-1 in both speech samples. Furthermore, CR in both speech tasks follows the expected tendency to decrease with age. The reduction of consonant clusters in the PN sample reaches its lowest frequency 1.06% at age 4;00 years (Group-5). However, in the SPON sample, its lowest frequency 10.4% is reached at age 3;06 years (Group-4). Contrastively, “Other” error type has its lowest frequency at Group-1 in both speech samples and has the tendency to increase with age. Furthermore, epenthesis of clusters has its highest frequency at Group-1 in both speech samples and has the tendency to decrease with age. Unlike epenthesis and cluster reduction, migration in consonant clusters is an atypical error type. Migration only occurred twice by two male participants in Group-2: once by participant G2-09 in PN sample and once by participant G2-07 in SPON sample. This is clearly reflected in the frequency of the error: 1.3% in PN and 0.7% in SPON samples of Group-2. Finally, “broken” error type is not as frequent as cluster reduction or epenthesis yet it is occurred more frequency in the SPON sample than in PN sample. In the PN sample, broken clusters did not exceed 5% but this figure nearly doubles in the SPON sample. In general, CR followed by CE are the most common error types in the production of consonant clusters by young children. For this reason, detailed analysis on those two types of errors follows in sections 6.7.1 and 6.7.2 below.

6.7.1. Cluster Reduction (CR)

In the current study, cluster reduction is defined as the realisation of a two-element onset or coda clusters in the IPA target as a single element in the IPA actual. In this section, only errors in the production of tauto-syllabic clusters are considered. On the other hand, CR errors in the production of hetero-syllabic clusters were incorporated in the analysis of SCD in section 6.4.1. Table 6.69 below provides descriptive statistics: Mean and standard deviation values for the occurrence of CR in both speech tasks: PN and SPON.

Unlike all other phonological processes investigated in the current study, all participants produce more CR errors in the SPON sample than in PN sample (Figure 6.51). Almost no clusters are reduced by the age of four years, i.e. Group-5 in the PN sample whilst 13.50% of clusters were still reduced in the SPON sample by the same participants. As expected, greater individual differences were found in the youngest participants in both speech tasks. These differences decrease drastically overtime.

Table 6.69.

The Percentage of Cluster Reduction Errors in Two Speech Tasks.

Age Group	PN CR Errors		SPON CR Errors	
	Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	28.67	35.32	41.17	37.10
G2	22.10	23.19	33.98	29.92
G3	11.19	15.99	22.78	14.83
G4	2.98	3.72	10.44	8.49
G5	1.56	3.88	13.50	8.15

Key: CR= Cluster Reduction, PN= Picture Naming, SPON= Spontaneous.

Cluster Reduction Errors in Two Speech Tasks

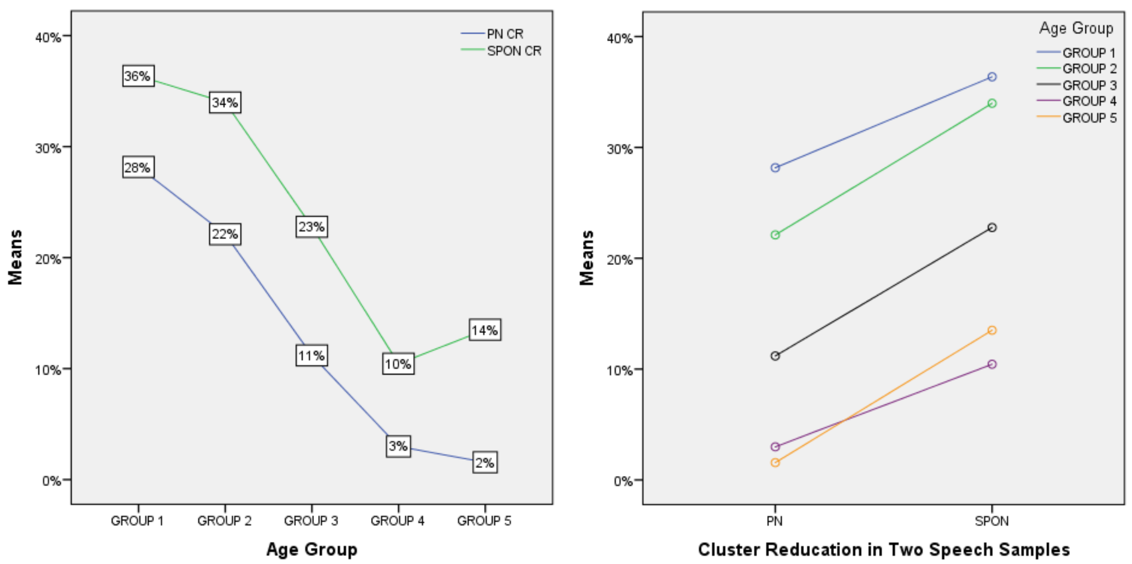


Figure 6.51. The Percentage of cluster reduction in two speech tasks: as a function of age group (left) and speech task (right). Key: CR= Cluster Reduction, PN= Picture Naming, SPON= Spontaneous.

Also, by comparing the mean values across gender (Table 6.70 and Figure 6.52), it is notable that both genders in general make more CR errors in the SPON sample. Moreover, in PN sample, female participants aged 3;00 years or older (Groups 3, 4, and 5) nearly outgrow their CR errors whilst male participants still reduce 20% of their clusters at Group-3 (average age 3;00 years). On the other hand, both female and male participants struggle longer with CR errors in SPON sample with 12.5% and 14.5% consecutively of their clusters reduced at Group-5 (average age 4;00 years).

Table 6.70.

The Occurrence of Cluster Reduction Errors in Two Speech Tasks: Gender Comparison.

Age Group	**Gender**	**PN CR Errors**		**SPON CR Errors**	
		Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	Females	22.65	30.14	52.04	42.47
	Males	33.68	41.26	30.29	30.67
G2	Females	26.75	28.65	30.70	26.84
	Males	17.46	17.61	37.26	34.97
G3	Females	1.39	3.40	16.85	12.00
	Males	20.99	17.90	28.70	15.99
G4	Females	3.75	4.12	12.84	9.48
	Males	2.22	3.47	8.04	7.39
G5	Females	2.08	5.10	12.53	7.92
	Males	1.04	2.55	14.48	9.01

Key: CR= Cluster Reduction, PN= Picture Naming, SPON= Spontaneous.

Cluster Reduction Errors: Age-Group, Speech Task, and Gender Comparison

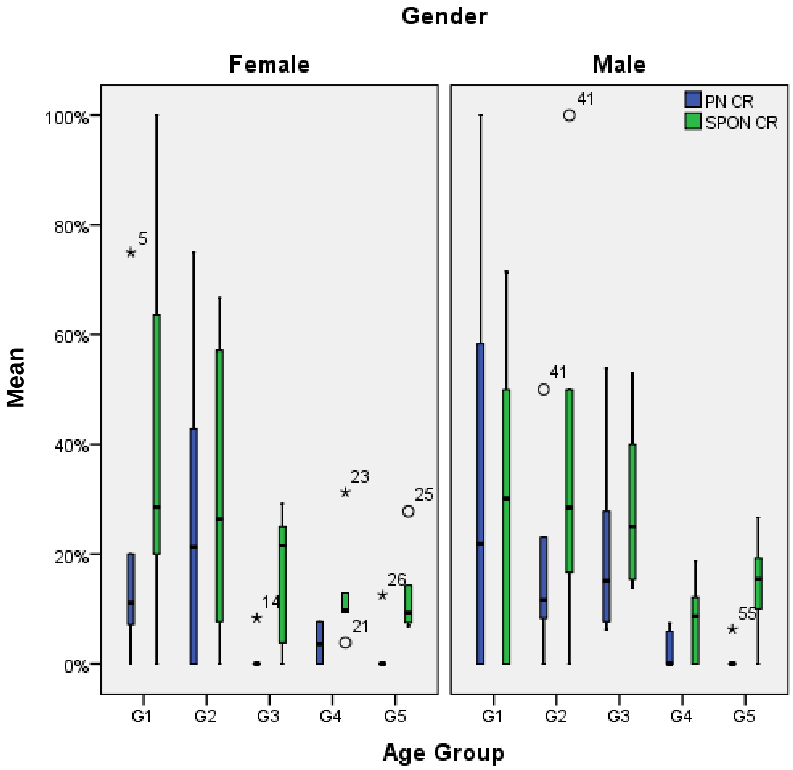


Figure 6.52. The occurrence of cluster reduction errors in two speech tasks: gender comparison. Key: CR= Cluster Reduction, PN= Picture Naming, SPON= Spontaneous.

The CR data is normally distributed in all age-groups in the SPON sample. However, it is not normally distributed in four age-groups in the PN sample (see Appendix-BZ for more details). For this reason, non-parametric Wilcoxon Singed Ranks Test was completed to compare CR between the two speech tasks. The test results show a significant difference in CR between the two speech tasks (z = 3.820, N - Ties = 53, $p < .001$, two-tailed) (Appendix-CA-a).

Additionally, Kruskal-Wallis Test was also completed to explore whether Age-Group had an effect on CR in either speech task. The results suggest that Age-Group had a significant effect on CR errors in PN sample $\chi^2(4, N = 59) = 14.870$, $p = .005$ and also in the SPON sample $\chi^2(4, N = 60) = 10.116$, $p = .039$. Then, Mann-Whitney Test was completed to explore whether Gender had an effect on CR in either speech task. The results suggest that the Gender of the participant had no effect on the occurrence of CR in either speech sample: $p > 0.05$ (Appendix-CA-b).

Despite the abnormal distribution, a 2x5x2 Mixed ANOVA with two between-subjects factors: gender with two levels (female; male) and age-group with five levels and a single within-subjects factor being speech task with two levels: picture naming (PN); spontaneous (SPON) and the dependant variable was the proportion of CR errors was also completed on the same data to confirm the findings and to explore the DV and IV interactions. Mauchly's Test of Sphericity was significant $p < .001$ (see Appendix-CB), therefore the Greenhouse-Geisser correction was applied to the degrees of freedom and consequently a significant main effect of Speech-Task was found, i.e. at different age groups, the means of PN-CR and SPON-CR are significantly different: $F(1, 49) = 8.784$, $p = .005$, partial $\eta^2 = .152$. However, the speech-task by age-group interaction was not significant: $F(4, 49) = .081$, $p = .988$, partial $\eta^2 = .007$. Also, the speech-task by gender interaction was not significant: $F(1, 49) = .198$, $p = .658$, partial $\eta^2 = .004$. Similarly, the three-way interaction between speech-task, age-group, and gender was not significant: $F(4, 49) = .842$, $p = .506$, partial $\eta^2 = .064$.

Additionally, the Test of Between-Subjects effect showed that the effect of Age-Group was significant: $F(4, 49) = 5.752$, $p = .001$, partial $\eta^2 = .320$. However, the effect of the Gender was not significant: $F(1, 49) = .264$, $p = .609$, partial $\eta^2 = .005$. Similarly, the Age-Group by Gender interaction was not significant either $F(4, 49) = .644$, $p = .634$, partial $\eta^2 = .050$. Finally, a Tukey Post Hoc test was applied to make pair-wise comparisons between the groups. Pairwise comparisons were only found significant between age groups that are at least 18 months apart, all results are listed in Table 6.71 (see Appendix-CC for more details).

Table 6.71.

Cluster Reduction Errors Post-Hoc Test between Age-Groups.

AG	G1		G2		G3		G4		G5	
	MD	**SEM**	**MD**	**SEM**	**MD**	**SEM**	**MD**	**SEM**	**MD**	**SEM**
G1	NA		-4.20	6.89	-15.25	6.89	-25.52**	6.89	-24.70**	6.89
G2	4.20	6.89	NA		-11.05	6.89	-21.32*	6.89	-20.50**	6.89
G3	15.25	6.89	11.05	6.89	NA		-10.26	6.89	-9.44	6.89
G4	25.52**	6.89	21.32*	6.89	10.26	6.89	NA		.82	6.89
G5	24.70**	6.89	20.50*	6.89	9.44	6.89	-.82	6.89	NA	

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: AG= Age Group MD = Mean Difference, SEM = Standard Error of the Mean, NA = Not Applicable

Moreover, the frequency CR errors was further investigated in relation to consonant cluster position within the word. Because word-medial tauto-syllabic clusters are not permissible in Standard Arabic and only occurred twice in the data, the analysis will only focus on word-initial (WI) and word-final (WF) clusters. The positional CR data is not normally distributed in almost all age groups (see Appendix-CD for more details). Consequently, non-parametric analysis was carried away using Friedman Test to compare the two word positions in both speech tasks. The results showed that confidence varied significantly between those four conditions: $\chi^2(3, N = 59) = 28.367$, $p < .001$ (Table 6.72). It is worth nothing that $N = 59$ because one participant in Group-1 failed to attempt any words containing a consonant cluster. Mean ranks suggest that CR occurs the most in word-initial and word-final position in the SPON sample, followed by word-final in the PN sample, and occurs least in word-initial position in the PN sample. Moreover, Figure 6.53 provides descriptive statistics comparing CR in both PN vs. SPON samples and word-initial vs. word-final positions.

Table 6.72.

Positional Cluster Reduction: Friedman Test.

					Percentiles		
Conditions	***N***	**Mean Rank**	**Min**	**Max**	25th	50th (Median)	75th
WI-CR PN	59	1.96	.00	50.00	.00	.00	5.88
WF-CR PN	59	2.38	.00	75.00	.00	.00	11.76
WI-CR SPON	59	3.02	.00	100.00	.00	7.14	17.94
WF-CR SPON	59	2.64	.00	50.00	.00	4.28	8.69

Key: *N*= Number of participants, Min = Minimum, Max = Maximum, WI-CR PN = Word-Initial Cluster Reduction in Picture Naming sample, WF-CR PN = Word-Final Cluster Reduction in Picture Naming sample, WI-CR SPON = Word-Initial Cluster Reduction in Spontaneous sample, WF-CR SPON = Word-Final Cluster Reduction in Spontaneous sample.

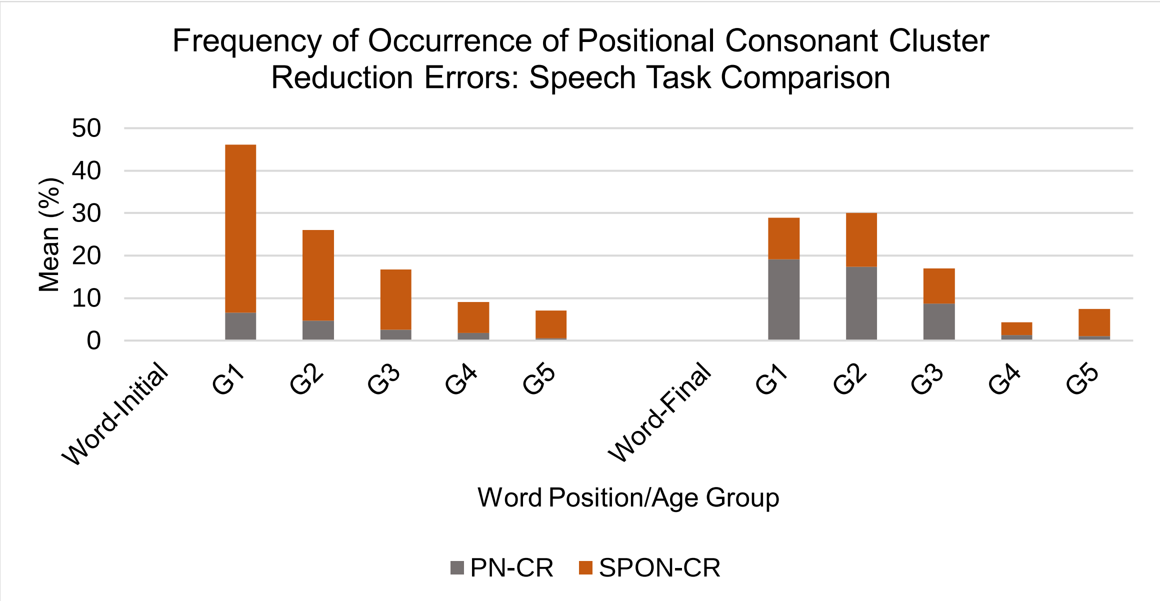


Figure 6.53. Positional cluster reduction errors in two speech tasks. Key: PN = Picture Naming, SPON = Spontaneous, CR= Cluster Reduction.

Furthermore, a series of Wilcoxon Signed Rank Tests were also completed to explore the significance between positional CR within the same speech task; i.e. word-initial vs. word final CR in within the same speech task and also to compare same-position CR between the two speech tasks. Since each dependent variable is only tested twice, the Bonferroni corrected/adjusted *p* value was calculated using the following equation:

$$\alpha = \frac{.05}{2} = .025$$

Finally, the test results were compared to the new and adjusted *p* value α = .025 as the higher boundary for significance. The test results confirms that there was a significant difference in the occurrence of CR in word-initial vs. word-final positions in the PN sample (z = 3.258[a], N – Ties = 28, p = .001, two-tailed). However, there was no significant difference in the occurrence of CR in word-initial vs. word-final positions in the SPON sample (z = 2.122[b], N – Ties = 45, p = .034, two-tailed). Moreover, there was a significant difference in the occurrence of word-initial CR in PN vs. SPON samples (z = 4.493[a], N – Ties = 43, p < .001, two-tailed). However, there was no significant difference in the occurrence of word-final CR in PN vs. SPON samples (z = .119[b], N – Ties = 42, p < .905, two-tailed), see Appendix-CE for more details. Please note that *z* values for this test are: [a] based on negative ranks and [b] are based on positive ranks.

In summary, of all phonological processes investigated in the current study, CR is the only process that occurred more frequently in the SPON sample rather than in the PN sample with a Group1-to-Group-5 range of 41.1-13.5% and 28.6-1.5% consecutively. Moreover, this difference was proven to statistically significant via non-parametric statistical analysis. Additionally, the age-group of the participants, but not the gender, had a significant effect on CR reduction errors with a clear tendency for errors to decrease with age. Also, parametric analysis of CR data revealed identical results despite the abnormal distribution of the data. Parametric analysis was carried out for the main purpose of exploring the interaction between the CR as DV and the IVs: Speech-Task, Age-Group, and Gender, however, none of the interactions were found to be significant. Furthermore, post Hoc analysis revealed that the mean difference of CR errors in the two speech tasks was only significantly different between age groups that are at least 18 months apart. Finally, the word position had a statistically significant effect on CR errors. In other words, the occurrence of CR errors favoured clusters in different word positions in the following order: SPON word-initial = SPON word-final>PN word-final >PN word-initial.

6.7.2. Cluster Epenthesis (CE)

In the Current study, cluster epenthesis is defined as the realisation of a consonant cluster in the IPA target as two consonants separated by a vowel in the IPA actual. Also, it is worth noting that in this analysis, a distinction has been made between two types of Epenthesis of word-initial clusters: Acceptable and Error, see example in Table 6.73. Word-final clusters are not typically epenthesized in Najdi Arabic, therefore any epenthesis of a WF cluster is routinely considered an error.

Table 6.73.

Examples of Acceptable and Error Epenthesis in Consonant Cluster Production

Target	**Meaning**	**Realization**	**Decision**
/ˈħsˤɑːn/	horse	[ħɪˈsˤɑːn]	Acceptable
		[ʔɪħˈsˤɑːn]	Error

In the Figure 6.54 below, the frequency of correct and acceptable epenthesis of consonant clusters is presented in addition to the combined the frequency of both to compare the progression of what is considered correct production of clusters by a native Najdi-Arabic speaker in both speech tasks over time. Figure 6.54 below shows that children are more likely to produce consonant clusters correctly or with acceptable epenthesis in their spontaneous speech. Slightly more errors have been detected in the PN sample. Overall, it can be clearly seen that the frequency of correct/acceptable production of consonant clusters follows the expected linear tendency of increasing with age as child's speech matures to resemble adult-like speech. It reaches its highest accuracy of nearly 50% at Group-5 (average age 4;00 years) in both speech samples. However, the correct production of consonant clusters on its own only reaches 25.3% in PN and 31.8% SPON samples in the oldest age group.

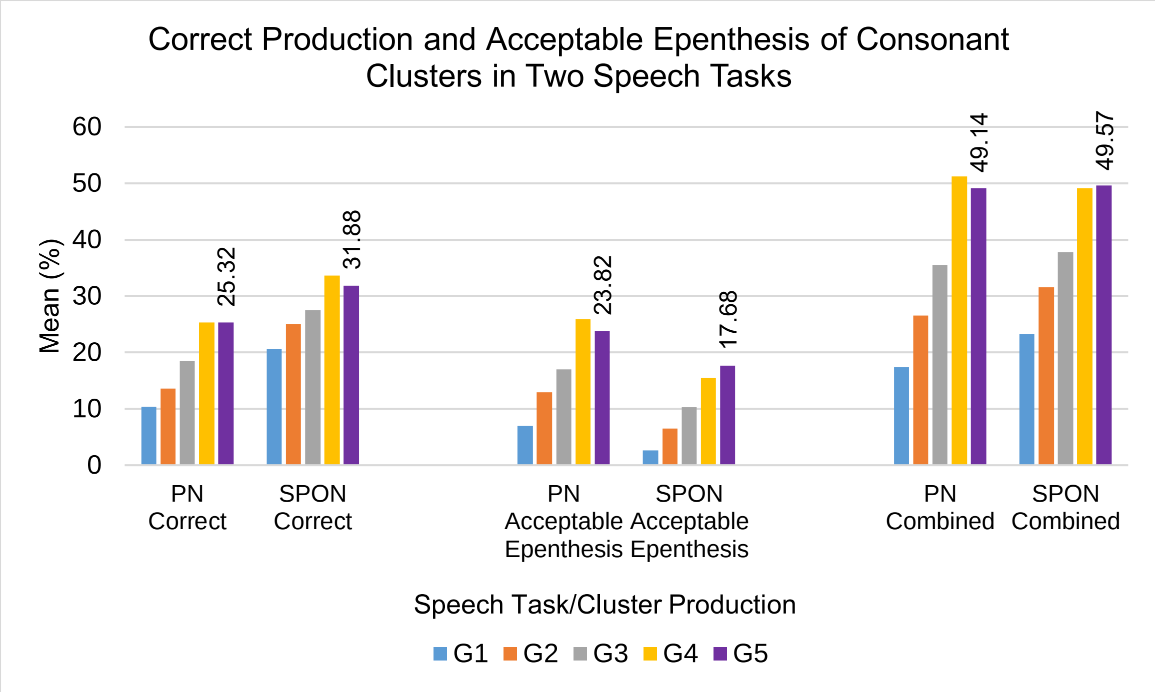


Figure 6.54. Correct production and acceptable epenthesis of consonant clusters in two speech tasks. Key: PN= Picture Naming, SPON= Spontaneous, Combined= Correct + Acceptable.

Table 6.74 provides descriptive statistics: Mean and standard deviation values for the occurrence of CE in both speech samples: PN and SPON. Clearly, all participants produce more CE errors in the PN sample than in the SPON sample (Figure 6.55). As expected, greater individual differences are found in the youngest participants in both speech tasks. These differences decrease drastically overtime.

Table 6.74.

The Percentage of Cluster Epenthesis in Two Speech Tasks.

	PN CE Errors		**SPON CE Errors**	
Age Group	Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	36.85	27.82	22.09	30.93
G2	21.76	17.84	13.86	16.85
G3	18.70	8.17	13.80	9.90
G4	13.01	6.69	17.27	11.11
G5	10.69	8.20	12.16	9.61

Key: PN= Picture Naming, SPON= Spontaneous, CE= Cluster Epenthesis.

Cluster Epenthesis Errors in Two Speech Tasks

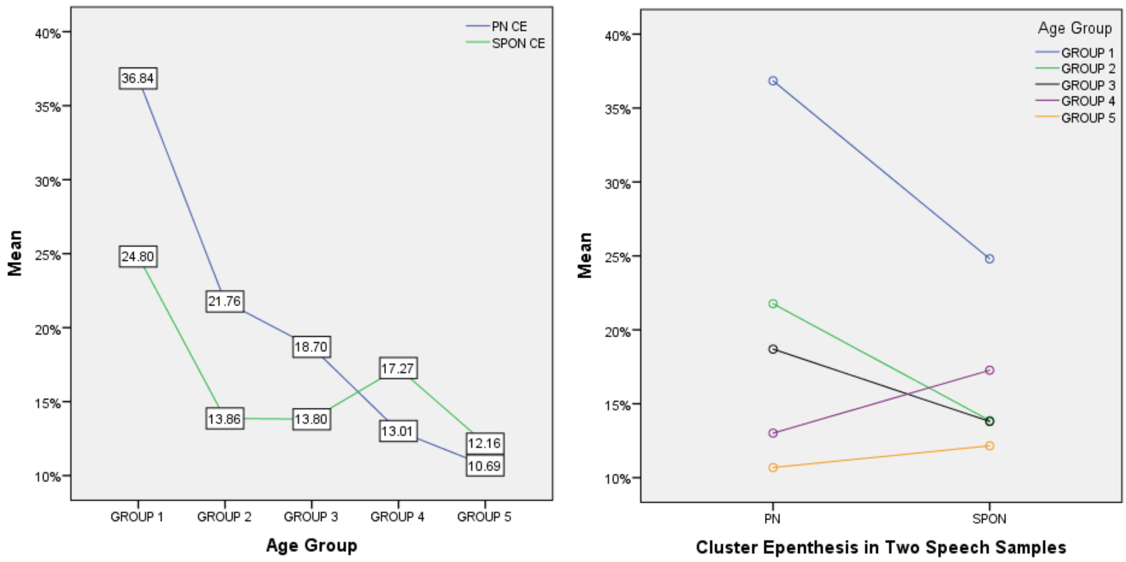


Figure 6.55. The percentage of cluster epenthesis errors in two speech tasks: as a function of age group (left) and speech task (right). Key: PN= Picture Naming, SPON= Spontaneous, CE = Cluster Epenthesis.

Also, by comparing the mean values across gender, it is notable that the females in general (except in Group 2) epenthesized their consonant clusters equally or more often than their male peers in both speech tasks (Table 6.75 and Figure 6.56).

Table 6.75.

The Occurrence of Cluster Epenthesis Errors in Two Speech Tasks: Gender Comparison.

Age Group	Gender	**PN CE Errors**		**SPON CE Errors**	
		Mean (%)	Standard Deviation	Mean (%)	Standard Deviation
G1	Females	36.78	20.62	27.14	39.54
	Males	36.91	34.75	17.04	21.92
G2	Females	19.86	12.79	10.08	13.40
	Males	23.67	22.97	17.65	20.27
G3	Females	20.64	8.80	14.13	10.56
	Males	16.75	7.78	13.48	10.20
G4	Females	13.57	8.15	17.70	11.04
	Males	12.46	5.60	16.84	12.22
G5	Females	13.98	6.34	11.09	5.94
	Males	7.39	9.04	13.22	12.86

Key: PN= Picture Naming, SPON= Spontaneous, CE= Cluster Epenthesis.

Cluster Epenthesis Errors: Age-Group, Speech Task, and Gender

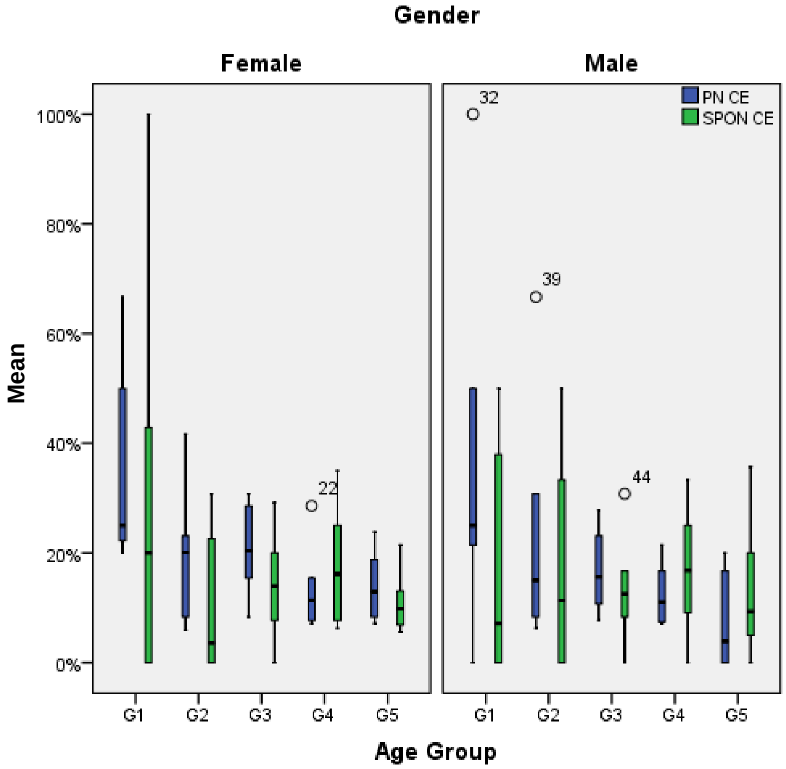


Figure 6.56. The occurrence of cluster epenthesis errors in two speech tasks: gender comparison. Key: PN= Picture Naming, SPON= Spontaneous, CE= Cluster Epenthesis.

The CE data is normally distributed in 60% of all age groups, i.e. normally distributed Groups 1, 3, and 5 in PN sample and Groups 3, 4, and 5 in SPON sample (see Appendix-CF for more details). For this reason, non-parametric Wilcoxon Singed Ranks Test was used to compare CE errors in the two speech tasks. The test results (Appendix-CG-a) show that there is no significant difference between the two speech tasks (z = 1.717, N - Ties = 56, p = .086, two-tailed).

Additionally, Kruskal Wallis Test was completed to explore whether the Age-Group of the participants had an effect on CE in either speech task. The results suggest that the Age-Group had a significant effect on CE errors in PN sample $\chi^2(4, N = 59) = 14.772$, $p = .005$ but had no significant effect on CE errors in the SPON sample $\chi^2(4, N = 60) = 1.728$, $p = .786$. Furthermore, Mann-Whitney Test was applied to explore whether Gender had an effect on CE in either speech task. The results suggest that the Gender of the participant had no effect on the occurrence CE in either speech task: $p > 0.05$ (Appendix-CG-b).

Moreover, a 2x5x2 Mixed ANOVA with two between-subjects factors: gender with two levels (female; male) and age-group with five levels and a single within-subjects factor being speech task with two levels: picture naming (PN); spontaneous (SPON) was completed to explore the DV and IV interactions. The dependant variable was the proportion of CE errors. Mauchly's Test of Sphericity was significant: $p < .001$ (see Appendix-CH for more details), therefore the Greenhouse-Geisser correction was applied to the degrees of freedom and consequently the main effect of Speech-Task was found not significant, i.e. at different age groups, the means of PN-CE and SPON-CE are not significantly different: $F(1, 49) = 1.844$, $p = .181$, partial $\eta^2 = .036$. Similarly, the speech-task by age-group interaction was not significant: $F(4, 49) = 1.110$, $p = .363$, partial $\eta^2 = .083$. Also, the speech-task by gender interaction was not significant: $F(1, 49) = .000$, $p = .992$, partial $\eta^2 = .000$ and the three-way interaction between speech-task, age-group, and gender was not significant either: $F(4, 49) = .520$, $p = .721$, partial $\eta^2 = .041$.

Additionally, the Test of Between-Subjects effect showed that the effect of Age-Group was significant: $F(4, 49) = 3.468$, $p = .014$, partial $\eta^2 = .221$. However, the effect of the Gender was not significant: $F(1, 49) = .188$, $p = .667$, partial $\eta^2 = .004$. Also, the Age-Group by Gender interaction was not significant $F(4, 49) = .374$, $p = .826$, partial $\eta^2 = .030$. Finally, a Tukey Post Hoc test was applied to make pair-wise comparisons between the groups. Pairwise comparisons reached significance differences only between Group 1 and Group 5, all results are listed in Table 6.76 (see Appendix-CI for more details).

Table 6.76.

Cluster Epenthesis Errors Post-Hoc Test between Age-Groups.

AG	G1		G2		G3		G4		G5	
	MD	SEM	MD	SEM	MD	SEM	MD	SEM	MD	SEM
G1	NA		-12.65	5.54	-14.22	5.54	-15.33	5.54	-19.05*	5.54
G2	12.65	5.54	NA		-1.56	5.54	-2.67	5.54	-6.39	5.54
G3	14.22	5.54	1.56	5.54	NA		-1.10	5.54	-4.82	5.54
G4	15.33	5.54	2.67	5.54	1.10	5.54	NA		-3.72	5.54
G5	19.05*	5.54	6.39	5.54	4.82	5.54	3.72	5.54	NA	

*. The mean difference is significant at the .01 level.
Key: AG= Age Group, MD = Mean Difference, SEM = Standard Error of the Mean, NA = Not Applicable

Moreover, the frequency of occurrence CE errors were further investigated in relation to the consonant cluster's position within the word. Because word-medial tauto-syllabic clusters are not permissible in Standard or Najdi Arabic, only word-initial (WI) and word-final (WF) clusters were included in this analysis. The CE data is not normally distributed in most age groups (see Appendix-CJ for more details), therefore non-parametric Friedman Test was completed to compare the two word positions in both speech tasks. The results showed that confidence varied significantly between those four conditions: $\chi^2(3, N = 59) = 33.200$, $p < .001$. Table 6.77 provides CE descriptive statistics in both positions and in both speech tasks. It is worth noting the $N = 59$ because one participant in Group-1 failed to attempt any words containing a consonant cluster. Finally, Mean Ranks suggest that CE occurs the most in Word-Initial position in the PN sample, followed by Word-Initial position in the SPON sample, then by Word-Final in the PN sample, and occurs the least in Word-Final in SPON sample (Figure 6.58).

Table 6.77.

Positional Cluster Epenthesis: Friedman Test.

					Percentiles		
Conditions	***N***	**Mean Rank**	**Min**	**Max**	25th	50th (Median)	75th
WI-CE PN	59	2.97	.00	66.66	5.88	8.33	16.66
WF-CE PN	59	2.31	.00	25.00	.00	5.88	8.33
WI-CE SPON	59	2.87	.00	50.00	.00	7.14	17.14
WF-CE SPON	59	1.86	.00	100.00	.00	.00	3.22

Key: *N*= Number of participants, Min = Minimum, Max = Maximum, WI-CE PN = Word-Initial Cluster Epenthesis in Picture Naming sample, WF-CE PN = Word-Final Cluster Epenthesis in Picture Naming sample, WI-CE SPON = Word-Initial Cluster Epenthesis in Spontaneous Sample, WF-CE SPON = Word-Final Cluster Epenthesis in Spontaneous Sample.

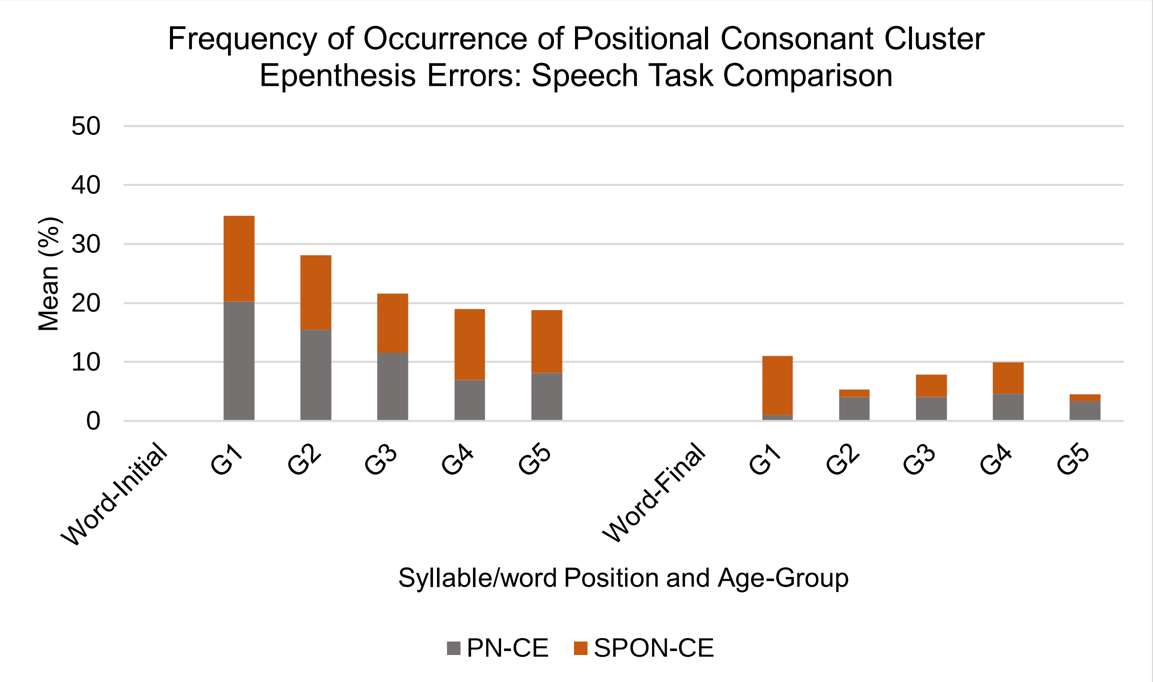


Figure 6.57. Frequency of positional consonant cluster epenthesis errors: speech task comparison. Key: PN= Picture Naming, SPON= Spontaneous, CE = Cluster Epenthesis.

Furthermore, a series of Wilcoxon Signed Rank Tests were completed to explore the significance between positional CE within the same speech task; i.e. word-initial vs. word final CE in within the same speech task and also to compare same-position CE between the two speech tasks. Since each dependent variable is only tested twice, the Bonferroni corrected/adjusted *p* value was calculated using the following equation:

$$\alpha = \frac{.05}{2} = .025$$

Finally, the test results were compared to the new and adjusted *p* value α = .025 as the higher boundary for significance. Consequently, it can be concluded that there is a significant difference in the occurrence of CE in word-initial vs. word-final positions in the PN sample (z = 3.531, N – Ties = 47, p < .001, two-tailed). Similarly, there was a significant difference in the occurrence of CE in word-initial vs. word-final positions in the SPON sample (z = 3.710, N – Ties = 40, p < .001, two-tailed). Moreover, there was a significant difference in the occurrence of word-final CE in PN vs. SPON samples (z = .2.785 , N – Ties = 39, p = .005, two-tailed). However, there was no significant difference in the occurrence of word-initial CE in PN vs. SPON samples (z = .691, N – Ties = 53, p = .490, two-tailed), see Appendix-CK for more details. Please note that *z* values for this test are all based on positive ranks.

In summary, descriptive statistics suggest that CE errors occurred more in the PN sample than in the SPON sample with Group1-to-Group-5 range 36.8-10.6% and 22-12.1% consecutively. However, this difference was proven not to be statistically significant via the use of non-parametric tests. Additionally, the age-group of the participants, but not the gender, had a significant effect on CE reduction errors with a clear tendency for errors to decrease with age. Moreover, parametric analysis of CE data revealed identical results despite its abnormal distribution. Parametric analysis was carried out for the main purpose of exploring the interaction between the CE as DV and the IVs: Speech-Task, Age-Group, and Gender, however, none of the interactions were significant. Furthermore, post Hoc Analysis revealed that the mean difference of CE errors between the two speech tasks only differed between age groups 1 and 5.

Furthermore, the word position had a statistically significant effect on CE errors. In other words, the occurrence of CE errors favoured clusters in different word positions in the following order: PN word-initial = SPON word-initial>PN word-final >SPON word-final. These findings suggest that CE predominantly occurs in word-initial clusters.

6.8. Summary

The main aim of the study was to investigate the frequency of occurrence of phonological process in Najdi-Arabic speaking children and to establish a timeline at which age should one expects such processes to fade. In relation to the consonant acquisition criteria in Chapter-5, the same +90% accuracy measure was used as cut-off point where consonants were acquired, and phonological processes faded. Table 6.78 below presents a timeline of the expected age at which the phonological processes investigated in the current study are out-grown, i.e. their occurrence dropped below 10%. To make the comparisons easier, the phonological processes were categorised into four main groups centred on their frequency of occurrence in Group-1, where one would expect to find most errors as follows:

- *Rare processes:* 0-10% occurrence rate
- *Less frequent processes:* 11-20% occurrence rate
- *Frequent processes:* 21-30 % occurrence rate.
- *Very frequent processes:* +30% occurrence rate.

Table 6.78.

The Age at which the Occurrence of Phonological Errors Fade in Two Speech Tasks.

Frequency of Errors	**Phonological Process**	**Age (yrs; mons) at which occurrence of phonological errors in Najdi Arabic faded/dropped below 10%**					
		Under 2 yrs	2;06 yrs	3;00 yrs	3;06 yrs	4;00 yrs	4;00+ yrs
Rare	Coronal-backing						
	Glottalization						
	Lateralization						
	SCD						
	Liquid gliding/vocalization						
Less Frequent	Velar-Fronting						
	Voicing						
Frequent	Devoicing						
	Fricative-Stopping						
	WSD						
Very Frequent	De-affrication						
	De-emphasis						
	CR						
	CE						

Key: Gray-shaded cells= Picture Naming sample, ,
SCD= Singleton Consonant Deletion, WSD= Weak-Syllable Deletion, CR= Cluster Reduction, CE= Cluster Epenthesis.

From Table 6.78, it can be concluded that Coronal-backing, Glottalization, Lateralization, SCD, and Liquid gliding/vocalization errors fade before the age of 2;00 years or occurred less than 10% in both speech tasks. Rare process that also did not decrease with age can be considered as atypical to the normal development of Najdi-Speaking children, i.e.: Coronal- Backing and Lateralization errors. However, all other rare process (Glottalization, SCD, and Liquid gliding/vocalization) were sensitive to the age of the participants and show a significant effect of the age group, i.e. the occurrence of errors decreased with age. On the other hand, very frequent errors involving the production of complex consonants/components (affricates, emphatics, and consonant clusters) persisted in the speech of a typically developing children beyond the age of 4;02 years, i.e. Deaffrication, De-emphasis, CR, and CE. Similarly, some frequent errors, i.e. Devoicing and Fricative stopping also persisted up to or beyond the age of 4;02 years. It is worth noting that in some phonological errors the frequency of occurrence dropped below 10% in SPON sample at least 6 months earlier than in it did in the PN sample as seen in: Fricative-stopping, WSD, Velar-fronting, and Voicing. In contrast, CR is the only process that faded in PN sample (at 3;06 years) before it faded in the SPON sample (+4;00 years).

Furthermore, the effect of elicitation/sampling method, age-group, gender and syllable/word position were all investigated. In section 6.8.1 through section 6.8.4 below an overall summary each of these variables is presented and section 6.8.5 presents a summary of the general trends found in the results.

6.8.1. Speech-Task effect

In general, children in all age groups made significantly more errors in the PN sample when compared to the SPON sample in phonological errors that are classed as frequent (Devoicing, Fricative-stopping, and WSD) or less frequent (Velar-fronting and Voicing). Similarly, the same trend persisted in two rare phonological processes: Glottalization and SCD. In contrast, only CR errors (very frequent) occurred more frequently in the SPON sample. Finally, there was no significant Speech-Task effect; i.e. no difference in the occurrence of errors between PN and SPON samples in most errors that are classed as very frequent

(De-affrication, De-Emphasis, CE) or rare (Coronal-backing, Lateralization, Liquid gliding/vocalization).

6.8.2. Age-Group effect

In most phonological processes, there was significant main effect of age-group. These errors were very frequent: CR, frequent: devoicing, fricative-stopping, and WSD, less frequent: Velar-fronting and voicing, or rare: Glottalization, SCD and Liquid gliding/vocalization. Interestingly, Gliding errors were found to have a significant age-group effect in the SPON sample but not in the PN sample. On the other hand, age-group had no significant effect on errors that were only classes as very-frequent: Deaffrication, De-emphasis and CE or rare: Coronal-backing and Lateralization.

6.8.3. Gender effect

In the majority of phonological errors investigated in this study, the main effect of Gender was not statistically significant. Even when descriptive statistics suggested that there was a difference in error rates between female and male participants, statistical analysis confirmed that velar fronting, coronal backing, glottalization, voicing, devoicing, fricative stopping, deaffrication, lateralization, liquid gliding/vocalization, SCD, CR, and CE occurred equally in the speech of female and male participants. However, there were two exceptions where Gender had a significant main effect on the occurrence of phonological errors: de-emphasis and positional WSD. In de-emphasis errors, the female participants made significantly more errors than their male peers with moderate effect size ($\eta^2 = .102$) and insufficient power <.8. In other words, the gender of a randomly selected data point might be predicted solely based on its de-emphasis error rate. Also, the low observed power of the test indicates that there is only a 58% chance that the difference in de-emphasis errors between the two genders is true. In contrast, in positional WSD errors the male participants made significantly more errors than their female peers also with moderate effect size ($\eta^2 = .082$) and insufficient power <.8. In other words, the gender of a randomly selected data point might be predicted solely based on its positional WSD error rate. Additionally, the low observed power of the test indicates that there is only a 53% chance that the difference in positional WSD errors between the two genders is true.

6.8.4. Syllable/Word Position effect

The syllable/word position had no significant effect on the occurrence of phonological errors only in processes that were classed as very frequent (i.e. Deaffrication) or rare (i.e. Coronal-backing, Glottalization, and Liquid gliding/vocalization). In contrast, significant positional differences were found in process that were classed as: very frequent: De-emphasis, CR, and CE, frequent: devoicing, Fricative-stopping, and WSD, less frequent: Velar-fronting, and voicing, or even rare: Lateralization and SCD. Moreover, amongst all phonological process that had a significant effect of syllable/word position, consonants in SIWI were the least likely to incur Velar-fronting, Voicing, Fricative-stopping, Lateralization, De-emphasis, and SCD errors and the most likely to incur devoicing errors. On the other hand, consonants in SIWW were the most likely to incur Velar-fronting, Voicing, Fricative-stopping, and Lateralization errors. However, consonants in SFWF and SFWW incurred the most errors in De-emphasis and SCD respectively. Moreover, weak-syllables were deleted the most in word-medial followed by word-initial positions and were least deleted in word-final position. Furthermore, consonant clusters incurred more reduction error in word-final position and more Epenthesis errors in word-initial position.

6.8.5. General trends in phonological errors:

In conclusion, there was a clear trend that suggests phonological errors that are very frequent or rare are less likely to be affected by different elicitation/sampling method, Age-group, or syllable/word position with some exceptions. On the other hand, phonological errors that are frequent or less frequent were almost consistently affected by Speech-Task (sampling method) with more errors in the PN sample except for CR which occurred more in the SPON sample. Moreover, frequent and less frequent errors were also affected by the Age-group with fewer errors occurring in older age groups. Additionally, syllable/word position also had an effect on the occurrence of frequent or less frequent errors. Also, the positional distribution of the errors differed between phonological process. However, in general consonants in the absolute onset (SIWI) incurred the least amount of errors. Finally, the Gender of the participant appeared to have a very limited effect that was only observed in de-emphasis errors in advantage to the males, and in positional WSD errors in advantage to the females. The Gender of the participants had no significant effect on any other phonological process investigated in the current study.

Chapter 7: Discussion and Conclusion

The aim of this study is to address vital gaps in the knowledge of typical phonological development in the Arabic language in the field of child language development. Specifically, this study offers a unique perspective of phonological development with respect to: (1) the collection and comparison of two speech samples: Picture Naming (PN) and an elicited spontaneous sample (SPON); (2) the effect of syllable/word position on consonant acquisition and phonological errors; and (3) the use of statistical tests to compare data across conditions such as gender, age, syllable position and so on, that have been previously presented descriptively in the majority of the literature. This study will contribute to the knowledge of the phonological acquisition of Arabic as it provides information that is crucial for SLTs working with Arabic-speaking children in the Middle East.

In this chapter, a summary of results is presented and compared cross-dialectally and cross-linguistically. To start, in section 7.1., the token frequency of NA consonants that is calculated from the targets of children's SPON samples is compared to previous studies on the Arabic language and other languages. In sections 7.2., 7.3., and 7.4., the effects of: Speech-Task, Syllable/word position, and the token frequency on: PCC, consonant acquisition, and the occurrence of phonological errors are discussed as the three indicators of the maturation of the phonological system under investigation. Within those sections, the effects of the age-group and gender of the participants is also discussed. Section 7.5 provides a summary and a conclusion of the theoretical implications of the findings followed by the contribution of the current study and its clinical implications in section 7.6. Finally, the limitations of the current study in addition to suggestions of the future research are all presented in section 7.7.

7.1. Token Frequency of Consonants

In earlier studies, children's phonological knowledge/development has been linked to the frequency of patterns in the ambient language (Amayreh and Dyson, 2000, Stites et al., 2004, Zamuner et al., 2005). Although both type and token frequencies have been studied and to the present date, there is no consensus in the literature as to which has more influence on phonological development in children. Type frequency is thought to affect the order in which consonants are acquired (Zamuner et al., 2005, Pye, 1979, Edwards et al., 2015) whilst token frequency has been linked to a broader effect on various phonological segments (e.g. consonant, lexical and morphological acquisition) (Stokes and Surendran, 2005). Contrastively, Zamuner et al. (2005) analysed frequencies of English consonants in child directed speech and found that the order in which consonants are acquired is more sensitive to their input token frequency. Similarly, in Japanese, Tsurutani (2007) found that the token frequency of palato-alveolar consonants in child-directed speech predicts the order of acquisition of: /t͡ʃ/, /ʃ/, and /s/. Another study on Kuwaiti Arabic had similar findings in spite of using children's own speech to compile the frequencies of consonants (Alqattan, 2014). In the current study, only on the token frequency of consonants in Najdi Arabic was investigated. The token frequency of consonants were derived from the IPA target of the children's own utterances in the SPON sample and reported in two categories: (a) The token frequency of individual consonants; (b) The token frequency of consonantal manner of articulation groups, in two contexts: comparing and across all syllable/word positions. The main reason for not including type frequency in the analysis is due to the anticipated limited lexicon in children under the age of 4;00 years (i.e. the source for frequency counts in the current study) which will undoubtedly correspond to much lower type frequency counts when compared to adult speech.

7.1.1. Token Frequency: Cross-dialectal Comparison

The frequency of consonants has been studied in several languages of the world, e.g.: Cantonese and English (Stokes and Surendran, 2005); English (Zamuner et al., 2005); Japanese (Tsurutani, 2007), however, for Arabic it has only been reported in adults' speech in a single study on Educated Spoken Arabic (ESA from here after) (Amayreh et al., 1999).Amayreh and Dyson (2000) reported that five of the six most common consonants:/ʔ/, /t/, /b/, /j/, and /l/ in children's speech also occur with high frequency in adult speech (in top ten), yet their frequencies varied considerably between the adults and children (Table 7.1).

Table 7.1.

The Token Frequency of Five Most Frequent Consonants in Two Arabic Dialects and Educated Spoken Arabic.

Study	**(Amayreh and Dyson, 2000)**	**(Amayreh et al., 1999)**	**The current study**
Dialect	*Child's productions in Jordanian Arabic*	*Educated Spoken Arabic 'adults'*	*Najdi Arabic*
[ʔ]	16.4	7.1	8.3
[t]	12.5	6.8	3.1
[b]	8.2	5.1	6.5
[j]	7.8	5.6	3.4
[l]	7.3	12.6	7.4

On the other hand, the token frequency of consonants in ESA (Table 7.1.) appears to be more comparable to the token frequency of the same consonants in children's speech in the current study, perhaps due to age criteria difference between the studies: 12-24 months in Amayreh *et al.* (1999) compared to 22-50 months in the current study. Also, Amayreh *et at.* (1999) had a limited pool of meaningful words within the first 100 utterances to report on for each Jordanian Arabic-speaking child: min = 30 and max = 82 words. Whilst in the current study, all meaningful words were transcribed and included in the analysis in a 20-30 min recording duration: min = 52 and max = 883 words. Moreover, the difference in the frequency of [l] between in the current study and in ESA can be attributed to the expected increase of use of the article 'the' [ʔal] or [ʔɪl] by adults, especially in a more formal or 'educated' form.

Moreover, the token frequency of consonants manner of articulation groups in NA (in the current study) in general is also comparable with other dialects of Arabic (also calculated from child's own target utterances); Kuwaiti (KA), Jordanian (JA), and Egyptian (EA) (Table 7.2). In the table below, Stops, Nasals, and Fricatives are the most frequent manner groups in all Arabic dialects.

Table 7.2.

Token Frequency of Manner of Articulation Groups in Four Arabic Dialects.

	(Amayreh and Dyson, 2000)	**(Saleh et al., 2007)**	**(Alqattan, 2014)**	**Current Study**
Dialect	*Jordanian*	*Egyptian*	*Kuwaiti*	*Saudi/Najdi*
Age range	*1;02-2;00*	*1;00-2;06*	*1;04-3;07*	*1;10-4;02*
Stops	50%	46%	29%	27%
Nasals	12%	19%	16%	14%
Fricatives	17%	17%	31%	33%
Approximants	13%	9%	6%	8%
Laterals	8%	9%	6%	8%
Tap	NR	NR	5%	3%
Trill	NR	NR	*	2%
Affricates	2%	NR	2%	1%
Emphatics	NR	NR	4%	5%

Key: NR= Not Reported, *Trill reported with Tap in Alqattan's study (2014)

In the current study and in KA (Alqattan, 2014) Fricatives were the most frequent of all manner of articulation groups whilst Stops were the most frequent amongst all manner groups in both JA and EA. This difference can, perhaps be attributed to the differences in age-range of target populations between the studies. In both JA and EA, participants were younger than 2;06 years. On the other hand, the age-range of participants in the current study and in KA included participants over the age of 2;06 years while those on JA and EA did not. This too, may have influenced the reported token frequencies in all four dialects. The findings of the current study is supported by similar findings cross-linguistically in longitudinal study on the frequency of consonants in English-speaking children (Robb and Bleile, 1994) where Stops were the most frequent manner groups and the frequency of fricatives remained low and relatively constant between the age of 8 and 25 months.

In the same way, when the token frequency of most frequent consonants was compared to their frequency in other dialects e.g. JA, EA and KA, the token frequency in the current study continued to be most comparable to KA (Table 7.3). Although both Jordan and Kuwait are of similar geographical proximity to Najd, the central region of Saudi Arabia, Jordan is classed as one of Levant Region countries. Similarly, Egypt is classed as a Nile/North-African country whilst both Kuwait and Saudi Arabia are of the Arabian Gulf region. Because both are located within the same geolinguistic[14] region, it is expected that NA and KA have more similarities with each other than with JA or EA. This is especially apparent in the larger number of consonants and phonemes in both dialects: 29 and 32 in KA and 30 and 35 in NA.

[14] Geolinguistics refers to scientific discipline that is concerned with the analysis and implications of the geographical location, distribution and structure of language varieties from an economic, political, and historical standpoint (Al-Wer, 1997).

Table 7.3.

Token Frequency of Most Commonly Produced Consonants in Four Arabic Dialects

	(Amayreh and Dyson, 2000)	**(Saleh et al., 2007)**	**(Alqattan, 2014)**	**Current Study**
Dialect	*Jordanian*	*Egyptian*	*Kuwaiti*	*Saudi/Najdi*
Age	*1;02-2;00*	*1;00-2;06*	*1;04-3;07*	*1;10-4;02*
b	8%	10%	8%	6.5%
t	13%	11%	3%	3%
d	9%	6%	4%	3.5%
k	2%	NR	4%	3%
ʔ	16%	20%	7%	8%
m	7%	8%	7%	4.5%
n	5%	11%	8%	9%
s	NR	6%	3%	2.5%
ħ	2%	4%	3%	3.5%
ʕ	NR	2%	3%	4%
h	6%	6%	8%	8%
j	8%	5%	5%	4%
w	4%	3%	3%	4%
l	7%	9%	6%	7%

Key: NR= Not Reported

Similarly, the token frequency of individual consonants in NA closely resembled its frequency in the Kuwaiti dialect with some differences that can be mainly explained by dialectal variations (Figure 7.1). For example, in SFWF /k/ is realized as [t͡ʃ] in KA but as [t͡s] in Najdi Arabic (Al-Rojaie, 2013, Alqattan, 2014). Also, /j/ has higher frequency in Kuwaiti as it functions as an allophone of /d͡ʒ/ in MSA and NA. For example, [d͡ʒa:b] 'brought' in NA and MSA is realised as [ja:b] in KA and [dɪ.ˈd͡ʒaːd͡ʒ] 'chicken' in NA and MSA is [dɪ.ˈjaːj] in KA. Also, some consonants did not exist in this data: /v/, /ʒ/, /dˤ/, and /zˤ/ and thus were not presented in figure-7.1 below (all of which have frequency below 0.06 in Kuwaiti Arabic).

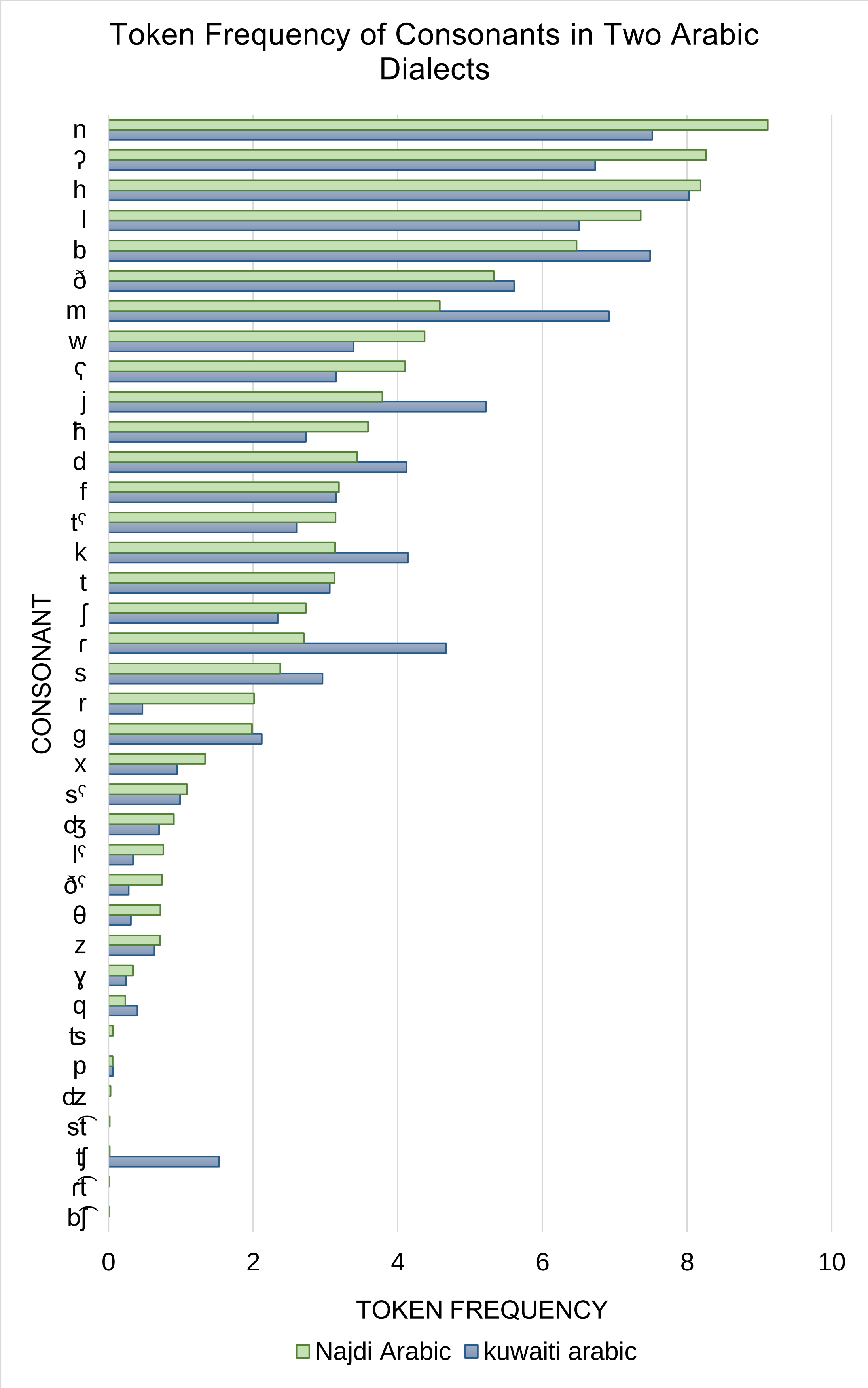


Figure 7.1: Token frequency of Consonants in Najdi and Kuwaiti Arabic.

7.1.2. Token Frequency in a Cross-linguistic Comparison

In English, Wang and Crawford (1960) concluded that dialects had minimal effect on the consonant frequency. In that study, the frequency of English consonants were compared in 10 English dialects and the alveolar place of articulation dominated the top seven most frequent consonants which often were: /t/, /n/, /d/, /s/, /l/, /r/ and /ð/ (Wang and Crawford, 1960). In general, English fricatives appeared to be less frequent than stops with the exception of /s/ and /ð/. The high frequency of the fricative /s/ can be explained by its functional load in plural and possessive forms and the commonality of s-clusters. Likewise, the words: ***the, this, that, those, these, and them*** sustain most of the credit for the high token but low type frequency of /ð/. The token frequency of the inter-dental fricative in English does not corresponds to an early of acquisition; i.e. acquired >7 years (Dodd et al., 2003). In another study that focused on conversational English, the alveolar consonants: /n/, /t/, /s/, /r/, /l/, and /d/ were the most frequent (Mines et al., 1978). However, in the current study, the top 10 frequent consonants vary across six places of articulation: bilabial: /m/, /b/, and /w/, interdental: /ð/, alveolar /n/ and /l/, palatal /j/, laryngeal /ʕ/, and glottal /ʔ/ and /h/ and include three fricatives. In the current study, the high frequency of fricatives did not directly translate into the accuracy of their production especially at a young age: PCC mean 16.97% at Group-1 (see Table 5.13 in chapter 5 for more details) which challenges the role of token frequency as an independent factor.

It is likely that some of the differences between the reported consonant frequencies in Arabic and English originates from methodological differences. In the majority of Arabic studies, the frequencies were derived from the targets of child's own speech (Amayreh and Dyson, 2000, Alqattan, 2014, Saleh et al., 2007). On the other hand, English studies reported consonant frequency from dictionary forms, written, conversational, and child-directed speech. This difference is likely to affect the frequency of Arabic consonant in three ways: (1) the unknown factors affecting child's choice of lexicon; e.g., whether the children avoided words with difficult sounds they could not produce; (2) The limitation of lexical knowledge expected in children under the age of five years; (3) The variation in the frequency of some consonants across Arabic dialects, some of which may or may not be represented in the children's speech. For example, the realization of WF /k/ as [t͡ʃ] in WF when addressing a singular female in KA makes this affricate far more frequent in KA than other Arabic dialects which lack this characteristic. However, Alqattan (2014) reported that some younger children dropped the dialectal realization of /k/ as [t͡ʃ] when speaking to females. The same levelling of the dialect; i.e. the loss of dialect specific realization of /k/ as [t͡s], is also seen in females and younger generations of Najdi-Arabic speakers (Al-Rojaie, 2013). These cross-dialectal comparisons indicate that the changes in the dialect-specific realization of consonants plays a notable role affecting their token frequency that may differ according to the age or gender of the speaker. Therefore, to obtain the most accurate frequency measure of consonants in a specific language, the data must be collected from a representative sample from adults and children speakers of both genders.

In the next few sections, major findings of the current study which are clinically more relevant are discussed in detail: PCC, Acquisition of Najdi consonants, and the development of phonological errors patterns in sections 7.2, 7.3, and 7.4 respectively while considering of the role of token frequency in each section.

7.2. Percent Consonants Correct:

PCC is an accuracy production measure that can allow clinicians to assess the severity of their client's phonological impairment and monitor their progress objectively. Very often, PCC is used in SWAs as in the Diagnostic Evaluation of Articulation and Phonology-DEAP (Dodd et al., 2006) but it also can be calculated in a SSS. In normative studies, PCC has been used as a measure of phonological progression and maturity (Alqattan, 2014, Dodd et al., 2003, Owaida, 2015). In the sections 7.2.1 and 7.2.2. below, the effect of sampling method and syllable/word position on PCC is discussed.

7.2.1. The effect of speech sampling method on PCC

For decades, researchers and clinicians have debated the merits of SSS and SWA and their representation of the child's true phonological abilities. This debate arose from the enthusiasm and commitment to conduct accurate and time efficient assessments and effective treatment planning and delivery. As mentioned earlier in the chapter 2, only a few studies compared SWA and SSS (Morrison and Shriberg, 1992, Wolk and Meisler, 1998, Healy and Madison, 1987, Johnson et al., 1980, Faircloth and Faircloth, 1970, Andrews and Fey, 1986, DuBois and Bernthal, 1978, Masterson et al., 2005, Kenney and Prather, 1986, Hua, 2002), however only in children with known phonological difficulties (participants were often recruited from referrals to speech-language clinics). Moreover, almost all of these studies did not factor in the age of the participants as a variable affecting their performance in either speech task. Although PCC was not reported in the majority of these studies, it was concluded that phonologically impaired children made more errors in SSS and were most accurate in SWA (Faircloth and Faircloth, 1970, DuBois and Bernthal, 1978, Andrews and Fey, 1986, Healy and Madison, 1987). Consequently, SSS was the preferred method of choice by the authors for assessing children with known phonological difficulties.

Furthermore, more recent studies that compared SWA and SSS productions in phonologically impaired children reported higher consonant accuracy in the SSS whilst the SWAs showed more articulatory and phonological errors (Wolk and

Meisler, 1998, Masterson et al., 2005, Morrison and Shriberg, 1992). For example, Morrison and Shriberg (1992) reported that 77% of their subjects had superior PCC in the SSS sample. These findings contradicted the results reported in earlier studies discussed above.

Some researchers argued that the contradiction between these findings can be attributed to the facilitation of the SWA task via the use of prompting techniques, e.g.: phonemic cuing, forced alternatives, and delayed/immediate imitation… etc. Such methods are typically used to avoid missing data when a child fails to spontaneously name the target word using the designed stimulus. Moreover, Wolk and Meisler (1998) found that children had higher PCC in the SSS than in SWA and consequently argued that studies that show less accuracy in the SSS may have used a SWA task that is too simple and does not represent the complexity of the language under investigation. Nevertheless, Wolk and Meisler (1998) only had 13 male subjects with known phonological difficulties, used a very long SWA task that included 162 targets, and excluded short words; i.e. prepositions and conjunctions from their SSS analysis which may have interfered with the accuracy measures calculated in the sample. The specifics of Wolk and Meisler's study may in fact indicate that their SWA task may have been too complex and their SSS is not comprehensive due to elimination of short words. Additionally, their data lacks the representation of the performance of female participants, as a result the generalization of their results on the general population is questionable.

On the other hand, only two studies compared the performance of typically developing children in different speech tasks. Kenney *et al* (1984) investigated PN, story-retelling and the repetition of non-sense words in 4;04-4;08 year-old typically developing English speaking children but limited their interest to eight speech sounds: /t/, /k/, /l/, /s/, /f/, /r/, /t͡ʃ/, and /ʃ/. The authors did not report any significant differences in children's performance (i.e. error type or rate) between the three speech tasks, however gender differences were noted. A more recent study on typically developing Saudi-Arabic-speaking children revealed that younger participants were most accurate in the SSS (Bahakeem, 2016). To my knowledge, no other studies have compared the differences between these elicitation methods in typically developing children.

The findings of the current study contradicts the findings of the earlier studies that compared the accuracy of speech production in SWA vs. SSS (Faircloth and Faircloth, 1970, DuBois and Bernthal, 1978, Andrews and Fey, 1986, Healy and Madison, 1987), however it is in agreement with the findings of the recent ones whether conducted on typically developing children (Bahakeem, 2016, Kenney et al., 1984) or on those with phonologically impaired children (Wolk and Meisler, 1998, Masterson et al., 2005, Morrison and Shriberg, 1992). In spite of methodological differences, all age-groups in the current study had greater SPON-PCC than PN-PCC in general and in all consonantal manner of articulation groups. The difference between PN-PCC and SPON-PCC was especially evident in the production of Fricatives in Group-1(aged 1;10-2;02): SPON-PCC =35.77% vs. PN-PCC 15.51% and the production of Affricates in Group-5 (aged 3;10-4;02): SPON-PCC = 64.33% and PN-PCC = 26.79% where the participants were more than twice as accurate in their productions in SPON sample. These findings suggest that Fricatives are particularly difficult in PN targets at a young age and Affricates remain very challenging in PN targets at all age-groups.

Finally, it can be concluded that the research methods implemented by recent studies (Wolk and Meisler, 1998, Masterson et al., 2005, Morrison and Shriberg, 1992), i.e. the statistical analysis of PCC, resulted in the accurate reporting of true performance differences between SWA and SSS in children and that descriptive differences reported in earlier studies maybe misleading. Also, the contradiction in findings suggest that phonologically impaired children may perform differently from typically developing children in SWA and SSS, however these results need to be replicated on a larger scale comparing the two elicitation methods in both populations using the same SWA targets.

7.2.2. The effect of syllable/word position on PCC

In the literature, most studies do not investigate the difference between onset and coda in medial consonants (e.g. Ayyad et al. (2016), Amayreh and Dyson (1998), Owaida (2015), Smit et al. (1990), Topbas (1997), Arlt and Goodban (1976), MacLeod et al. (2011)) although a minority do (e.g.:Alqattan (2014), Amayreh and Dyson (2000), Amayreh (2003), Topbas (1997)). On the other extreme, others do not even consider testing any word-medial consonants (To et al., 2013, Prather et al., 1975, Lowe, 1989). In the current study, positional PCC was used as a guide to determine the difficulty level of the accurate production of consonants in four syllable/word positions: SIWI, SIWW, SFWW, and SFWF. The findings suggest that children under the age of 3;06 years consistently struggle with the correct production of consonants in medial-coda position; i.e. SFWW and older children aged 4;00 appear to have their lowest PCC in absolute coda; i.e. SFWF. The comparison between all four syllable/word positions clearly suggest a significant difference between the two onsets, two medial, and two codas positions in the order in figure 7.2. below:

Figure 7.2. Syllable/word position difficulty levels.

In contrast, Amayreh and Dyson found that Jordanian-Arabic-speaking children were most accurate in the production of word medial consonants. However, in their stimulus design, all medial consonants were in the medial-onset position except for two consonants in medial-coda (Amayreh and Dyson, 1998). If Amayreh and Dyson's medial consonants are considered equivalent to SIWW consonants in the current study, the results of both studies appear comparable. For instance, PCC in their medial consonants ranged between 48% at age 2;00 yrs and 78% at age 4;00 years and the SIWW-PCC in the current study ranged between 49.8% and 81.3% in the same age range (see Table 7.4 for more details about other age groups). The same trend continues when the percent correct of individual consonants in both speech samples was calculated (as discussed in chapter 5 section 5.5.2.).

Table 7.4.

PCC of Medial Consonants in Onset Position: Cross-dialectal Comparison.

PCC	**Study**	**2;00 yrs**	**2;06 yrs**	**3;00 yrs**	**3;06 yrs**	**4;00 yrs**
Medial consonants	Jordanian Arabic* (Amayreh & Dyson)	48%	57%	70%	68%	79%
SIWW	Najdi-Arabic (Current study)	50%	61%	64%	74%	81%

*. Standard consonants: Percentages obtained from graphs in (Amayreh and Dyson, 1998). Key: PCC= Percent Consonants Correct, SIWW= Syllable-Initial Within-Word

Although only relevant to languages that permit word-medial CVC syllables in their word shapes, it can be conclude that the discrimination between onset and coda within medial consonants is vital and can affect the age of acquisition of the consonants which is discussed in more detail in section 7.3.2. of this chapter.

Furthermore, the proposed order of positional difficulty in the current study is in agreement with universal grammar assigning CV as the universal syllable shape and thus it is considered the least marked whilst other syllable shapes including those comprising coda consonants are more marked (Fee, 1992, McCarthy and Prince, 1986). This in turn gives the advantage of an unmarked/easy/onset position to consonants in SIWI or SIWW whilst coda consonants (SFWW and SFWF) are automatically allocated a more challenging environment with increased markedness and an obvious increase in the articulation complexity of the syllable via the addition of an extra element. Moreover, in Arabic consonants in SFWW almost always create a word-medial heterosyllabic cluster creating an extra level of difficulty by neighbouring consonants in SIWW. The combination of these factors create more chances for production errors in coda consonants and/or in syllables with coda consonants as clearly confirmed by the positional PCC results where consonants in coda positions were significantly less accurate than those in either onset position. Similarly, this proposed positional difficulty can also be explained by the notion of phonologic saliency. In general, consonants in the absolute onset position are considered the most salient, i.e. auditory noticeable, thus are less likely to incur errors. The results of this study highlight the same conclusion via reporting the highest positional percent correct of consonants in SIWI (detailed positional PCC results discussed in section 5.6).

7.2.3. The effect of token frequency and speech sampling method on PCC

As demonstrated earlier in chapter-5 section 5.5.1.1 that the PC of all consonants steadily increased with age. In this section, the relation between the PC of individual consonants and their token frequency is further examined. In the current study, consonants that were produced correctly more than 50% of the time by the youngest age group (average age 2;00 years) also had high token frequency in the SPON sample. This is true for all consonants except for /ð/ and /ʕ/. Because Arabic dialects in the Gulf region are very similar, /ð/ is suspected to have a low type frequency in Najdi Arabic in spite of its high token frequency similar to Alqattan's findings in the Kuwaiti dialect (Alqattan, 2014). Also, /ʕ/ which had high token frequency but very low accuracy at a young age: 25.4%. There is some evidence in the literature that suggest that the token frequency of consonants, derived from child directed speech or child's own target utterances, has a significant impact on their production accuracy and the order of their acquisition (Zamuner et al., 2005, Alqattan, 2014). Below, all consonants produced with accuracy >50% at age 2;00 years are listed along with their corresponding token frequency in the current study. It is clear that none of the highly accurate consonants is low in frequency and vice versa.

Consonant	**Accuracy at Group-1 (speech tasks combined)**	**Token Frequency**
/ʔ/	82%	8.26
/w/	81%	4.37
/n/	79%	9.11
/m/	78%	4.58
/b/	74%	6.47
/l/	66%	7.36
/d/	66%	3.44
/j/	59%	3.79
/h/	51%	8.19

Furthermore, all highly frequent consonants appear to be either unmarked and relatively easy to produce: /n/, /m/, /w/, /j/, /b/, and /d/ or have a high functional load in Arabic: /ʔ/, /l/, and /h/. For example, both /ʔ/ and /l/ are the two consonants in the Arabic equivalent of the definite article 'the': [ʔal] and [ʔɪl]. Also, /h/ in Arabic is used to indicate 3rd person possessiveness of objects. For example, /kuːb/ is 'cup' but [ˈkuː.ˌba.ha] is 'her cup' and [ˈkuː.ˌba.hu] is 'his cup'. Thus, it is only logical to presume that /ʔ/, /l/, and /h/ will also have high input frequency in adults speaking NA due to their grammatical and phonological value.

Almost consistently, all consonants which were targeted in both speech samples had higher accuracy of production in the SPON sample (see section 5.5.2.3). On some occasions, this was not comparable when low frequency consonants: /θ/, /ðˤ/, /ɣ/, /lˤ/, and /t͡s/ were not produced in the SPON sample mainly due to lexical choice. Most interestingly, the comparison of PC of individual consonants revealed that in Group-1, many consonants were not produced correctly in the PN sample presumably due to limited cooperation in a structured task or the failure to identify PN targets despite utilizing the JISH Arabic Communication Development Inventory which was based on the MacArthur-Bates Communicative Development Inventories as a guide to early acquired words in Arabic in the PN design. This in turn limited their PN phonetic inventory to one bilabial and five alveolar consonants namely: /b/, /tˤ/, /s/, /n/, /l/, and /ɾ/. At the same time, their consonant inventory in the SPON sample comprised of 16 consonants: /b/, /t/, /tˤ/, /d/, /k/, /ʔ/, /ð/, /ʃ/, /ʕ/, /h/, /m/, /n/, /l/, /ɾ/, /w/, and /j/ and included bilabial, alveolar, post-alveolar, palatal, velar, and glottal consonants. Another possible explanation to why consonants were more accurately produced in the SPON sample is that SWA including the PN task in the current study are designed to incorporate all possible accounts of the phonological development in a relatively short task. This often mandates the use of marked syllable and word shapes including but not limited to CVC, CCVC, and CVCC in addition to incorporating tri-syllabic and multi-syllabic words. As a result, the task design almost always poses an unnaturalistic representation of the child's ambient language via the increased markedness and articulation complexity in comparison to the SSS/SPON task.

These results highlights the predictable and well documented limitation of using PN in the phonological assessment at a young age (Smit, 1986, Schwartz et al., 1980, Faircloth and Faircloth, 1970, Bauman-Waengler, 2000, Morrison and Shriberg, 1992). For example, Prather et al. (1975) reported that a maximum of 12 of 21 participants aged 2;00 years were able to name the entire of PN targets. Similarly, Fox (2000) had to conduct SSS to assess the youngest participants in spite of using SWA older groups. The combined outcome of all these studies suggest that from a clinical standpoint, SSS is the most sensitive and revealing method in the assessment of young children.

7.3. The Acquisition of Najdi Arabic consonants

In the history of normative phonological studies, methodological differences in data analysis pose a problematic aspect for reporting the age of acquisition of consonants (Smit, 1986). Apart from the sampling method and the age-range of the participants, the criteria of which a speech sound is judged to be acquired makes the comparison hard if not impossible at times. To determine the age of acquisition of consonants, a researcher must decide:

- Whether a sound has to be produced correctly in all or some word positions to be considered as acquired. Some studies only accepted consonants to be acquired when they were produced in all word positions: initial, medial, final (e.g.: Poole (1934), Templin (1957), and Smit et al. (1990)) while Smit (1986) and Prather et al. (1975) considered the correct productions in initial and final positions satisfactory. Lowe (1989), on the other hand, considered a sound acquired if 90% accuracy was reached in either initial or final word position. Other studies used the number of lexical items as a reference instead of the syllable/word position, e.g. correct in two different lexical items (Fox, 2000).
- The minimum percentage of correct production required for a speech sound to be considered as acquired. The majority of studies that used SWA method to collect their data do not state what percentage of correct production of a speech sounds is required in their criterion. Instead they use word or syllable positions to indicate the percentage. This is simply because speech sounds in SWA are likely to be only targeted once in each position therefore studies that required correct production in all investigated positions, a 100% accuracy is implied as the requirement. On the other hand, studies that required the correct production in two out of three word positions have implicitly applied 66.66% criterion. The fact that consonant acquisition occurs gradually and progressively over a long period of time encouraged Amayreh and Dyson (1998) to investigate different levels of acquisition: Mastery level: when 90% of the participants produced the consonant correctly in all word positions; Acquisition level: when 75% of the participants produced the consonant correctly in all word positions; and

Customary production level: when 50% of the participants produced the target consonant correctly in at least two word positions. Although Amayreh and Dyson do not state what counts as 'produced correctly', however the authors used SWA to collect their data. Therefore, 100% accuracy it is implied for the mastery and acquisition levels and 66.66% accuracy is required for the customary production level. Moreover, further distinctions in acquisition levels were also reported: *phoneme emergence*: when a consonants produced correctly at least once, and *phoneme stabilization*: when a consonant is produced correctly in two of three opportunities (Hua, 2002).

- The required percentage of participants in each age group who produced the consonant correctly (at the minimum accurate production level as explained above) to assign an age where the speech sound is considered as acquired. For example, Poole (1934) use 100% criterion whilst both Prather et al. (1975) and Templin (1957) used the 75% criterion. These differences led to a reported earlier age of acquisition of consonants in (Prather et al.) and Templin's when compared to Poole's who applied much more stringent rules. In more recent studies, even more variation can be found in this domain: e.g., 50% in Alqattan (2014), 83% (or 5/6 children) in Naidoo (2003), and 90% criterion has been in a large scale normative study on 684 British English speaking children (Dodd et al., 2003, Dodd et al., 2006).

In the current study, 90% criterion was used, i.e. a consonant is considered mastered by an age group if it was produced with +90% accuracy by 90% of the participants in that age group. The 90% criterion was used because it was estimated that speech disorders in the general population falls between 3-10% (Enderby and Philipp, 1986). Additionally, the at the acquisition and customary production levels: 75% and 50% accurate productions by 90% of the participants respectively (results reported in chapter 5 section 5.8). Moreover, for the purpose of comparison with other normative studies on Arabic, additional analysis was conducted and reported using 90% criterion in two word positions in PN and 90% criterion in 50% of the groups in SPON sample.

7.3.1. The effect of speech sampling method on the acquisition of consonants

Descriptively, fewer consonants appear to be Mastered, Acquired, or Customary Produced in PN sample. Whilst no consonants were mastered by the majority of participants in either speech sample, the differences emerge at the acquisition and customary production levels. In general, consonants that have been acquired or customary produced in the SPON sample are often acquired or customary produced in the PN sample too. However, some consonants only appear acquired in SPON but not in PN sample. Similar discrepancies have been reported in the literature where established sounds were more accurate in the SSS whilst emerging sounds were more accurately produced in SWA (Morrison and Shriberg, 1992). Table 7.5. lists all mastered, acquired, and customary produced consonants in addition to consonants that are consistently present or consistently absent in the current study. For example, /m/ appears as acquired in SPON Group-4 but not in PN Group-4. The same thing occurs at the customary production level of /b/ and /j/ in Group-4 and /b/, /m/, and /n/ in Group-5. In contrast, consonants that have been acquired or customary produced in the PN sample: i.e. /ħ/ at acquisition level and /ɾ/ at customary production level in Group-5 could represent the child's articulation ability or simply be attributed to the task design that accounted for these consonants in the majority of participants whereas in the SPON sample, there was no guarantee that any consonant will be targeted by the majority of the participants in any age group.

Table 7.5.

Najdi-Arabic Phonological Development Profile in Two Speech Tasks: 90% Criterion.

AG/AR	ST	Mastered	Acquired	Customarily produced	Consistently Present	Consistently Absent
G1 1;10-2;02	PN	-	-	-	-	dˤ, q, ðˤ, t͡s, d͡ʒ, lˤ
	SPON	-	-	-	-	dˤ, q, ðˤ, t͡s,
G2 2;04-2;08	PN	-	-	-	-	sˤ, t͡s, lˤ
	SPON	-	-	-	-	dˤ
G3 2;10-3;02	PN	-	-	-	-	-
	SPON	-	-	-	n, l, ɾ, r	dˤ
G4 3;04-3;08	PN	-	-	l	f, n	t͡s
	SPON	-	m	b, l, j	f, ʕ, n, r	dˤ
G5 3;10-4;02	PN	-	ħ	l, r, ɾ	b, d	t͡s
	SPON	-	-	b, r, m, n, l	t, tˤ, f, s, ʃ, ʕ, j	-

Key: AG = Age Group, AR= Age Range, ST = Speech Task, PN= Picture Naming, SPON= Spontaneous,

Qualitatively, it is notable that consonants that are reported as acquired or customary produced in PN sample: /ħ/ and /ɾ/ can be classed as marked/complex and are also less frequent than those reported in the SPON sample: /m/, /n/, /b/, and /j/ which are considered unmarked/easy and are of the 10 most frequent consonants. These results shed the light on the role of token frequency and markedness in the acquisition of consonants in the SPON sample.

Moreover, consonants that are Consistently Present (produced correctly at least once by 90% of the participants in each age group) start emerging at Group-3, indicating great variability in the phonemic inventory amongst children under the age of three years. All consonants that are consistently present have token frequency of 2.0 or more. On the contrary, consonants that are consistently absent from the inventory of the majority of the participants in both speech samples are very similar. These consonants are consistently an emphatic, an affricate, or are not typically found in NA: /q/ and /dˤ/ and have token frequency ≤ 1.

7.3.2. Syllable/word position and gender effects on the acquisition of consonants

Two normative phonological studies on English that assigned a different age of acquisition based on position within a word (Smit et al., 1990, Olmsted, 1971). Olmsted (1971) reported earlier acquisition of /t/ and /θ/ in word-initial and final positions than in medial position. On the other hand, /l/ was acquired before the age of 4;00 years in word-initial position and after 4;00 in medial and final positions. In contrast, /z/ was acquired in word-medial and final positions before the age of 4;00 years and in word-initial beyond the age of 4;00 years. Similarly, Smit et al. (1990) reported an earlier word-initial age of acquisition of two consonants: /f/ and /l/ when compared to their acquisition in word-final position. He also reported gender related age-of-acquisition differences in 10 English consonants. In the majority of those consonants, the females' age-of-acquisition was much earlier than their male peers.

In the current study, the cross comparison of gender and syllable/word position showed a greater effect on the age of acquisition of NA consonants. Table 7.6 below lists all mastered consonants in each syllable/word position using +90% criterion in majority of same gender participants: i.e. 5/6 females or 5/6 males.

Table 7.6.

Positional Mastery of Najdi-Arabic Consonants: Speech Task, Age and Gender Comparison

S/WP	ST	G1 1;10-2;02		G2 2;04-2;08		G3 2;10-3;02		G4 3;04-3;08		G5 3;10-4;02	
		F	M	F	M	F	M	F	M	F	M
SIWI	**PN**	-	-	ʔ	-	ʔ, l, w	-	f, ħ, l, ɾ, w	w	k, ħ, n, l, ɾ, w	tˤ, ʔ, f, ħ, h, l, ɾ, w
	SPON	-	m, w	-	-	w	-	b, k, l, w	-	f, ħ, l, w	k, w
SIWW	**PN**	w	-	ʔ, w	-	g, l, lˤ, w	-	t, g, ʔ, h, n, w, j	g, w	t, g, ʔ, ʃ, x, ħ, l, r, w	t, ʔ, x, ɣ, ħ, l, w
	SPON	-	m, w	w, j	n, w	w	j	b, k	k, j	ħ, m, n, w	b, k, m
SFWW	**PN**	-	-	-	-	w, j	m, n	b, k, g, f, ħ, h, n, w, j	g, f, n	b, f, x, ħ, h m, j	b, f, sˤ, ʃ, x, ħ, w
	SPON	-	m	-	d	-	k, m	-	ħ	f, m,	j
SFWF	**PN**	-	-	ʔ, f, m, j	-	ʔ, j	m	k, g, ʔ, f, ħ, m, n	ʔ, f, ʃ, j	d, k, g, f, ʃ, x, ħ, ʤ	tˤ, d, k, f, θ, ʃ, x, j
	SPON	-	m, w	m	-	ʔ	-	m,	-	f	ħ

Key: S/WP= Syllable/Word Position, ST= Speech Task, PN= Picture Naming, SPON= Spontaneous, F= Female, M=Male, SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word ,SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

An obvious pattern can be seen in the results in favour of the females aged ≥2;04 years. These findings are in agreement with the known higher prevalence of Speech disorders in boys (Shriberg et al., 1999, Wren et al., 2016, Beitchman et al., 1986, Stevenson and Richman, 1976). The majority of the female participants in groups 2, 3, and 4 consistently mastered consonants before their male peers across speech samples and syllable/word positions. In Group-1, males appear to perform better in the SPON sample than their female peers whilst there was no obvious difference in the PN sample across all syllable/word positions except in SIWW, where females acquired a single consonant /w/ and their male peers acquired none. In contrast, Group-5 (3;10-4;02 years) has no clear pattern that differentiates female and male participants' performance. In general, by the age of 4;00 years the gender differences are less drastic and are more speech-task and syllable/word position specific. For example, male participants master more consonants in SIWI position in PN, whereas the females master more consonants in both SIWI and SFWW of the SPON sample and in SIWW in both speech samples. However, in SFWF position, female and male participants show mastery of roughly the same number of consonants across both speech samples. In general, females are likely to master consonants at an earlier age than their male peers. For example, in the PN task, /ʔ/ is mastered in SIWI and SFWF by the females at age 2;06 and by the males at age 4;00 and 3;06 years consecutively. Similarly, /w/ in PN-SIWW is mastered by the females at age 2;00 years and by the males at age 3;06 years.

Positional differences also occur within same-gender participant. For example, in the PN sample, /ħ/ is mastered by the female participants by the age of 3;06 years in SIWI, SFWW, and SFWF but at age 4;00 years in SIWW. Similarly, females master /l/ in absolute and medial onset positions by the age of 3;00 years yet they fail to master it even a year later in either coda position. On the other hand, male participants in Group-1 demonstrated the mastery of /m/ in the SPON sample in all four syllable/word positions yet mastered /w/ in three positions only: SIWI, SIWW, and SFWF.

What is clear is that gender differences are present at a young age (2;04-3;08 years) in favour of the females. Nonetheless, males appear to catch up on their phonological development by the age of 4;00 years.

The differences between female and male participants are also seen on a larger scale when looking at manner of articulation categories. For example, two fricatives: /f/ and /ħ/ are mastered by the females in Group-4 in SIWI, SFWW, and SFWF in the PN sample yet are not mastered by their male peers until at least six months later. Moreover, two emphatic consonants appear to be mastered only by the male participants in Group-5: /tˤ/ at word boundaries and /sˤ/ in medial coda position whilst only SIWW /lˤ/ was mastered by the females in Group-3 and no other emphatics have been acquired at any age group in the PN sample[15]. However, females in Group-5 master the affricate /ʤ/ in the PN sample while the males in any age group did not. Table 7.7 below summaries the gender and speech-task differences in the mastery of Najdi consonants across all syllable/word positions. Table 7.7. also highlights the conflict between the higher number of consonant mastered in the PN sample by both genders (between the ages of 1;10-3;08 years in females and 3;10-4;02 years in males) in spite of the increased markedness and complexity of the PN task (previously discussed in section 7.3.2.). Even though the PN task included more marked structures, there is an undeniable pattern in which unmarked but also marked consonants appear as mastered in the PN sample whereas mostly unmarked consonants appear as mastered in the SPON sample. These results may be affected by connected speech effect in SPON sample and/or the controlled and guaranteed opportunities for targeting all consonants (marked and unmarked) in PN task as discussed earlier in section 7.3.1.

[15] These findings may mirror a socio-phonetic pattern in the adult community, whereby females de-emphasise more than males as it is thought to be ‘more feminine’.

Table 7.7.

The Age of Mastery of Arabic Consonants by Najdi-Arabic Speaking Children in at least one syllable/word position: Speech-Task and Gender Comparison.

Age Range		≤2;02 yrs	2;04-3;08 yrs	3;10-4;02 yrs	Not Acquired
Females	PN	w	b, t, k, g, ʔ, f, ħ, h, l, lˤ, ɾ, m, n, j	d, ʃ, x, r, d͡ʒ	Stops: q Fricatives: θ, ð, s, z, ʕ, ɣ Affricate: t͡s Emphatic: tˤ, dˤ, ðˤ, sˤ
Females	SPON	-	b, k, ʔ, l, m, w, j	f, ħ, n	Stops: t, d, g, q Fricatives: θ, ð, s, z, ʃ, x, ʕ, ɣ, h Tap & Trill: ɾ, r Affricate: t͡s, d͡ʒ Emphatic: tˤ, dˤ, ðˤ, sˤ, lˤ
Males	PN	-	g, ʔ, f, ʃ, n, w, j	b, t, tˤ, d, k, θ, sˤ x, ɣ, ħ, h, r, l, m, j	Stops: q Fricatives: ð, s, z, ʕ Tap: ɾ Affricate: t͡s, d͡ʒ Emphatic: dˤ, ðˤ, lˤ
Males	SPON	m, w	d, k, n, j	b, ħ	Stops: t, ʔ, g, q Fricatives: f, θ, ð, s, z, ʃ, x, ʕ, ɣ, h Tap & Trill: ɾ, r, Lateral & Affricates: l, t͡s, d͡ʒ Emphatic: tˤ, dˤ, ðˤ, sˤ, lˤ

Key: PN= Picture Naming, SPON= Spontaneous.

7.3.3. The effect of proportional positional token frequency on the acquisition of consonants

When the proportional positional frequency was compared amongst manner of articulation groups, a clear relationship was evident between the proportional token frequency at a specific syllable/word position and its accurate production in that same position (Table 7.8). For example, stops were found to be most frequent in SIWI whilst emphatics most frequently occurred in SFWW position. Consonants in SIWI were the least likely to exhibit erroneous productions as they are most salient. Also, in the current study consonants in SIWI had the highest PCC however, the correct production of consonants in SFWW was the most challenging (see section

5.6. in chapter 5). Subsequently, the late acquisition of emphatic consonants can be explained by the combination of several factors that makes them 'hard': low general token frequency, proportional positional token frequency favouring SFWW position, and a complex secondary place of articulation. Nevertheless, the interpretation of these results remain deductive in nature and cannot be confirmed as the literature lacks statistics on the positional type/token frequency of speech sounds in Arabic-speaking adults due to the lack of large corpora that are mined for this kind of information and due to the absence of dictionary knowledge on particular dialects.

Table 7.8.

Syllable/word Positions with Highest and Lowest Proportional Positional Token Frequency in Manner of Articulation Groups.

Manner of Articulation Groups	**Syllable/word Position**	
	Highest proportional token frequency	*Lowest proportional token frequency*
Stops	SIWI	SFWW
Nasals	SFWF	SFWW
Fricatives	SIWI, SIWW	SFWW
Affricates	SIWI, SIWW	SFWF
Tap	SIWW	SFWF
Trill	SFWF	SIWI
Approximants	SFWW	SFWF
Laterals	SFWW	SIWI
Emphatics	SFWW	SIWI

Key: SIWI = Syllable-Initial Word-Initial, SIWW = Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

The same pattern continues when other manner groups of consonants were examined. Fricatives in the current study were the most frequent type of consonants yet Nasals, Approximants and Stops in general were acquired first. These cannot be explained by token frequency or the sonority index, which suggests most sonorous consonants are acquired first whilst least sonorous are acquired late. In the sonority index, Stops are the least sonorous; nevertheless, they are universally acquired early. The results of the proportional positional token frequency may offer a plausible explanation, at least in the Najdi dialect. In the current study, Stops were most frequently positioned in SIWI and least frequently positioned in SFWW positions. This distribution alongside the findings of positional PCC gives Stops the advantage over Nasals and approximants that are most frequent in SFWF and SFWW respectively. This difference in the proportional positional frequency may have led to an accurate production and early acquisition of Stops despite being more 'complex' than Nasals and Approximants. Even when the distribution of the proportional frequency was similar, e.g. as in between Stops and Fricatives, Stops have the advantage of being 'easier' thus were acquired earlier.

Moreover, whilst all manner of articulation groups became more accurate over time, the proportional positional token frequency provides a partial explanation to the fluctuation in the accurate production of nasals seen earlier in Figure 5.16. In the current study, Nasals were found to be most frequently located in the absolute coda position (SFWF) which is a marked position within the syllable that also has the second lowest PCC (detailed results in chapter 5 section 5.6.). Additionally, participants in Groups 4 and 5 acquired fewer consonants at word boundaries especially in SFWF by the females (as discussed in the summary of chapter 5 in table 5.63.). The combination of low PCC in SFWF, positional token frequency distribution favouring SFWF, and the age-related shift seen in positional consonant acquisition findings can clarify the regression in the correct production of nasals in Group-5.

Similarly, in the current study, the results of positional token frequency and positional acquisition of consonants indicate that individual consonants can be mastered at different rates in different syllable/word positions. It logical to assume that the age of acquisition of a consonant is directly related to its typical distribution (i.e. type and token frequency) and the phonotactic constraints in that specific language/dialect. Even though Arabic allows almost all consonants to occur in all syllable/word positions, the rates of their occurrence in each syllable/word position differ (see section 5.4.2.2. for details on the positional token frequency of NA consonants). As a result, the low positional token frequency limits the ‘training’ opportunities a child gets in his/her phonological development journey of that specific sound in that specific position. For example, /ð/ is one of the most frequent consonants in English; however, it mostly occurs in SIWI position. Therefore, studies that required consonants to be produced correctly in SFWF or word-final position (in addition to other positions) before considering /ð/ as mastered may have reported a much later age of acquisition: >6 years (e.g. Dodd et al. (2003), McLeod and Crowe (2018)). On the other hand, studies that considered different age of acquisition in different syllable/word positions often reported an earlier age of mastery in at least one position. Only one study examined and reported positional differences in the age of acquisition of English consonants (Olmsted, 1971). In that study, six consonants: /t/, /θ/, /z/, /t͡ʒ/, /d͡ʒ/, and /l/ were reported to be sensitive to syllable/word position influencing the age at which they were acquired. Likewise, in the current study, positional differences in the age of mastery can be seen in even more consonants (in combination with speech-task and gender differences). For example, in the PN task, female participants mastered /ʔ/ at 2;06 years in SIWI, SIWW, and SFWF but >4;00 years in SFWW; /f/ at 2;06 years in SFWF, at 3;06 in SIWI and SFWW, and >4;00 in SIWW; /ħ/ at 3;06 in SIWI, SFWW, and SFWF, and at 4;00 in SIWW; and /l/ at 3;00 in SIWI and SIWW, but >4;00 in both SFWW and SFWF (refer to table 7.6 for full details). For this reason, the natural distribution of the consonants was taken into consideration during data analysis and in the reporting of the age of acquisition of all NA consonants.

In conclusion, the acquisition of any consonant or group of consonants can seldom be explained via a particular characteristic or feature. It is, in fact, the result of multiple factors competing against one another. This examination of the effect of syllable/word position has additional benefits as reported in the analysis of phonological error patterns in chapter 6 and discussed in later sections of this chapter.

7.3.4. NA consonant acquisition: cross-dialectal comparison

In the current study, a dilemma was faced when comparing the results of the current study with previous yet limited studies on Arabic. Not only do they differ on which Arabic dialect was investigated, but also in data collection method, i.e. speech task, age range, and the criterion used to report on the results. While a few studies focused on SSS (Amayreh and Dyson, 2000, Al-Buainain et al., 2012, Alqattan, 2014, Saleh et al., 2007, Khattab, 2007), the majority used SWA (Amayreh and Dyson, 1998, Amayreh, 2003, Dyson and Amayreh, 2000, Morsi, 2003, Ayyad et al., 2016, Abou-Elsaad et al., 2019, Owaida, 2015)[16].

Below, a comparison of the detailed findings of consonant acquisition in three Arabic dialects, two studies using SWA (Owaida, 2015, Amayreh and Dyson, 1998) and another that used SSS (Alqattan, 2014) is presented. Although all the studies used the same 90% criterion in their analysis, they applied it differently. In the current study, consonants were mastered if they show +90% accurate production in all syllable/word positions in +90% of the participants. In Owaida (2015) consonants were reported as acquired if 90% of the participants produced them correctly in two word positions: I and F or M and F. Owaida chose to report on the acquisition of consonants in two word positions only based on her insignificant PCC results between I and M consonants, thus implicitly applied a 66.66% criterion of the overall correct production. Moreover, Amayreh & Dyson reported three stages of acquisition: Mastery: correct production by 90% of the participants in all three positions, Acquisition: correct production by 75% of the participants in all three positions, and Customary production: correct production by 50% of the participants in at least 2 of 3 positions (I, M, and F). As explained earlier in section 7.3., Amayreh & Dyson applied 100% criterion in mastery and acquisition levels and 66.66% criterion in customary production level. It is also worth noting that the authors of both studies offered no discrimination between the onset and coda in the medial position. On the other hand, Alqattan (2014) did discriminate between onset and coda in word-medial position; however, the mastery of Alqattan's

[16] Only one study was completed as a partial fulfilment of a Ph.D research degree investigated both SSS and SWA (Bahakeem, 2016). Unfortunately, its detailed findings could not be compared to the current study as it had restricted access.

consonants was reported on the basis of 90% accuracy in only 50% of the participants in each age group which yielded earlier age of acquisition of most consonants in Kuwaiti Arabic. For the purpose of comparison, the findings of the current study are also reported using the same criteria the authors used in these studies in Tables 7.9, 7.10, 7.11 and 7.12 below. Moreover, all studies cover a similar age range under investigation as in the current study, yet with overlapping age groups that either include different age intervals (Alqattan, 2014, Amayreh and Dyson, 1998) or slightly different age range resulting in higher average age amongst age groups (Owaida, 2015) which makes a straight forward comparison quite difficult.

Table 7.9.

The Acquisition of Arabic Consonants in SWA: Cross-Dialectal Comparison.

	Syrian Arabic (Owaida, 2015)	Jordanian Arabic (Amayreh and Dyson, 1998)		Najdi Arabic (The current study)		
Approx. average age	**Mastered** *90% accurate productions in 2/3 positions (I, M, & F)*	**Mastered** *90% accurate productions in all positions (I, M, & F)*	**Acquired** *75% accurate productions in all positions (I, M, & F)*	**Mastered** *90% accurate in all four positions 90% of participants*	**Acquired** *75-89% accurate in all four positions in 90% of participants*	**Modified criteria** *90% accurate productions in 2 positions*
2;00 yrs	NISA NISA	2;00-2;04 -	2;00-2;04 ʔ, m	1;10-2;02 -	1;10-2;02 -	1;10-2;02 -
2;06 yrs	2;06-2;11 b, f, j, h, m, n, l, w, ʔ, t,	2;06-2;10 n, w	2;06-2;10 t, k, q, j, f, ħ, n, w	2;04-2;08 -	2;04-2;08 -	2;04-2;08 ʔ
3;00 yrs	3;00-3;05 d, h	3;00-3;04 q, ʔ, f, j	3;00-3;04 b, d	2;10-3;02 -	2;10-3;02 -	2;10-3;02 ʔ, l, w, j
3;06 yrs	3;06-3;11 ʕ, s, z	3;06-3;10 k, m	3;06-3;10 l	3;04-3;08 -	3;04-3;08 -	3;04-3;08 k, g, ʔ, n, w, j, f, ħ, h
4;00 yrs	4;00-4;05 x	4;00-4;04 t	4;00-4;04 d͡ʒ	3;10-4;02 -	3;10-4;02 ħ	3;10-4;02 tˤ, g, ʔ, f, ʃ, x, ħ, h, l, w, j
+4;00	4;06-6;05* k, dˤ, tˤ, ɣ, r, sˤ , ʃ	4;06-6;06* b, θ, x, dˤ l, r	4;06-6;06* x, θ, s, h, l, ðˤ, sˤ, ɣ, j	NISA	NISA	NISA

*. Combined multiple groups, Key: I= Initial, M= Medial, F= Final, NISA= Not Included in Study's Age-range

In spite of all the methodological differences, there are some similarities. For example, /ʔ/ is acquired by the age of 2;06 years; /w/ by the age of 3;00 years; /n/ by 3;06 years; and /x/ by 4;00 years. These results are not surprising given the universal predictability of the early acquisition of glottal, glide, and alveolar nasal sounds. Although the studies used SWA/PN to target all consonants, the fact remains that the studies used different stimuli. The current study only has 13 targets in common with Owaida (2015). Most importantly, Owaida's task design used simpler word shapes: i.e. 20 mono-syllabic, 26 di-syllabic, six tri-syllabic targets, only 13 targets that have consonants in SFWW position, and none targeted consonant clusters. Similarly, Amayreh and Dyson's stimulus contained 10 mono-syllabic, 30 disyllabic, 18 tri-syllabic targets with only two consonants in SFWW and no consonant clusters were targeted either. In the current study, the design included: 19 mono-syllabic words 14 of which include WI or WF clusters, 39 disyllabic, 10 tri-syllabic, and two quadri-syllabic targets, and most importantly all consonants were targeted in SFWW position. This clear difference in the level of complexity in the number and shape of syllables of the chosen targets is known to interfere with the consonants' production accuracy (Panagos et al., 1979, Kirk and Demuth, 2006).

In the SPON sample (Tables 7.10, 7.11 and 7.12) consonant acquisition results in the current study are compared to Kuwaiti Arabic (KA from here after) at Mastery, Acquisition, and Customary production levels. Again, in the current study stricter rules for consonant acquisition have been applied when compared to the criterion applied by Alqattan (2014) in KA. Therefore, and for the purpose of fair comparisons, the results of the current study have been revised and reported using the same 90% accuracy criterion in 50% of the participants (third column). Because Alqattan (2014) used different age ranges, the inventory of consonants in the youngest and overlapping groups were merged to best match the age-groups in the current study. In general, earlier age of Mastery is reported on most consonants in the KA than in NA despite the application of identical criterion (Tables 7.10, 7.11 and 7.12).

Table 7.10.

The Mastery of Arabic Consonants in SSS: Cross-Dialectal Comparison.

Approx. average age	**(Alqattan, 2014) "Kuwaiti Arabic"**	**The current study "Najdi Arabic"**	
	90% accurate in 50% of participants	*90% accurate in all four positions in 90% of participants*	*90% accurate in all four positions in 50% of participants*
<2;00 yrs	1;04-1;11***** ʔ	NISA	NISA
2;00 yrs	2;00-2;03 k, ʔ	1;10-2;02 -	1;10-2;02 m, n, w
2;06 yrs	2;04-2;11***** k, m, n, ʔ, w	2;04-2;08 -	2;04-2;08 n, w
3;00 yrs	3;0-3;3 b, k, m, ʔ, n, h, w, l	2;10-3;02 -	2;10-3;02 w
3;06 yrs	3;04-3;07 p, b, t, d, k, g, ʔ, m, n, f, s, w, l, ɫ	3;04-3;08 -	3;04-3;08 k, m, n, w
4;00 yrs	NISA	3;10-4;02 -	3;10-4;02 dˤ, k, x, ħ, n, ɾ, w, j

*. Combined groups. Key: SSS= Spontaneous Speech Sample, NISA= Not Included in Study's Age-range

In general, the results of the current study follow the predictable universal pattern of speech sound acquisition. For example, in Table 7.10 above, NA-speaking children mastered /m/, /n/ and /w/ at least six months earlier than their KA-speaking peers who have only acquired these sounds (Table 7.11 below). Similarly, Saudi children acquire /ʔ/ by the age of 2;00 (Table 7.11 below) years whilst their Kuwaiti peers have mastered it (Table 7.10). In contrast, Kuwaiti children mastered /k/ more than 18 months earlier than their Saudi peers. Both studies agree that /m/, /n/, /w/, and /k/ are the earliest consonants to be mastered however, Kuwaiti children display the mastery of a few more consonants by the age of 3;03 years: /b/, /ʔ/, /h/, and /l/ which are only acquired by their Saudi peers. By the age 3;07 years Kuwaiti children have mastered most stops, two laterals, and two front fricatives /f/ and /s/. The same consonants are not mastered by Saudi children at age 4;00; however, Saudi children appear to have mastered other marked consonants: emphatic /dˤ/, tap /ɾ/, velar fricative /x/, and pharyngeal fricative /ħ/.

Table 7.11.

The Acquisition of Arabic Consonants in SSS: Cross-Dialectal Comparison.

Approx. average age	**(Alqattan, 2014) "Kuwaiti Arabic"**	**The current study "Najdi Arabic"**	
	75-89% accurate in 50% of participants	*75-89% accurate in all four positions in 90% of participants*	*75-89% accurate in all four positions in 50% of participants*
<2;00 yrs	1;04-1;11***** b, m, n, t, w, j	NISA	NISA
2;00 yrs	2;00-2;07 b, t, d, k, m, n, s, h, l, w, j	1;10-2;02 -	1;10-2;02 b, ʔ
2;06 yrs	2;08-2;11***** b, t, d, n, r, f, h, w, j, l	2;04-2;08 -	2;04-2;08 d, ʔ, m
3;00 yrs	3;0-3;3 t, d, g, ɾ, n, f, s, z, ʃ, ħ, j, ʧ, ðˤ, tˤ	2;10-3;02 -	2;10-3;02 b, d, k, ʔ, m, l, j
3;06 yrs	3;04-3;07 r, z, ʃ, x, ħ, ʕ, h, j, ʤ, ʧ, tˤ, sˤ	3;04-3;08 m	3;04-3;08 b, d, g, ʔ, ʕ, h, n, r, j
4;00 yrs	NISA	3;10-4;02 -	3;10-4;02 b, t, tˤ, ʔ, f, ð, h, l

*. Combined groups. Key: SSS= Spontaneous Speech Sample, NISA= Not Included in Study's Age-range.

Surprisingly, /t/ is acquired by Kuwaiti children more than 2 years earlier than the participants in the current study. Similarly, /d/, /tˤ/, /g/, and /r/ are acquired at least 6 months earlier by KA-speaking children than by NA-speaking children. However, some similarities rise in the acquisition of fricatives. Overall, in both dialects, children appear to start mastering fricatives beyond the age of 3;00 years. For example, /ʕ/ and /h/ are both acquired at 3;06 in both dialects. On the other hand, KA-speaking children acquire three emphatics: /ðˤ/, /tˤ/ and /sˤ/ by the age of 3;07 years whilst NA-speaking children only acquire /tˤ/ by the age of 4;00 years.

At the customary production level (Table 7.12 below), consonants that are complex/marked: trill, dorsal fricatives, affricates, and emphatic are reported in

Kuwaiti dialect. Similar trend in the Najdi dialect is reported, however on a smaller scale.

Table 7.12.

The Customary Production of Arabic Consonants in SSS: Cross-Dialectal Comparison.

Approx. average age	**(Alqattan, 2014) "Kuwaiti Arabic"**	**The current study "Najdi Arabic"**	
	50-74% accurate in 50% of participants	*50-74% accurate in all four positions in 90% of participants*	*50-74% accurate in all four positions in 50% of participants*
<2;00 yrs	1;04-1;11 yrs t, d, k, g, s, ʃ, h, w, l	NISA	NISA
2;00 yrs	2;00-2;07 yrs t, d, g, f, z, x, ħ, h, l, ʧ, ʤ, sˤ	1;10-2;02 yrs -	1;10-2;02 yrs j
2;06 yrs	2;08-2;11 yrs g, s, z, x, ħ, ʕ, ðˤ	2;04-2;08 yrs -	2;04-2;08 yrs t, s, ħ, h, l, ɾ
3;00 yrs	3;0-3;3 yrs r, θ, ð, x, ʕ, ɫ, ʤ , sˤ, zˤ	2;10-3;02 yrs -	2;10-3;02 yrs t, g
3;06 yrs	3;04-3;07 yrs q, ɾ, ɣ, ðˤ	3;04-3;08 yrs b, l, j	3;04-3;08 yrs -
4;00 yrs	NISA	3;10-4;02 yrs b, r, m, n, l	3;10-4;02 yrs s, z, ʕ, ʤ

Key: SSS= Spontaneous Speech Sample, NISA= Not Included in Study's Age-range.

To further advance the discussion, the results of the current study are presented and compared to previous developmental studies on Arabic phonology in a categorical fashion based on an age-range of acquisition i.e.: *Very Early sounds:* mastered at 1;00-2;06 years, *Early sounds:* mastered at 2;07-4;00 years, *Intermediate sounds:* mastered at 4;01-6;04 years, and *Late sounds*: mastered after 6;04 years (tables 7.13 and 7.14). In general, Stops, Nasals, and Glides are acquired first with the occasional appearance of other consonants: a lateral or a fricative. Despite the discrepancies between the findings of the studies, there was general agreement on a group of sounds that are the first to be acquired: /b/, /t/,

/d/, /k/, /g/, /ʔ/, /ħ/, /m/, /n/, /l/, /w/, and /j/ in SWA studies (Table 7.13) and /b/, /d/, /m/, and /n/ in SSS studies (Table 7.14) before Tap, Trill, Fricatives (especially coronals), Affricates and Emphatics.

Table 7.13.

Categorical Acquisition of Arabic Consonants in SWA studies.

SWA studies	***Amayreh & Dyson (1998)***	***Ammar & Morsi (2006)***	***Ayyad (2011)***	***The current study***	
Dialect	Jordanian	Egyptian	Kuwaiti	Najdi	
Age	2;00-6;04	3;00-5;00	3;10-5;02	1;10-4;02	
N	180	36	80	60	
Gender	F & M	F & M	F & M	F	M
b	E	E	E	E	
t	E	E	E	E	E
tˤ	L	E	I		E
d	E	E	E	E	E
dˤ	L	I	I		
k	E	E	E	E	E
g		E	E	E	E
q	E		E		
ʔ	E	E	E	E	E
f	E	E	I	E	E
θ	I	E			E
ð	L				
ðˤ	I		E		
s	I	E			
sˤ	I	E	E		E
z	I				
ʃ	I	E		E	E
x	I	E	E	E	E
ɣ	I	I	I		E*
ħ	E	E	E	E	E
ʕ		E			
h	I	E	E	E	E
t͡s			E		
t͡ʃ			E		
d͡ʒ	I		I	E*	
m	E	E	E	E	E
n	E	E	E	E	E
l	E	E	E	E	E
lˤ				E	
ɾ				E	
r	I	E	E	E	E
w	E	E	E	VE	E
j	E	E	E	E	E

Key: SWA= Single-Word Assessment, N= Number of participants, F= Female, M= Male, VE = Very Early (1;00-2;06 yrs), E = Early (2;07-4;00 yrs), I = Intermediate (4;01-6;00 yrs), L = Late (> 6;04 yrs). *Can also be considered Intermediate as it is mastered in Group-5 aged 3;10-4;02 in the current study.

Table 7.14.

Categorical Acquisition of Arabic Consonants in SSS studies.

SSS studies	***Amayreh & Dyson (2000)***	***Saleh, et al (2007)***	***Alqattan (2014)***	***The current study***	
Dialect	Jordanian	Egyptian	Kuwaiti	Najdi	
Age	1;02-2;00	1;00-2;06	1;04-3;07	1;10-4;02	
N	13	30	70	60	
Gender	F & M	F & M	F & M	F	M
b	VE	VE	E	E	E
t	VE	VE	E		
tˤ					
d	VE	VE	E		E
dˤ					
k			E	E	E
g			E		
q					
ʔ	VE		VE	E	
f			E	E	
θ					
ð					
ðˤ					
s			E		
sˤ					
z					
ʃ	VE				
x					
ɣ		VE			
ħ	VE	VE		E	E
ʕ	VE	VE			
h	VE				
t͡s					
t͡ʃ					
d͡ʒ					
m	VE	VE	E	E	VE
n	VE	VE	VE	E	E
l	VE		E	E	
lˤ			E		
ɾ					
r					
w	VE		VE	E	VE
j	VE	VE		E	E

Key: SSS= Spontaneous Speech Sample, N= Number of participants, F= Female, M= Male, VE = Very Early (1;00-2;06 yrs), and E = Early (2;07-4;00 yrs)

Fricatives that were acquired early by either gender in the current study in the PN data were also reported to be acquired early by at least two other Arabic dialects. Most of these fricatives: /f/, /sˤ/, /x/, /ɣ/, /ħ/, and /h/ are produced at the back of the vocal tract; i.e. velar, pharyngeal or glottal. On the other hand, only two fricatives have been reported as acquired early by either gender in SPON data: /f/ and /ħ/ that have also been reported as acquired early by other studies on Arabic (Amayreh and Dyson, 2000, Alqattan, 2014, Saleh et al., 2007).

The difference between SWA and SSS in seven studies on Arabic phonology supports the methodology of choice for data collection in the current study. In other words, SWA may be a quick and cost-effective clinical method to assess child's articulation and phonology but it surely does not represent the functionality or the transfer of such skills into connected speech in everyday life. This was especially clear when the same participants in the current study took part in both tasks and performed differently.

Now that the acquisition of NA consonants have been compared to other Arabic dialects, in the next sections they are further compared cross-linguistically to English and other languages.

7.3.5. The acquisition of NA consonants: cross-linguistic comparison

Methodological differences in the collection and analysis of normative phonological studies continue to hinder the comparability of results not only within the same language but also in cross-linguistically. Speech sampling method, acquisition criteria, application of criteria on group, syllable/word positions, number of participants in the study all affect the results as discussed in section 7.3 of this chapter. However, in cross-linguistic comparisons, other factors play a role too, such as the difference in frequency and functional load of consonants between the languages.

In earlier phonological studies on various Arabic dialects it was reported that fricatives are acquired at a much earlier age than English Speaking children. This was often justified by the fact that Arabic has more fricatives than English (Amayreh and Dyson, 1998). However, the findings suggest that the speech-sampling method, syllable/word position and gender differences greatly influence which fricatives are acquired at an early age, i.e. ≤4;00 years. For example, based on the PN task alone one could conclude that males in Group-5 acquired eight fricatives: /f/, /θ/, /ʃ/, /sˤ/, /x/, /ɣ/, /ħ/, and /h/. Whereas if one takes the SPON sample into consideration, it would show that /ħ/ is the only acquired fricative. Similarly, based on the PN sample alone, their female peers appear to have acquired five fricatives: /f/, /ʃ/, /ħ/, /x/, and /h/, at the same time as they appear to have only acquired two fricatives: /f/ and /ħ/ in the SPON sample.

In English, the fricative /f/ has been reported to have a different age of acquisition according to the study in question: 2;04 years in Prather et al. (1975), 3;00 years in Templin (1957), 3;06 years in Smit et al. (1990) and Dodd et al. (2003), and < 4;00 years in Olmsted (1971). If such inconsistency is reported over several decades between normative studies on the English language, more differences are expected cross-linguistically. In the current study, /f/ was acquired in the PN sample between the ages of 3;10 and 4;02 years whilst in KA it was reportedly acquired earlier at the age of 3;06-3;10. Similar to Prather et al. (1975), Topbas (1997) reported an early acquisition of /f/ at the age of 2;00-2;04 years in Turkish.

Moreover, in table 7.15 below early, intermediate, and late acquisition of consonants were compared between developmental studies on English, Arabic, and the current study. It is worth noting that English studies used a slightly later age range for the early and intermediate sounds. Consequently, the results of Arabic studies were revised and reported in a manner that fits the age range for each category as assigned in English studies. In the first instance, it is obvious that the upper age limit in the current study precludes any conclusions regarding the age of acquisition of late consonants beyond the age of 4;02 years. Moreover, the stringent rules of analysis used in the current study (+90% criterion in 90% of the participants) led to reporting later mastery of most consonants when compared to earlier studies on English or Arabic phonology that used the 75% or even 50% criterion. However, there are still some noteworthy cross-linguistic comparisons to be made of the similarities and differences between the acquisition of sounds up to age 4;00 (Table 7.15).

Table 7.15.

The Acquisition of Consonants in Arabic versus English Languages.

Language →		**English**	**Arabic**	**Current study****	
Manner ↓				**PN**	**SPON**
Early <2;00-3;00 yrs	*Stops*	/p, b, t, d, k, g/	/b, t, d, k*, q*, ʔ/		
	Nasals	/m, n/	/m, n/		/m/
	Trill		/r/*		
	Fricatives	/f*, h/	/f, ʃ*, ħ, ʕ*, h/		
	Laterals		/l/		
	Approximants	/j/	/w, j/	/w/	/w/
	Affricates				
Intermediate 3;01-4;00 yrs	*Stops*		/k, g, q/	/b, t, d, k, g, ʔ/	/b, d, k, ʔ/
	Nasals			/m, n/	/m, n/
	Trill/Tap		/ɾ/	/ɾ, r/	
	Fricatives	/f, s, z, ʃ/	/f, θ, s, z, ʃ, ħ, x, ɣ, ʕ, h/	/θ, f, ʃ, x, ɣ, ħ, h/	/f, ħ/
	Laterals	/l/		/l/	/l/
	Approximants	/w/		/j/	/j/
	Affricates	/t͡ʃ/	/t͡ʃ*, d͡ʒ/	/d͡ʒ/	
	Emphatics		/tˤ, sˤ*, ðˤ, dˤ/	/tˤ, sˤ, lˤ/	
Late >4;00 yrs	*Trill*	/r/		NISA	NISA
	Fricatives	/θ, ð/	/ð/		
	Affricates	/d͡ʒ/	/d͡ʒ/		
	Emphatics		/ðˤ/		

*. Reported by one study, **. Acquired in at least one position by either gender. Key: PN = Picture Naming, SPON=Spontaneous, NISA= Not Included in Study's Age-range.

The major differences yielded from this study lay in the acquisition of affricates and emphatics. In the current study, the affricate /d͡ʒ/ was acquired earlier than studies on other Arabic dialects: Egyptian, Kuwaiti, Jordanian, and Qatari Arabic or in English. Similarly, the current study is the first to report the intermediate acquisition of highly frequent emphatics /tˤ/ and /sˤ/ before the age of 4;00 years whilst less frequent emphatics /ðˤ/ and /dˤ/ were acquired later (not acquired by the oldest age group in the current study).

Moreover, differences between studies on all Arabic dialects and English can be seen in the acquisition of Rhotics and the Approximant /w/. Rhotics are classed as early/intermediate sounds in Arabic but as late sounds in English. This difference can reflect the difference in its realization as a Tap or Trill in Arabic versus an approximant in English. Also, despite its markedness and complexity, /θ/ has an earlier age of acquisition in Arabic when compared to English which may be indicate the involvement of other factors that are different between the two languages such as the presence of phonemic contrast between the two sounds in Arabic. For example, [θʌm] and [ðʌm] have very different meanings in Arabic: 'mouth' vs. 'insult' respectively. This contrast also exists in English but is predominantly located at WF position where voiced consonants are typically devoiced: e.g. bath vs. bathe. Similarly, /w/ is classed as an early acquired sound in Arabic and intermediate in English. In contrast, /g/ has an earlier age of acquisition in English than in the current or earlier Arabic studies. Also, /s/ and /z/ are not acquired by the oldest group of participants in this study (i.e. 4;00 years) whilst it has been reportedly acquired before the age of 4;00 years in English and other Arabic dialects.

Furthermore, there were some similarities across English and Arabic:

- The fricative /ð/ is acquired late in both languages.
- /l/ is acquired at the same age in NA and KA as English speakers but reportedly acquired early by other Arabic dialects.
- /t͡ʃ/ is acquired in both English and KA at the same age, but not in other Arabic Dialects, where it is considered not to have a similar functional load (Alqattan, 2014).

Although it has been claimed that Arabic speaking children acquire fricatives sooner than English speaking children (Amayreh and Dyson, 1998), the results of this study contradict this claim. Earlier studies of Arabic also report the early acquisition of several fricatives before the age of three years. However, the relatively later acquisition of Fricatives in the current study can be attributed to how the 90% criterion has been applied requiring a uniform +90% correct production of 90% of the participants in each age group. In general, it can be deducted that the literature points to an accelerated acquisition of Fricatives by Arabic-speaking children due to the fact that Arabic has many fricatives falling across all places of articulation. Much earlier acquisition of fricatives has also been reported in a normative study on Turkish, another Semitic language. For instance, Topbas (1997), reported even earlier age of acquisition of several Fricatives and Affricates than reported by any phonological studies in either Arabic or English: /ʃ/, /t͡ʃ/, and /d͡ʒ/ at 1;08-2;02 years; /f/, /v/, /s/, and /ʒ/ at 2;04-2;08 years; and /z/ at 2;09-2;11 years.

In general, there is an agreement that Stops, Nasals, and Approximants are acquired early and some Fricatives and Affricates are acquired later. Similarly, in both Arabic and English, the majority of consonants are acquired before the age of 4;00 years however, some consonants remain difficult in both Arabic and English, most typically Fricatives, Affricates, and in Arabic Emphatics. Although some language-specific patterns exist, the acquisition of Arabic and English consonants also show similarities supporting the notion of a universal pattern of speech sound acquisition across all natural languages. In the next section, the conflict between factors influencing the acquisition of consonants is discussed in detail.

7.3.6. Conflicts and theoretical implications in the role of markedness, articulation complexity, sonority, phonological saliency, functional load, and frequency[17] on the acquisition of NA consonants.

Although markedness, articulation complexity, sonority, and phonological saliency often provide a universal guide to which consonants are acquired across all languages, nonetheless there an ongoing debate in the literature to which factor has the most influence (as previously discussed in detail in chapter 2 section 2.3.). These factors are also known to be influenced by language specific characteristics such as: functional load and frequency. This section is primarily focused on examining examples of this conflict where it was observed in the current data between two or more of these factors.

Emphatic Arabic consonants are known for their articulation complexity and markedness. In the current study, token frequency appears to expedite the acquisition of the two most frequent emphatic consonants: /tˤ/ and /sˤ/ (frequency 3.14 and 1.09 respectively) in comparison to other less frequent emphatics: /lˤ/ and /ðˤ/ (frequency .76 and .74 respectively). Higher token frequency will have allowed for more articulatory practice, which in turn corresponded to the higher percentage of the correct production of both consonants (as seen in figure 5.17)[18]. However, /lˤ/ too was produced correctly with high percentage. However, this particular result can be attributed to the fact that the emphatic /lˤ/ almost always occurred in a geminate environment (more salient than singletons) in the current data. Moreover, Romani et al. (2017) reported that input frequency can speed up the age of acquisition, yet articulation complexity, in spite of frequency, can also slow it down. Nonetheless, in the Kuwaiti dialect, the high frequency (coinciding with high functional load) overruled markedness and articulation complexity in the accurate production and early acquisition of the affricate /t͡ʃ/ (Alqattan, 2014). Romani et al. (2017) reported a similar conflict in the role of markedness and frequency and

[17] The input frequency of Arabic consonants in CDS is unknown as it is under researched, therefore the token frequency calculated in the current study was used as reference to input frequency instead.

[18] The token frequency of the emphatic /dˤ/ in the SPON sample of NA-speaking children = 0 as it is was always realised /ðˤ/. It only surfaced in the PN sample with high PC.

consequently concluded that consonants' age of acquisition sometimes abides by markedness and other times by frequency.

Kirk and Demuth (2003) states that learning is particularly facilitated when frequency and markedness coincide. In the current study, evidence in the delayed acquisition of affricates and emphatics suggest that the opposite is also true. In other words, marked consonant that are also low in frequency, as in /d͡ʒ/ frequency .91 in NA, is expected to be acquired late and it was (i.e. >4;02 years with the exception of being mastered by females in SFWF in the word [ˈθald͡ʒ] 'ice' in the PN task). In contrast, in the current study, markedness beyond the phoneme level failed to explain why more consonants appear as mastered in the PN task (where marked and more complex syllable and word shapes were used) in comparison to the SPON task. One plausible explanation is that the PN task controlled and guaranteed the inclusion of all consonants in the stimulus, marked and unmarked, whilst some consonants may not have been targeted at all in the SPON sample. The nature of the speech task, with PN reasonably requiring more awareness and consciousness to what needs to be articulated/said, also offers another possible explanation. Additionally, the PN task is comprised of single utterances lacking the effect of connected speech in comparison to the SPON task.

Furthermore, Parker's sonority scale (Figure 2.3) is based on English and puts voiceless plosives and fricatives below their voiced counterparts on the scale, i.e. voiced consonants are more sonorous and thus are expected to be acquired first. Stoel-Gammon (1985) reported that voiced consonants are acquired before their voiceless counterparts in English. On the contrary, voiceless consonants are reportedly acquired before voiced ones in Italian, Spanish, and French (Romani et al., 2017). The results of the current study also support the notion that sonority is languages specific Parker (2002) In NA, some voiceless consonants were acquired before their voiced counterparts which violates the voiced/voiceless order in Parker's sonority scale. For example, /ħ/ was acquired before /ʕ/, /x/ before /ɣ/, and /t/ before /d/ within the same syllable/word position. In contrast, /g/ was acquired before /k/ in SIWW but not in SIWI and both were acquired at the same age in both coda positions by the female participants (See Table 7.6). These findings cannot be consistently explained by the consonants' token frequency either (as reported in chapter 5 figure 5.10) with /ħ/ and /t/ being less frequent than /ʕ/ and /d/ whilst /x/ and /k/ are more frequent than /ɣ/ and /g/ respectively. Similar findings have been reported in the acquisition of Dutch voiceless consonants before their voiced counterparts despite being less frequent (Kager et al., 2007). Romani et al. (2017) concluded that the "voiced" quality of the speech sounds should be considered as marked which then extends to voiced consonants being more marked than voiceless ones. In NA as well as in Italian (Romani et al., 2017), consonant frequency strongly depended on their syllable/word position. In the current study, when syllable/word position was taken into consideration, it provided some explanation to the order of which consonants are acquired (as discussed previously in section 7.3.3. of this chapter).

Additionally, the high functional load of some NA consonants explains their high token frequency (e.g. /ʔ/ and /l/ in the Arabic equivalent of the article 'the', /h/ as a gender marker, /b/ and /f/ in the Arabic equivalent of the prepositions 'with' /bɪ/ and 'in' /fiː/), and /w/ in the Arabic equivalent of 'and' /wă/ which did not always correspond to their accurate production or acquisition age. In contrast, /ð/ has low functional load in spite of its high token frequency (mostly occurred in the Arabic equivalent of the word 'this' /ˈhaˑðə/). Like English, /ð/ is one of the latest acquired consonants. In fact, both interdental fricatives /ð/ and /θ/ are the latest to be acquired in both Arabic and English (Dodd et al., 2003, Amayreh and Dyson, 1998, Ayyad et al., 2016, Wellman et al., 1931, Poole, 1934). This late acquisition of interdental fricatives in several languages sheds the light into the role of the place of articulation in consonant acquisition.

A recent cross-linguistic review of consonant acquisition in 27 languages revealed that the place of articulation plays a major role in the order of consonants acquisition (McLeod and Crowe, 2018). In general, the acquisition of consonants produced with the lips (bilabial and labiodental), pharynx (pharyngeal, epiglottal and glottal), and consonants produced with a posterior lingual placement (palatal uvular and glottal) proceeded the acquisition of consonants produced with an anterior tongue placement (dental, alveolar, postalveolar, and retroflex).

Nonetheless, these results also came with a conflict of their own. The place of articulation was found to interact with the manner of articulation in the acquisition of Stops, Fricatives, and Affricates. In other words, Stops were acquired earlier at an anterior rather than a posterior tongue placement whilst fricatives and affricates were acquired earlier at a posterior tongue placement (McLeod and Crowe, 2018). Similarly, Ladefoged and Maddieson (1996) also found that posterior fricatives (uvular) were acquired before fricatives produced with anterior tongue placement (alveolar and palatal). The authors suggested that the earlier acquisition of posterior fricatives is directly linked to the fact that their production generates a greater amount of low frequency energy which makes them auditorily more salient. Nonetheless, several Arabic studies found that almost all voiceless fricatives are acquired before their voiced counterparts regardless of their place of articulation (e.g. Amayreh and Dyson (1998), Alqattan (2014), and the current study).

Although the previous discussion focused more on presenting conflicts than agreements, a universal agreement amongst all languages exists. However, the existence of these conflicts suggests that the role of markedness, articulation complexity, sonority, phonological saliency, in addition to place of articulation is not independent from one another. In fact, it signifies that the degree of influence each factor may have can occasionally be language specific guided by functional load and frequency. Moreover, the results of the current study support the principles of the emergence approach where the children's intrinsic capabilities interact with extrinsic factors during their phonological acquisition journey (Davis and Bedore, 2013). In other words, the results of the current study demonstrate that NA-speaking children acquired a few place and manner phoneme categories following a universal pattern seen in other languages which supports Jacobson's theories (Jakobson, 1968). On the other hand, the variability found amongst different gender participants and within the same gender (demonstrated in the large standard deviation especially in young age groups) endorses individual variability and the cognitive model of speech acquisition proposed by some theorists (e.g. Vihman (1996)). Furthermore, the results of the current study upholds some (but not all) principles of markedness, sonority, and the biological approach to speech acquisition as proposed by Kent et al. (1992). Additionally, it also highlights the role of other factors: frequency, functional load, speech task, and syllable/word positions, all of which are significantly under researched in the Arabic language.

7.4. The development of phonological error patterns

Studying the phonological development of languages of the same origin often yields results that are comparable, allowing researchers to explore similarities and establish general patterns. However, the comparison between languages of different origins often bring up differences in addition to similarities that pose a challenge in comparison and interpretation (Pye, 1979).

In the current study, the effect of speech sampling method and the syllable/word positions on the occurrence of phonological errors has been investigated. Nonetheless, prior to discussing the effects of speech sampling method and syllable word position (sections 7.4.3. and 7.4.4.) and the differences and similarities of phonological error patterns occurring across Arabic dialects and cross-linguistically (sections 7.4.5. and 7.4.6), in section 4.7.1. methodological differences that are likely to impose difficulties in the comparison and generalization the results are discussed followed by highlighting of some of the unique characteristics that are specific to the Arabic language in section 4.7.2.

7.4.1. Methodological differences in the reporting of phonological processes

Some of the earlier phonological studies only identified three types of errors: omission, substitution, and distortion (Healy and Madison, 1987, Johnson et al., 1980) while in the current study, 14 different phonological processes have been investigated. Also, the method of data collection also differed: SSS and SWA. Even when studies used SWA, the comparison was problematic as some studies used a standard articulation test as their SWA (Morrison and Shriberg, 1992), whilst others used their own lists which also differed drastically in the number of targets: 152 targets in (Wolk and Meisler, 1998), 55 targets in (Andrews and Fey, 1986), 20 targets in (DuBois and Bernthal, 1978), and nine targets in (Faircloth and Faircloth, 1970). Furthermore, some studies limited their investigation to a specific pool of sounds (DuBois and Bernthal, 1978, Kenney and Prather, 1986). Furthermore, the method at which the calculations of the occurrence of errors also differed. In the current study, the percentage of errors was calculated in relation on the number of opportunities where this error was possible and then grouped in four categories based on their occurrence rate <10% as rare, 11-20% as Less-Frequent, 21-30% as Frequent, and +30% as Very-Frequent. However, the majority of previous studies calculated the percentage of errors based on the number of participants within a group that have produced the same error pattern.

Moreover, the same accuracy measure principle: +90% error-free speech was used as the cut-off point after which errors were judged as faded. In other words, when the error frequency dropped below 10%, the error was considered as outgrown. In the same way, both Dyson and Amayreh (2000) and Alqattan (2014) identified 5% and 10% consecutively as the percent where errors fade.

7.4.2. Unique properties of the Arabic language

The Arabic language has unique properties that may not be relevant to other languages. One of these properties is diglossia. At an early age, children are exposed to dialectal version of Arabic at home and in social setting and continues to do so all their lives. However, in more formal setting: e.g. nursery, school, television, and prayers they are exposed to Modern-Standard Arabic (MSA). It is hypothesized that SWA triggers the naming of the target using MSA due to the structured nature of the task (Dyson and Amayreh, 2000). Additionally, the presence of emphatic consonants is the another unique property of the Arabic language; however, the number of emphatic consonants differs across different Arabic dialects. For example: /zˤ/ exists in both Egyptian and Lebanese Arabic but not in Najdi Arabic.

7.4.3. The effect of speech sampling method on phonological processes

A few studies compared the occurrence of phonological errors in SWA versus SSS, but this was carried out with participants with known phonological impairment or difficulty (Morrison and Shriberg, 1992, Wolk and Meisler, 1998, Healy and Madison, 1987, Johnson et al., 1980, Faircloth and Faircloth, 1970, Andrews and Fey, 1986, DuBois and Bernthal, 1978, Masterson et al., 2005) (detailed review of these studies provided in chapter 2, section 2.4). These studies aimed to establish which assessment method provided accurate diagnosis in a time-efficient manner. In the majority of the studies, the children made more errors in the SSS when compared to their performance on the SWA (Healy and Madison, 1987, Johnson et al., 1980, Faircloth and Faircloth, 1970, Andrews and Fey, 1986, DuBois and Bernthal, 1978). However, three studies found that some errors types occurred more in the SSS. For example, Morrison and Shriberg (1992) concluded that cluster-reduction, consonant and syllable deletion, and consonant cluster errors in WI and WF positions occurred more in the SSS sample. Similarly, Wolk and Meisler (1998) found that cluster-reduction, WI and WF consonant deletion, syllable deletion, assimilation and stopping occurred more in the SSS. Also, Johnson et al. (1980) found that omission errors are more evident in the SSS and therefore concluded that SSS is more sensitive at picking up errors than SWA. Moreover, in two of those studies the majority of their participants had higher PCC in SSS than in SWA (Johnson et al., 1980, Wolk and Meisler, 1998). Both studies criticized the SWA method. Wolk and Meisler (1998) claimed that studies that had fewer errors reported in SWA have a task that is too simple and is not representative of the complexity of the language under investigation. On the other hand, Morrison and Shriberg (1992) concluded that SWA provide neither typical or optimal measures of speech performance and that SSS are the ideal method for assessing intelligibility of speech and the severity of the disorder.

In contrast, only one study compared both speech sampling methods: SWA and SSS (in addition to delayed imitation in a story retelling task) in typically developing children. The authors of this study found no difference between all sampling methods for type and number of errors but reported difference in error types amongst different genders; i.e. females produced more omission errors whilst males produced more substitution errors (Kenney et al., 1984). However, they only recruited participants between the ages of 4;04 and 4;08 years and limited their investigation to eight sounds most of which can be classed as marked or complex: /t, k, l, s, f, r, t͡ʃ, ʃ/. Additionally, the recruitment at such late age could mean that the difference between SWA and SSS could have been missed in younger participants.

In the current study, the same comparison between SWA/PN and SSS/SPON was conducted in typically developing children. The results suggest that: Cluster-epenthesis, Coronal-backing, Lateralization, De-emphasis, De-affrication, Lateralization, and Liquid Gliding/vocalization were not affected by speech sampling method, i.e. they occur at similar rates in both samples. In contrast, Weak-syllable Deletion, Singleton-consonant deletion (SCD), Velar-fronting, Glottalization, Devoicing, Voicing, and Fricative-stopping errors occurred significantly more in the PN sample. Also, very frequent errors (occurrence >30%) were identified and recognised that they involved complex articulation effort that involves:

- two places of articulation as in emphatic consonants
- two manners of articulation as in affricates
- the production of two elements as in consonants clusters

These very frequent errors; i.e. Cluster-reduction (CR), Cluster-epenthesis (CE), De-emphasis and Deaffrication, appear not to be affected by speech sampling either (except for CR) which is the only process in the current study that occurred more frequently in SPON sample. The results of the current study are consistent with the findings of two studies that also found CR errors to be more common in SSS than in SWA (Morrison and Shriberg, 1992, Wolk and Meisler, 1998). This raises the matter of the effect of connected speech on the accuracy of consonant cluster production.

In general, all participants made significantly more errors in the PN sample when errors were frequent (20-29%): Devoicing, Fricative-Stopping, and WSD or less-frequent (10-19%): Velar-Fronting, and Voicing. Also, frequent and less-frequent errors appear to be outgrown 6-12 months earlier in the SPON sample with one exception: Devoicing errors. The age at which Devoicing errors are faded cannot be determined in the current study as devoicing continues to exist above 10% in both speech samples until the upper age limit in the current study; i.e. 4;02 years. In the sections 7.4.4. and 7.4.5., phonological errors are further compared across several Arabic dialects and cross-linguistically with the English language.

7.4.4. The effect of syllable/word position on the incidence of phonological processes

In the current study, a few phonological processes were not affected by syllable/word position: Coronal-backing, Glottalization, Gliding, and De-affrication. Three of these processes also occurred less than 10% of the time in either speech sample. De-affrication, on the other hand, although frequent, has a limited pool of consonants to which it may occur: /d͡ʒ/ and /t͡s/. Additionally, the low token frequency of affricates in all syllable/word positions (i.e. <1.5) also resulted in absence of the positional effect the occurrence of deaffrication errors. Conversely, devoicing errors occurred in SIWI more than any other position and De-emphasis errors favoured SFWF position. Also, Lateralization, Fronting, Voicing and Fricative-stopping errors favoured SIWW position whilst SCD was most common in SFWW positions. The high occurrence of Fricative-stopping in in NA can be explained in part by the calculated higher token frequency of fricatives in onset positions (34% in SIWI and SIWW) than in coda positions (24% in SFWW and 26% in SFWF) which increases the chances at which Fricative-stopping can occur. Also consonants in SIWI are more salient therefore least likely to incur erroneous productions. Consequently, fricatives in SIWW became the most susceptible to stopping confirmed by the findings of the current study. Similarly, the ‘r’ sound is mostly realized as a Tap in the onset positions (1.23% in SIWI and 5.88% in SIWW) and as a Trill /r/ in coda positions (3.97% in SFWW and 8.43% in SFWF) in NA. The Trill /r/ is more salient than the Tap and thus the Tap is more likely to undergo lateralization errors. This distribution could explain why lateralization errors occurred mostly in SIWW where the Tap was most frequent (see Table 5.10 in chapter-5 for positional frequencies of manner of articulation groups).

Very few studies examined the effect of syllable word position on the occurrence of phonological errors in typically developing children (Llach and Palmada, 2012, Davis, 1998, Smit, 1993). Smit (1993) analysed the distribution of phonological errors from data collected via SWA form over 1000 typically developing English-speaking children and found that phonological errors were applied differently to different phonemes and word positions. For example, she reported that fronting was the most common error for WI Stops but backing was rare. Also, Stops in WF position (especially labial and alveolars more than velars) were prone to deletion. However, deletion of WI consonants was limited to glides and liquids. Similarly, the type of phonological process a liquid sustains is dependent on its position within the word, i.e. gliding in WI and vocalization in WF.

Llach and Palmada (2012) also reported positional differences in the occurrence rate of phonological errors in 90 typically developing Catalan-speaking children. The authors used SWA task (in addition to non-sense word repetition task) to differentiate between errors in the production of onset and coda consonants in four syllable/word positions. Phonological errors were reported an overall occurrence and then in relation to errors in place, manner, voicing, and in their combinations. Overall, medial consonants (SIWW and SFWW) were more prone to erroneous production than consonants at word boundaries but the error rate between the two medial positions was not statistically significant. However, in the analysis of different error types; the effect of syllable/word position was statistically significant on the occurrence of all error types (voicing, place, manner, voicing+place, Voicing+manner, place+manner, and voicing+place+manner). For example, voicing errors were most common in SIWW, errors in the place of articulation were most common in SFWW, and errors in the manner of articulation were most frequent in SFWF position. Additionally, consonants in SFWW were reportedly the most likely to be deleted which is in agreement with the findings of SCD in this study. The authors also conducted a series of post-hoc tests to report on the differences between syllable/word positions in all errors types and reported differences between consonants: at word boundaries (SIWI vs. SFWF), in onset positions (SIWI vs SIWW), in medial positions (SIWW vs SFWW), and in coda positions (SFWW vs. SFWF). Deletion, place assimilation, and manner substitution errors were reportedly significantly different between all paired-position comparisons above whilst place substitution errors was only significantly different between consonants in the onset positions: SIWI vs SIWW and manner assimilation errors differed significantly between both onsets and both medial consonants. Despite the fact that the author used a different classification or phonological errors than in the current study which made the comparison of results difficult, nonetheless their results confirmed the presence of a significant effect of the syllable/word position on the occurrence of phonological errors which emphasizes the onset/coda distinction amongst medial consonants.

On the other hand, other studies also investigated the effect of syllable/word position on the occurrence of phonological errors yet in children with known phonological delays/impairment (Davis, 1998, Rvachew and Andrews, 2002). For example, Rvachew and Andrews (2002) investigated the influence of syllable position on children's production of consonants in 13 phonologically delayed children. Similar to Llach and Palmada's findings, SCD was most prominent in SFWW position. Also, in their data, Velar-fronting was most prevalent at word boundaries: SIWI and SFWF whilst stopping had the highest occurrences in consonants in both onset positions: SIWI and SIWW. Similarly, Davis (1998) reported on some positional differences in the occurrence of phonological errors in the speech of 10 phonologically impaired children. In general, SCD was more common in both coda positions than in onset positions. Likewise, Velar-fronting occurred mostly at word boundaries and stopping occurred mostly in both onset positions. No other positional trends were reported in relation to the occurrence of phonological errors.

In general, positional differences in the occurrence of phonological errors are yet to be investigated thoroughly in the literature. However, in general singleton consonant deletion has been agreed upon to occur in coda positions and mostly in medial codas. The definition and different classification of phonological errors as explored in the paragraphs above makes the comparison between studies difficult. For example, place substitution or place assimilation errors described by Llach and Palmada (2012) can include backing, fronting, or even glottalization errors in the current study. Similarly, errors in voicing (Llach and Palmada, 2012) also include both voicing and devoicing errors in the current study both of which have different distribution of errors amongst syllable/word positions. Nonetheless, the frequency distribution of consonants and saliency of the syllable/word position must be taken into consideration in the analysis of positional effect on the distribution of phonological errors.

7.4.5. Cross-dialectal comparison of the effect of speech-task of the incidence phonological errors

As no studies on any Arabic dialect (that are accessible to the author) compared phonological errors patterns in SSS and SWA, in table 7.16 below phonological errors in the SPON sample in the current study were compared to the SSS in Kuwaiti-Arabic and those in the PN sample to the results of SWA on Jordanian Arabic (Amayreh and Dyson, 1998, Alqattan, 2014). Additionally, some comparison with Syrian and Cairene/Egyptian Arabic (EA from here after) are also provided when applicable throughout this section, yet the latter was not included in the Table 7.16 as the method used to calculate the occurrence of errors was extremely different. Abou-Elsaad et al. (2019), studied phonological process in typically developing Egyptian children between the ages of 2;00 and 5;00 years using SWA of 50 words. However, the author calculated the percent of which phonological process occurred based on the percent of children producing the same error type at least twice which is different from the current study where errors were reported in relation to the total number of possible occurrences in the sample.

In general, there is an agreement amongst all three dialects on which processes are most frequent: CR, De-emphasis, and Fricative-Stopping. In EA, CR was the second most common phonological error at 30%, following Syllable deletion at 39% (Abou-Elsaad et al., 2019). However, Fricative stopping in NA (PN sample) appears to be the most frequent in comparison to all other Arabic dialects. This can be attributed to the fact that all fricatives were assessed in four syllable/word positions including SFWW which was hardly targeted in the JA stimulus design as discussed previously in section 7.3.3. Similarly, in all three dialects, CE, WSD, SCD in WF position, Backing, Glottalization, Velar-fronting and Gliding occur less than 10% of the time though slightly higher in PN sample of the current study. However, Syllable deletion, Glottalization, Backing, and Velar-fronting were much more common in EA: 39%, 27%, 15%, and 19% respectively. Two processes were investigated in KA and JA but not in the current study as they occurred less than 5% and were thus not considered typical phonological processes in Arabic: De-nasalization and Spirantization (turning non-fricatives into fricatives).

Table 7.16.

Phonological Error Patterns in Three Arabic-Dialects: Speech-Task Comparison.

Method		**SSS**				**SWA**			
Dialect		**KA**		**Current Study**		**JA**		**Current Study**	
Age and % occurrence		% at 2;00	% at 3;07	% at 2;00	% at 4;02	% at 2;00	% at 4;00	% at 2;00	% at 4;02
Clusters	**CR**	36%	9%	41%	13%	17%	11%	28%	1%
	CE	0%	2%	22%	12%	Not computed		36%	10%
Deletion	**WSD**	7%	3%	9%	5%	5.9%	Not computed	21%	5%
	SCD	Not computed		2.5%	1.8%	Not computed		6%	2%
		WF 10%	**WF** 5%	**WF** >6%		**WF** 7%	**WF** 1%	**WF** 14%	**WF** 3.8%
Place	**Velar-Fronting**	3%	1%	8%	1.5%	7%	0%	14%	4%
	Coronal-backing	6%	4%	2%	.77%	Not included <5%		4.2%	.48%
	Glottalization	1%	0%	7.4%	2.3%	>5%		9%	3%
Voicing	**Devoicing**	**PoV** 4%	**PoV** 1%	15%	11%	**WF** 16%	**WF** 19%	28%	16%
	Voicing	**PrV** 4%	**PrV** 1%	11%	3.7%	**WI** 7%	**WI** 3%	16%	5%
Manner	**De-emphasis**	77%	11%	29%	17%	70%	44%	35%	17%
	De-affrication	0%	4%*	74%	26%	Reported with fricative-stopping		92%	21%
	Fricative-Stopping	17%	5%	20%	7%	12%	3%	29%	10%
	Lateralization	29%	21%	3.4%	.98%	35%	10%	3.7%	.81%
	Gliding	9%	2%	7%	1.2%	Not included <2%		3.7%	.26%
	De-nasalization	1%		Not computed		Not included 4-9%		Not computed	
	Spirantization	1%	0%	Not computed		Not included <5%		Not computed	

Key: SSS= Spontaneous Speech Sample, SWA= Single-word Assessment, KA= Kuwaiti Arabic, JA= Jordanian Arabic, CR = cluster reduction, CE = cluster epenthesis, WSD = weak-syllable deletion, SCD = singleton consonant deletion, WI = Word Initial, WF= Word Final, PrV = Pre-vocalic, PoV= Post-vocalic.

The occurrence of CR in NA is similar to KA in SSS and to EA (30%) in SWA but differs slightly from JA. This difference can be attributed to nature of the dialects. Precisely, WF clusters are often epenthesized in JA yet such epenthesis is considered as an error in NA. For example, /galb/ ‘heart’ can be only realizes as [galb] in NA, however both [galb] and [ˈga.lɪb] in JA are acceptable with the latter being more common. Similarly, CE in KA is permissible in both WI and WF positions, which explains the low occurrence of epenthesis errors when compared to NA that allows epenthesis only in WI clusters.

Moreover, Weak-Syllable Deletion (WSD) occurred at low rates (<10%) in both speech samples and all dialects except for its occurrence in the current study in PN sample. This can be explained via the number of multi-syllabic words included in the stimulus (see Table 5.6. in chapter 5). Syllable-deletion in EA reportedly was the most common phonological error occurring 39% of the time yet without the distinction of stress (Abou-Elsaad et al., 2019). Equally, Velar-fronting occurred at low rates in all dialects across sampling methods except for PN in NA. This is likely the result of targeting all velars in four syllable/word positions in PN task when compared to three word positions in JA. Abou-Elsaad et al. (2019) reported even higher rates of velar-fronting in their SWA, i.e. 19%. Although velar fronting occurred most frequently in SIWW followed by SFWF then SFWW, and least in SIWI, the inclusion of targeted velars in SFWW (not targeted in Dyson and Amayreh (2000)) meant that there are at least 25% more velar targets and fronting opportunities in the PN stimulus.

A few major differences can be seen between the three dialects of Arabic (not reported in EA). For example, deaffrication appears to only be extremely frequent in both speech samples of NA whilst it is not in either KA or JA. In KA, /t͡ʃ/ is more frequent than /d͡ʒ/ or /t͡ʃ/ in NA (1.5, 0.8, and 0.01 respectively). Also /t͡ʃ/ has a high functional load in KA as it is consistently used as an allophone of /k/ in MSA in WF inflections of possessiveness in nouns and verbs when addressing females. Therefore, it is less likely to withstand errors in production. The low occurrence of de-affrication errors in KA is in agreement with Ingram’s notion of exploring the functional load of a phoneme, especially the extent to which it ‘is necessary to the phonological system’ for the language under investigation (Ingram, 1989). Also, in

KA the affricate /d͡ʒ/ is typically realized as [j] and often as [ʒ] in JA thus [d͡ʒ] is rare in those dialects. Consequently, the comparison of the effect of speech sampling method on the occurrence of deaffrication errors amongst different dialects is not possible. On the other hand, De-emphasis reportedly occurred much higher in both KA (77%) and JA (70%) irrespective of the speech-task when compared to NA: SPON- 29% and PN-35% and not reported at all in EA. In spite of the occurrence rate, the speech-sampling method appears not to have an effect on the occurrence of de-emphasis across all three dialects. Although all three studies agreed on the emphatic status of four consonants: /tˤ/, /sˤ/, /ðˤ/, and /dˤ/, KA included /zˤ/, JA included /q/ and in the current study, the authors included /lˤ/ and excluded /dˤ/ from the analysis as it is often realised as [ðˤ] in NA. Interestingly, /dˤ/ in the current study appeared only in the PN sample, supporting Dyson and Amayreh's observation of children in school setting altering their dialect to produce the closest approximation to a more formal form of Arabic when asked to name a picture (Dyson and Amayreh, 2000). Furthermore, in the current study, a distinction has been made between two types of emphatic consonants: highly frequent: /tˤ/, and /sˤ/ and less frequent: /ðˤ/, /dˤ/, and /lˤ/ based on their token frequency. Such distinction between emphatic consonants has not been reported previously in the literature. The token frequency of such marked Arabic sounds had clear effect on the occurrence of positional de-emphasis, i.e. frequent emphatics were produced more accurately as they endured less De-emphasis (chapter-6 Table 6.56). This distinction led to finding a moderate negative association with the occurrence of positional de-emphasis of highly frequent emphatics and no association with less-frequent emphatics. As a result, it can be concluded that the token frequency of consonants can accelerate their acquisition, when markedness and articulation complexity are neutralized, which is evident in the earlier acquisition of frequent emphatics over less frequent ones. In contrast, Alqattan (2014) found that /tˤ/, and /sˤ/ were the emphatics that exhibited most of the errors in production even though their token frequency in both dialects is fairly similar.

Another major difference between the three Arabic dialects is obvious in the occurrence of Lateralization errors. In both KA and JA, Lateralization errors occurred quite frequently (29% and 35% respectively at age 2;00 years) whilst it rarely occurred in NA in either speech sample. Also, Lateralization occurred 24% of the time in Syrian Arabic at the age of 2;06 years (Owaida, 2015) and 29% of the time in EA between the age of 2-5 years (Abou-Elsaad et al., 2019). The low calculated occurrence of Lateralization in NA could result from the realization of the tap or trill by the approximant [ɹ], which was not classed as a Lateralization error.

Similarly, in NA voicing and devoicing errors have higher occurrence rate in comparison to KA and JA. This is likely due to methodological differences. The reporting of devoicing errors was restricted to post-vocalic consonants in KA and WF consonants in JA which disregarded the possible occurrence of devoicing errors pre-vocalically or in WI positions. Likewise, Alqattan only reported voicing errors in pre-vocalic KA consonants and Dyson & Amayreh limited their investigation to WI JA-consonants (Alqattan, 2014, Dyson and Amayreh, 2000). Both studies paid no attention to the occurrence of voicing errors post-vocalically or in WF position. In contrast, in the current study all instances of consonant devoicing and voicing error were calculated irrespective of its position within the syllable or the word. The occurrence of WF devoicing in SWA also differed considerably between JA (16% at 2;00 years) and Syrian Arabic (5.5% at 2;06 years). Similarly, in EA, Abou-Elsaad et al. (2019) reported very low voicing errors 1.6% but distinguished between pre-and post-vocalic devoicing errors that are more common: 20% and 51% respectively. These differences could suggest a dialect-specific effect. However, it also suggests that a considerable amount of devoicing errors occur post-vocalically, an error type that has been dismissed/not reported by other studies (Alqattan, 2014, Amayreh and Dyson, 2000). Across all dialects, both error types appear to have higher occurrence in the SWA task.

Finally, the occurrence of Fricative-stopping errors is compared in four Arabic dialects: Kuwaiti, Jordanian, Egyptian, and Najdi. In JA and EA Fricative-stopping occurred a lot less than it did in same sampling method in NA (12% in both JA and EA and 29% in NA). Conversely, the difference in the frequency of Fricative-stopping is less drastic in SSS between KA and NA: 17% and 20% respectively. These differences could be the result of targeting 25% more fricatives in the PN task (in SFWW position) in the NA when compared to JA and EA or could reflect similarities and/or differences between dialects rather than the sampling method. Goldstein and Iglesias (2001) emphasized the role of dialectal variation and language dominance in the interpretation of phonological assessment. Both NA and KA are classed as Arabia-Gulf dialects whilst Jordanian is has more in common with Levant dialects: Syrian, Lebanese, and Palestine and Egyptian Arabic has more in common with Sudanese Arabic (Nile dialects). These results may suggest that normative data on Arabic phonology may have to be specific to dialects of the same geolinguistic region.

7.4.6. Comparison of phonological error patterns: cross-dialectal and cross-linguistic comparison

The phonology of the ambient language is known to immensely affect the phonological development of the children speaking that language. This is specially conveyed by the error patterns produced and their frequency (Ingram, 1986, Ingram and List, 1987). For example, in KA consonants with low frequency; i.e., Affricates and Emphatics were susceptible to production errors more than other highly frequent consonants; e.g.: Stops (Alqattan, 2014). Also, Arabic has a large number of fricatives that in the current study were the most frequent consonants of all manner of articulation groups in three syllable/word positions: SIWW, SFWW, SFWF (as discussed in Chapter-5, Figure 5.11). This was clearly reflected on the occurrence of Fricative-stopping errors in the current study: >30% at a young age. In contrast, Fricatives in English have been reported to be amongst the least targeted sound types (Zamuner et al., 2005, Ingram, 1989). Also, fricative-stopping has been reported to occur between 8-23% in five different studies on English in children aged 21-33 months (Hare, 1983, Khan and Lewis, 1986, Dyson, 1986, Preisser et al., 1988, Dyson and Paden, 1983). Fricative-stopping too has been reported to persist in English speaking children for much longer than in Arabic (Alqattan, 2014). However, in languages with very few fricatives, Fricative-stopping may not be a prominent error pattern. For example, in Igbo, children only had 6% stopping errors at 2;00 years (Nwokah, 1986).

Emphatic consonants are a unique property of the Arabic languages. In all Arabic dialects, de-emphasis persisted the longest in children's speech; beyond the age of 4 years. Likewise, word-initial consonant deletions and backing are rare in both English and most Arabic dialects, however they are common in EA and Modern-Standard Chinese (MSC from here after) (Zhu, 2000). Backing and SCD deletion in NA and KA occur at a low rate (<10%) and is judged to be outgrown before the age of 2;00 and <2;06 in Syrian Arabic. Yet in EA, Backing unusually occurs at 15% across all age groups and is supressed by the age of 3;06-3;11 years. This may result from the generalization of the dialectal realization of /q/ and /g/ as [ʔ] in EA-speaking adults. Moreover, both backing and SCD errors persist in MSC beyond the age of 4;06 years. In many ways, it is safe to conclude that errors involving language-specific sounds that may not exist in other languages induce errors that are language specific and is related to the frequency of the consonants within the same language.

In the Table 7.17 below, the age at which phonological errors fade is compared in several Arabic dialects, Turkish, English, Chinese, and Spanish. Such comparisons between languages of similar and different origins shed the light on dialectal, language-specific, and universal patterns of phonological development. For example, two processes show dialectal variation amongst Arabic speakers: Devoicing and Glottalization errors. Whilst Devoicing persist all Arabic dialects beyond the age of four years, Alqattan (2014) reported its disappearance before the age of three years in KA. Similarly, Glottalization in KA and NA are resolved by the age of 2 years; however, they persist in Syrian and Egyptian Arabic speakers up to the age of 4;00 years.

Table 7.17. *The Age at which Phonological Errors are Out-grown: Cross-dialectal and Cross-linguistic Comparison*

Language and/or Dialect	**Arabic**						**Turkish** *(Topbas, 1997)*	**British English** *(Dodd et al., 2003)*	**MSC** *(Hua and Dodd, 2000)*	**Spanish** *(Goldstein and Iglesias, 2001)*
	Najdi		*Kuwaiti*	*Jordanian*	*Syrian*	*Egyptian*				
	PN	*SPON*								
De-affrication	>4;00	>4;00	3;00-3;03	-	3;00-3;05	-	-	5;06	-	<3;00
De-emphasis	>4	>4;00	>3;07	>6;00	4;06-4;11	-	-	-	-	-
CR	3;06	>4;00	3;00-3;03	>6;00	6;00-7;00	3;06-3;11	-	5;06	-	4;00
Devoicing	>4;00	>4;00	2;08-2;11	5;06	4;00-4;05	>5;00	-	-	-	-
Fricative-stopping	>4;00	4;00	3;00-3;03	3;00	2;06-2;11	3;06-3;11	2;08	3;06	4;00	<3;00
WSD	3;06	3;00	<1;04	<2;00	4;00-4;05	4;00-4;05	1;06-2;00	4;00		<3;00
Velar-Fronting	3;00	<2;00	<1;04	<2;00	3;00-3;05	4;00-4;05	2;00-2;06	4;00	>4;06	<3;00
Voicing	3;06	2;06	<1;04	<2;00	<2;06	4;00-4;05	-	3;00	-	-
Coronal-Backing	<2;00	<2;00	<1;04	-	3;06-3;11	3;00-3;05	2;00-2;06	-	>4;06	4;00
Glottalization	<2;00	<2;00	<1;04	-	3;06-3;11	3;06-3;11	-	-	-	-
Lateralization	<2;00	<2;00	>3;07	3;06-4;06	>6;06	4;06-4;11	3;00	-	-	-
SCD	<2;00	<2;00	-	<2;00	<2;06	-	3;00	-	>4;06	-
Gliding/vocalization	<2;00	<2;00	1;08-1;11	<2;00	4;00-5;00	2;06-2;11	-	6;00	3;06	-
Coda deletion	2;06	<2;00	2;04-2;07	-	-	2;06-2;11	-	-	-	<3;00

Key: MSC= Modern Standard Chinese, PN= Picture Naming, SPON= Spontaneous, CR= Cluster Reduction, WSD= Weak Syllable Deletion, SCD= Singleton Consonant Deletion

Furthermore, some language specific tendencies that are specific to the Arabic language can be observed across all dialects. For example, De-emphasis errors persist beyond the age of 4;00 years. Also, SCD is resolved as early as 2;00 years across all dialects of Arabic while it persisted in Turkish until the age of 3;00 and in MSC beyond the age of 4;06 years. Moreover, some universal tendencies can also be appreciated in errors that faded at similar ages across the dialects and languages, e.g. Fricative-stopping, Voicing, and Coda-deletion errors. Fricative stopping diminished in children's speech between the age of 3;00-4;00 years whilst Voicing and Coda-deletion hardly occurred beyond the age of 3;00 years with the exception of EA where it persists until 4;05 years. These results are in agreement with (Roberts et al., 1990) who reported that phonological errors decline rapidly between the ages of 2;06 and 4;00 years.

On the other hand, other phonological errors that differed amongst dialects of the same language and in between languages. For example, Deaffrication is resolved as early as 3;00-3;06 in Syrian and KA but persists in NA to beyond the age of 4;00 years and up to 5;06 in English. Similarly, Alqattan (2014) reported the earliest age of cluster-reduction fading at age 3;00-3;03 followed by EA at 3;06-3;11 years whilst it continued to occur significantly >4;00 in NA and >6;00 in JA Arabic and reportedly resolved by the age of seven years in Syrian Arabic. Also, CR reportedly persist until the age of 4;00 years in Spanish and 5;06 years in English. Similarly, the current study reports the youngest age of the disappearance of Lateralization errors, i.e. before the age of 2;00 years. In contrast, Lateralization errors persisted much longer in other dialects of Arabic and up to the age of 3;00 years in English. Moreover, Glottalization, in the majority of Arabic dialects is rare, however, in EA and Syrian Arabic it persisted significantly until the age of 4;00 years and the age of 6;00 years in English yet resolved by 3;06 years in MSC. Moreover, WSD faded in the majority of languages and Arabic dialects before the age of 4;00 years except in Syrian Arabic where it continued to present itself until the age of 5;00 years. Finally, Velar-fronting and Coronal-backing only persisted in the speech of MSC speakers beyond the age of 4;06 years as it resolved in various Arabic dialects before it did in Turkish, English, or Spanish.

7.5. Summary and Conclusion

This study shows that the consonant inventory of 90% of participants at age 4;00 years (± 2 months) comprises of 18 consonants with various accuracy production levels. These consonants are reported in the consistently present category: /b/, /t/, /tˤ/, /d/, /k/, /f/, /s/, /ʃ/, /x/, /ħ/, /ʕ/, /h/, /m/, /n/, /l/, /ɾ/, /r/, and /j/. At the first glance, it is notable that the consonant inventory of NA-speaking children includes consonants across all places of articulation: labial, coronal, dorsal, radical, and glottal. It also includes consonants with different manner of articulation: Stop, Nasal, Fricative, Lateral, Tap, Trill, Approximant, and a single Emphatic consonant. However, it clearly lacks the presence of Affricates. In general, the order of the acquisition of Arabic consonants in the SPON sample follows the same order found in other Arabic dialects and English, i.e. Nasals, Approximants, and Stops before Fricatives, Affricates, and Emphatics. The age of acquisition of Lateral, Trill and Tap consonants was found to be position dependant, which also corresponds to their positional token frequency. Most interestingly, some voiceless consonants were acquired before their voiced counterparts: /k/ before /g/, /x/ before /ɣ/, and /ħ/ before /ʕ/, which contradicts the principles of sonority. On the other hand, voiced sounds in Arabic are generally pre-voiced and thus are harder to produce than their voiceless counterparts. In contrast, in the PN sample, marked consonants (e.g. /f/, / ħ/, and /tˤ/ in SIWI) appeared as mastered before unmarked consonants (e.g. /b/, /t/, /n/ and /m/ also in SIWI). Equally, the same trend continues across all syllable word positions. These findings suggest that factors other than markedness and articulation complexity play a role in the order of which consonants are acquired. Finally, the gender comparison in the acquisition of consonants was in advantage to the female participants particularly from the age 2;06 years onwards. However, by the age of 4;00 years the male participants appear to have caught up with their female peers.

Alongside providing extensive and detailed information about the typical phonological development of NA-speaking children in Saudi Arabia between the ages of 1;10 and 4;02 years, the data in this study provides an interesting insight to the effects of two sampling/testing methods and the effect of syllable/word position. For decades, both methods have been repeatedly used in the exploration and/or assessment of children’s phonological development in either research or clinical settings, however they were rarely compared.

At first, the token frequency of consonants was examined in the SPON speech using the children’s own targets to provide some bases for discussion of the role of frequency of consonants on the accuracy of production, acquisition of consonants, phonological error patterns, and also for cross-dialectal comparisons. The token frequency in the current study was found to be the closest reported to the token frequency of consonants in the adult form as reported in Educated Spoken Arabic (Amayreh et al., 1999). Additionally, the token frequency of some consonants can explain their accurate production and acquisition at an early age; e.g. /ʔ/ and /w/, while it lacked the required sensitivity to explain the rather delayed acquisition of marked yet frequent consonants; e.g. /ʕ/ and /ð/ and also the unmarked frequent consonant /b/. These conflicting results are also found in both KA and in English. Additionally, the differentiation between more and less-frequent emphatics have shown a stronger influence of token frequency of two emphatics consonants /tˤ/ and /sˤ/ leading to an earlier acquisition when compared to less-frequent emphatics. These conflicting results of the role of token frequency and markedness suggest the involvement of other factors in the acquisition of consonants in NA such as syllable structure, syllable/word position, word length, and stress most of which are beyond the scope of the current study.

Furthermore, the computation of positional token frequency in the current study provided an innovative understanding of how token frequency on the level of groups of sounds played a role in their order of acquisition. In other words, consonant groups that are found to be most frequently occurring in a challenging syllable/word position face an additional obstacle in their acquisition journey, e.g. emphatics. Yet, when different consonantal groups’ positional frequencies favoured the same syllable/word position in their distribution, other factors dictated the order of acquisition, e.g. articulation complexity.

The two main aims of investigations carried out in the current study have yielded in several interesting results and fruitful discussions: Speech-Task and Syllable/word position comparisons. Although previously thought that children are more accurate in

PN, this study provides indubitable evidence that contradicts what has been reported in the literature. However, it must be emphasized that these results are only true for typically developing children. as the majority of previous studies that compared the two elicitation methods recruited children with known phonological delays or impairments. In the SPON sample, Saudi children had higher PCC scores, made fewer phonological errors, outgrew phonological process sooner, and had an earlier acquisition and customary production of consonants. Although the PN stimulus allowed the researcher to investigate the accuracy of production and acquisition age of all consonants, it also limited the chances and lexical option to which these consonants could surface. The PN sample was especially limited in providing sufficient insight into the phonological development of children in the youngest age group (average age 2;00 years) which was evident in their rather limited phonetic inventory when compared to their performance in SPON task. Moreover, the occurrence of phonological errors also showed a significant impact of the Speech-Task. In seven of the 14 phonological process that were investigated in the current study, the participants made significantly more errors in the PN sample: Velar-Fronting, Glottalization, Voicing, Fricative-stopping, WSD, Devoicing, and SCD. Only one error occurred more frequently in the SPON sample: CR and six error types occurred equally in both samples: CE, Backing, Gliding, Lateralization, Deaffrication, and De-emphasis. In general, the errors that showed no statistical significance of the effect of Speech-Task occurred at a very low rates (<5%); i.e. Backing, Gliding, and Lateralization, or at very high rates (>30%); i.e. Deaffrication, and De-emphasis. Similarly, consonants involving errors that are very frequent (Affricates and Emphatics) also had low token frequency <1 except for the voiceless alveolar emphatic /tˤ/.

The second major finding of the current study resides in the investigation of the role of syllable/word position on: production accuracy, consonant acquisition, and the occurrence of phonological errors. In general, consonants in SIWI are the most accurate followed by SIWW then SFWF, and consonants in SFWW are the least accurate. Similarly, when consonants in all acquisition levels were combined, children under the age of three years acquired the smallest number of consonants in SFWW. However, syllable/word position appear to affect female and male participants differently in their acquisition of consonants particularly beyond the age of three. The results suggest that females acquire the smallest number of consonants in the absolute coda position, yet males acquired the least number of consonants in the absolute onset position. Finally, syllable/word position also had a statistically significant effect on the occurrence of phonological errors of 10 of the 14 phonological processes that were investigated in the current study:

- Devoicing errors occurred mostly in SIWI position
- Velar-fronting, Voicing, Fricative-stopping, and Lateralization errors occurred the most in SIWW position
- De-emphasis occurred the most in SFWF position
- SCD occurred the most in SFWW position
- WSD occurred the most in WM position
- CR occurred more in WF position
- CE occurred more in WI position

Finally, the effect of age-group was significant in all the dependant variables under investigation except for the occurrence of three phonological processes namely: Backing, Lateralization and De-emphasis. However, post hoc tests conducted when the interactions with speech-task was significant rarely ever occurred between two consecutive age-groups. In fact, groups that were significantly different from one another were at least >12 months apart. This suggest that the six-month stratification of age-groups used in the current study maybe too small to detect significant interactions. In contrast, gender rarely had an effect on the dependant variables except for PCC, Positional PCC, and Positional WSD in favour for the females and in the occurrence of De-emphasis errors in favour for the males that is apparent in their earlier positional acquisition of two emphatic consonants. All gender differences yielded a significant difference with moderate effect size and low observed. On the other hand, descriptively, females appear to have an earlier acquisition of Arabic consonants and acquire a greater number of consonants than their male peers.

7.6. Contribution of the current study and clinical implications

The practice of Speech-Language-Therapy in Saudi Arabia remains mainly limited to hospital setting with restricted access to children with mild speech or language problems due to the accumulative and increasing high demand on the services. Additionally, the assessment resources available for clinicians are insufficient and often implement norms from the English language which is inappropriate. These translated/adopted tests often miss on language specific features, and consequently clinicians often opt for the diagnostic therapy approach. This allows the clinician to start with a small set of goals that were clearly set by the assessment procedure but include additional therapeutic goals that are deemed necessary by means of clinical judgment. This is particularly difficult for newly certified clinicians especially with the lack of normative data on Saudi dialects hence the desperate need for language-specific guidelines, norms, and assessment tools.

The author of this thesis has over 10 years of clinical experiences in Saudi Arabia as a paediatric Speech-Language-Therapist, therefore, the analysis of this study was aimed at extracting results that are likely to have a significant implication on the clinical practice of Speech-Language-Therapy. The strength of this thesis lays in the presentation of solid statistical evidence otherwise presented descriptively in the majority of the literature with the exception of investigating the effect of age and gender. Finally, a list of the most interesting clinical implications and recommendations for the design of a future phonological assessment tool in Arabic is presented:

- The PCC and age of consonant acquisition may have different norms depending on the stimulus used. Because the consonants acquired in the SPON sample in the current study were different or acquired earlier, the guideline for determining delayed or impaired development may differ slightly to these norms when PN sampling is the method used for assessment.
- The age of acquisition of consonant can be different in different syllable/word positions. Therefore, the judgement at which age consonants are acquired must be made with careful considerations to syllable/word position especially between medial consonants in onset versus coda positions.

- The results of the current study can provide a summary of clinical guideline of the level at which phonological process are considered age appropriate and when are they expected to fade; i.e. drop below 10% in the child’s speech with careful consideration to the impact of dialectal variation.
- The statistical comparison between syllable/word positions proving SFWW as the most challenging position commands the differentiation between onset and coda in word-medial consonants in assessment and therapy targets.
- Token frequency alongside type frequency (reported in other research) may possibly dictate which consonants must or must not be included in a phonological assessment tool.
- The results of positional token frequency can serve as a practical guide in the design of a phonological assessment tool in Arabic. Via highlighting which syllable/word position(s) must be targeted or eliminated for each consonant, the design of an assessment tool that is comprehensive, short, and efficient is facilitated. For example, consonants that rarely occur in a specific position could be eliminated from being assessed in that position as it is unlikely to have an effect on the child’s intelligibility.
- Consonants may no longer need to be tested in all positions, i.e. some consonants, especially those acquired early could only be targeted in challenging syllable word positions rather than easier ones where they are expected to be most accurate.
- For practical reasons, PN should continue to be the preferred method for assessment clinical setting however it is a necessity to include of a small connected speech sub-section targeting the assessment of production accuracy of consonant clusters.
- It is also recommend to include of a short spontaneous sample (e.g. a picture description task, story-telling, or problem solving sub-section) for the purpose of assessing the carryover of articulatory and phonological skills in connected speech without the need of lengthy analysis involving phonetic transcription. Similar to testing stimulability at the sound or syllable level often carried out by clinicians when the client fails to produce the target consonant correctly at word level. This section must have several targets where frequent and less-frequent phonological errors are likely to occur. The client’s ability to show an age appropriate

performance of phonological processing is then scored based on pass/fail principle.

- The data included in this study can be further analysed to eliminate PN targets that were not identified spontaneously by the participants and also to compile a list of most frequently used words in the SPON sample to create a short-list of words that are likely to be identified spontaneously and thus are the best to be used in the design of phonological assessment tool.

7.7. Limitations and suggestions for future research

Due to the limited time allocated for the completion of a PhD degree, the sample size of participants was relatively small and warrant the replication of the current findings on a larger scale. Similarly, the age-range of the participants included in the study prohibited the exact determination of the age of the acquisition of several late-acquired sounds thus, future research could expand the age range to include older children ideally up the age of 6-7 years. Also, the grouping of the participants in a cross-sectional design may have obscured individual variability. It also limited the capacity to compare the findings of the current study at the inter-individual level with those of a longitudinal study that follows the progression of phonological development at an intra-individual level over time.

Moreover, the data collected for this study exceed 50 recorded hours and required over three years of transcription and analysis alone. Therefore, some data have been collected but not analysed, or analysed but not reported in the results of the current study. These include but not restricted to: phonetic consistency of errors, type frequency of consonants, frequency of syllable and word shapes, mean-length-utterance, the effect of neighbouring sounds on the occurrence of phonological errors, the cross-sectional versus longitudinal comparisons of phonological development… etc. all of which provide an excellent future research opportunity. Alternatively, the focus of the current study was to report on unique discoveries that are yet to be reported in comparable normative studies, i.e. the effect of Speech-Task and Syllable/word position through an elaborate statistical analysis. Moreover, this data has already provided means for a research opportunity for a former colleague who investigated morphological acquisition in Najdi Arabic in the partial fulfilment of a master's degree thesis at the University of Sheffield. Also, it is intended to make this data readily available to the public through The Child Language Data Exchange System (CHILDES) (MacWhinney, 2000, MacWhinney, 2014) and TalkBank (MacWhinney, 2007) projects which then will allow even more opportunities for endless research opportunities on the Arabic language.

Finally, there is an urgent need for a unified definition of consonant acquisition and how it must be computed, i.e. what percent correct and in what percentage of the group? to facilitate the cross-linguistic comparisons and draw valid conclusions. Similarly, researchers are in desperate need for a computational guideline for the frequency of phonological errors that is lacking in the literature, hence the methodological differences reported extensively in this thesis which lead to problematic cross-dialectal and cross-linguistic comparisons.

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Appendices

Appendix-A:

School letters (English and Arabic).

Dear principle,

My name is Noura AlAjroush. I am a lecturer at Princess Nourah Bint Abdulrahman University-Riyadh and currently a full time Speech Sciences PhD student at the University of Newcastle upon Tyne in the United Kingdom. In the pursuit of my degree, I am conducting a research project that investigates aspects of normal development and acquisition of the Arabic language. The aim of the study is to examine the stages of typical speech sound acquisition and phonological development in 2-5 year-old Saudi children. This study has been approved by the research ethics committee of the Speech and Language Sciences Section at University of Newcastle upon Tyne. It would be of my great appreciation if you would give me the permission to conduct my study at your school. I enclose consent forms to be distributed to the children/nannies through the primary teachers and returned to me irrespective of parents' willingness to participate.

After parents' consent has been granted, each child will need to fulfill the preset inclusion criteria. The inclusion of the child will be determined by the parental answers to the questions in the consent form. Each child who fulfills the inclusion criteria will then join the researcher in a friendly environment, a quiet room in the school for data collection session. In it, the child will be engaged in a structured play activity using picture cards to prompt the production of target words followed by an elicited conversation activity via a story telling theme using funny pictures. The data collection session will be video or audio recorded and kept as a reference for further analysis. Each session will last for 45-60 minutes as long as the child is stimulated and cooperative. A short break will be given to the child upon request and data collection will be stopped if the child shows any sign of distress. At the end of the session, all participants will be rewarded by stickers and/or a balloon.

ALL participants' responses will be kept strictly confidential and scores will be identified only by a code number. Individual performance will not be revealed to anyone without their parents' permission in writing. I assure you that there are no known risks involved in the children's participation in this study. Each child's participation is voluntary and their parents may withdraw their consent and discontinue his/her child's participation in this research project at any time with no negative consequences. I thank you for you cooperation and support for scientific research in The Kingdom of Saudi Arabia.

If you have any questions or enquiries about this research project, please do not to hesitate to contact:

Noura AlAjroush, the researcher, at Noura.al-ajroush@newcastle.ac.uk or via phone at 0554477503 and/or her supervisors: Dr. Ghada Khattab at ghada.khattab@newcastle.ac.uk or via phone at: 0044-191-208 6583 Dr. Cristina McKean at cristina.mckean@ncl.ac.uk or via phone at: 0044-191-208 6528

Your cooperation and participation in the success of this project is of great value and is highly appreciated.

Best regards,

Noura AlAjroush

سعادة مديرة مدارس .... المحترمة

السلام عليكم ورحمة الله وبركاته..   أمّا بعد

أتشرف بالتقدم لسعادتكم بطلب التعاون مع مؤسستكم التعليمية لغرض البحث العلمي. فأنا أخصائية تخاطب ومحاضرة في جامعة الأميرة نورة بنت عبدالرحمن وحالياً طالبة في مرحلة الدكتوراة في جامعة نيوكاسل أبون تاين البريطانية.
ولحرصي على تعميم المنفعة من درجة الدكتوراة هذه قررت إجراء بحث العلمي يتعمق في دراسة المهارات اللفظية عند الأطفال الناطقين باللغة العربية. وللتوضيح أكثر فإن الغرض من هذا البحث هو دراسة واستكشاف مراحل التطور الطبيعية للغة اللفظية من حيث اكتساب الأحرف الهجائية ومراحل وضوح الكلام لدى الأطفال ما بين عمر 2 و 5 أعوام في المنطقة الوسطى في المملكة العربية السعودية. والجدير بالذكر أنه تمت الموافقة على إجراء هذه الدراسة من قبل مجلس البحوث العلمية في جامعة نيوكاسل أبون تاين البريطانية. لإجراء عملية جمع المعلومات اللازمة من الأطفال ستحتاج الباحثة لغرفة هادئة في مقر المدرسة لتسجيل مشاركة الأطفال بوضوح وبدون أي مقاطعات.

مرفق مع هذا الخطاب، صورة من الخطاب التعريفي بهذه الدراسة وخطاب "الموافقة المشفوعة بالعلم" الموجة للأهالي والذي سيتم توزيعه على الأطفال أو الحاضنات أو الأمهات ومن ثم جمعه مرة أخرى من قبل المعلمة الأساسية للصف. ستتواصل الباحثة مباشرة مع إدارة المدرسة والمعلمات الأساسيات لاستلام خطابات "الموافقة المشفوعة بالعلم" المعادة حتى وإن تم رفض الأهل لمشاركة طفلهم في الدراسة.

أما بعد الحصول على موافقة الأهالي بمشاركة طفلهم مع وعدم وجود أي أسباب تمنع مشاركة الطفل بناءً على الأسئلة المرفقة في خطاب "الموافقة المشفوعة بالعلم" سيتم التواصل مع المعلمة الأساسية للصف لاختيار اليوم والوقت المناسب لمشاركة الطفل بحيث لا يتغيب عن حصص المواد الرئيسية أو الوجبات أو وقت الراحة. وفي هذا اليوم، ستقضي الباحثة بعض الوقت في صف الطفل/الطفلة حتي يتعرف على الأخصائية ويألف وجودها ثم بعد ذلك يطلب منه/منها مرافقة الباحثة للعب والاطلاع على بعض الصور في حجرة مجاورة. ومن خلال اللعب، سيطلب من الطفل تسمية الصور أو شرح الأحداث في بعض الصور أو القصص. سيتم تسجيل كل جلسة مع كل طفل على حده ومن ثم حفظ التسجيل في مكان آمن لمراجعته والقيام بمرحلة تحليل القدرات اللفظية لاحقاً. كل جلسة تسجيل ستستمر لمدة 45-60 دقيقة كحد أقصى وسيعطى كل طفل استراحة عند طلبه. والجدير بالذكر أن جلسة التسجيل ستتوقف فوراً عندما يظهر الطفل أي علامة من علامات التعب أو التوتر. وفي نهاية كل جلسة، ستتم مكافئة كل طفل/طفلة لمشاركتهم بملصقات كرتونية "ستيكرز" وبالونات.

ومن المهم ذكره أن جميع تسجلات الجلسات والنتائج سيتم حفظها بسرية تامة باستخدام رمز لكل طفل بحيث لا يمكن التعرف على هويته بها. كما أن النتائج الفردية لكل طفل لن يتم إفشاؤها لأي كان إلا بعد الحصول على الموافقة الخطية من أحد الوالدين. كما يجدر بي أو أؤكد لكم أنه لا توجد أي مخاطر من مشاركة الأطفال في هذه الدراسة وأن مشاركتهم فيها أمر أختياري وعائد لوالدي الطفل. كما يمكن للوالدين سحب مشاركة طفلهم في هذه الدراسة في أي لحظة وبدون ذكر أي أسباب وبدون أي آثار سلبية عليهم او على الطفل نفسه.

كما يسعدني استقبال أسئلتكم أو استفساراتكم عن هذه الدراسة عن طريق البريد الالكترون

N.al-Ajroush@NCL.ac.uk أو بالاتصال على رقم: 0554477503 أو بالتواصل مع أحد المشرفات الأكاديميات:

بالعربية أو الانجليزية:	د. غادة خطّاب	ghada.khattab@newcastle.ac.uk	أو بالاتصال على رقم	0044-191-208 6583
بالانجليزية فقط:	د. : كرستينا ماكين	cristina.mckean@ncl.ac.uk	أو بالاتصال على رقم	0044-191-208 6528

وفي النهاية، أود أن أشكر لكم تعاونكم وحرصكم على تشجيع الأبحاث العلمية في المملكة العربية السعودية كما أن مشاركتكم في نجاح هذا البحث هو محل تقديرنا واهتمامنا.

الأخصائية نورا بنت أحمد العجروش

Appendix-B: Invitation to participate in a Research Study: Information Sheet (English and Arabic)

Understanding How Young Children Learn to Speak in Arabic

WHAT IS THIS ABOUT?

You are being invited to give consent for your child to take part in a research study. Before you decide it is important for you to understand why this is being done and what it will involve.

WHAT IS THE PURPOSE OF THIS STUDY?

The aim of the study is to understand how young Saudi children learn to speak clearly in Arabic between the ages of 2 and 5 years. This information will help us to identify and treat children with speech difficulties.

WHY HAVE I BEEN CHOSEN?

We are looking for Saudi Arabic speaking children between the ages of 1 year 10 months and 5 years 2 months. The head teacher of your child's school has given us permission to approach you and ask for your permission for your child to participate in this study.

DO I HAVE TO TAKE PART?

It is up to you whether or not you take part. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason.

WHAT WILL HAPPEN TO MY CHILD IF HE/SHE TAKES PART?

If you agree for your child to participate in the study and he/she is the right age for our study, your child will complete some simple, play-based activities with the researcher. The researcher is a trained and highly experienced speech and language therapist who understands how to work sensitively and appropriately with young children. After the child has got to know the researcher in their class they will work with the researcher in a quiet room in his/her school for a data collection session during school working hours. In this session, your child will be encouraged to describe some pictures and play with toys. The session will be video or audio recorded, upon your preference, and kept as a reference for analysis. Each session will last for 45-60 minutes as long as the child is stimulated and cooperative. A short break will be given to your child upon request and data collection will be stopped if your child shows any sign of distress. At the end of the session, your child will be rewarded by stickers and/or a balloon. Please note that some children will be recorded more than once over a twelve-month period for the purpose of tracking changes in their speech over time.

Please hold on to Information sheets of this document with you for future reference and kindly return consent form "last page" with your child to be given to his teacher as soon as possible.

WHAT ARE THE POSSIBLE DISADVANTAGES OF TAKING PART?

Your child will be taken out of their normal routine for maximum of one hour, at a time his primary teacher allows. Your child will also be seen by a speech and language therapist whom they don't know well. Other than that, I assure you that there are no known risks involved in the children's participation in this study and if your child ever decides they do not want to participate the activities will be stopped immediately.

WHAT ARE THE POSSIBLE BENEFITS OF TAKING PART?

The information we get from this study will help us understand normal developmental stages of the Arabic language and may help us to treat future children with speech and language difficulties better.

WILL MY TAKING PART IN THIS STUDY REMAIN CONFIDENTIAL?

Any information about you or your child which leaves the school will have your name and contact information removed so that you cannot be recognized from it. All information collected including your child's responses will be kept strictly confidential and will be identified only by a code number. All recordings of your child will be stored on a secure, password-protected server at Newcastle University with access only for the researchers.

WHAT WILL HAPPEN TO THE RESULTS OF THIS STUDY?

The recordings will be analyzed to find out how children develop their speech. The data will only be used for the purpose to which you have consented. This study results will be submitted as a PhD thesis in the field of Speech Sciences at the University of Newcastle upon Tyne and may be published in research journals.

WHO IS ORGANISING THE RESEARCH?

The School of Education, Communication and Language Sciences, Speech and Language Sciences Section, University of Newcastle-upon-Tyne and The School of Rehabilitation and Health Sciences at Princess Nourah Bint Abdulrahman University in Riyadh.

WHAT NOW?

If you agree to participate please sign and return the enclosed consent form and questionnaire to school as soon as possible. Your cooperation and participation in the success of this project is of great value and is highly appreciated. If you have any questions or enquiries about this research project, please do not to hesitate to contact the researcher: Noura AlAjroush, at Noura.al-ajroush@newcastle.ac.uk or via phone at 0554477503 and/or her supervisors: Dr. Ghada Khattab at ghada.khattab@newcastle.ac.uk or via phone at: +44(191)208 6583 and Dr. Cristina McKean at cristina.mckean@ncl.ac.uk or via phone at: +44(191)208 6528

Best regards,
Noura AlAjroush

Please hold on to Information sheets of this document with you for future reference and kindly return consent form "last page" with your child to be given to his teacher as soon as possible.

ما الغرض من هذه الدعوة؟

من خلال هذه الدعوة نتطلع إلى تعاونكم معنا بالسماح لطفلكم بالمشاركة في هذه الدراسة العلمية ولكن قبل هذا، يتوجب علينا توضيح تفاصيل ومجريات هذه الدراسة حتى يمكنكم اتخاذ قرار المشاركة على بيّنة.

ما الهدف من هذه الدراسة؟

تهدف هذه الدراسة إلى استكشاف مراحل التطور الطبيعي للغة اللفظية من حيث دقة مخارج الحروف ووضوح الكلام لدى الأطفال السعوديين من عمر 2 إلى 5 سنوات. وباكتشاف هذه المراحل، ستتوفر معلومات قيمة تساعد المختصين في تقييم وعلاج الأطفال الذين يعانون من اضطرابات في النطق أو صعوبات في اللغة اللفظية بشكل عام.

كيف تم اختيار طفلي للمشاركة؟

تهدف الدراسة إلى تقييم اللغة اللفظية لدى الأطفال في فئات عمرية محددة وذلك ابتدأ من عمر سنة و 10 أشهر وحتى 5 سنوات وشهرين. وبناء عليه، تم التواصل مع إدارة مدرسة طفلك والتي رحبت بإجراء هذا البحث وسمحت بالتواصل مع والدي الأطفال لغرض المشاركة في البحث.

هل أنا مضطر للمشاركة؟

ترحيب المدرسة بالبحث لا يعني أن طفلك مضطر للمشاركة، فالقرار بمشاركة كل الطفل عائد لوالديه فقط. ولهذا اعطيتم ورقة المعلومات هذه لتبقى لديكم بالإضافة إلى الصفحة الأخيرة والتي بها "الموافقة المشفوعة بالعلم" لتعبئتها مع العلم أنه يمكنكم سحب الموافقة بمشاركة طفلكم في أي وقت وبدون إعطاء أي أسباب.

ماذا سيحدث لطفلي عند الموافقة بالمشاركة بالدراسة؟

بعد الحصول على موافقتكم بمشاركة الطفل وبعد التأكد من أن طفلك يقع ضمن الفئة العمرية المطلوبة للدراسة، سيطلب من الطفل المشاركة في نشاطات لغوية بسيطة من خلال اللعب مع الباحثة. الباحثة نورا العجروش أخصائية تخاطب متمرسة ولديها خبرة طويلة في التعامل مع الأطفال من مختلف الأعمار وستراعي احتياج طفلك لمدة تهيئة لتقبل وجودها والتعاون معها. بعد التأكد من ارتياح الطفل للتواجد مع الباحثة على حدة ورغبته بالمشاركة، ستصطحبه الباحثة إلى احدى الغرف الهادئة في المدرسة للبدء في جلسة خطوات البحث والتي من خلالها سيطلب من الطفل تسمية أو شرح الأحداث الموجودة في الصورة أثناء اللعب. سيتم تسجيل الجلسة في مدة أقصاها 60 دقيقة وذلك لاستخدامها لاحقا في تحليل القدرات اللفظية للطفل. سيعطى كل الطفل فترة راحة عند طلبة وستتوقف الجلسة عند ظهور أي علامة من علامات عدم الراحة كالتعب أو النعاس أو الجوع. في نهاية كل جلسة سيعطى كل طفل هدية رمزية لمشاركته وتعاونه مع الباحثة كالبالونات والملصقات (ستيكرز).
والجدير بالذكر أنه سيقع الاختيار على بعض الأطفال عشوائيا لتكرار جلسة خطوات البحث مرتان إضافيتان على الأقل خلال هذا العام وذلك لتتبع تطور القدرات اللفظية للطفل مع مرور الوقت.

ماهي المساوئ الممكنة لمشاركة طفلي في هذه الدراسة؟

سيترك طفلك صفه المدرسي لمدة ساعة على الأكثر ولكن ذلك سيحدث فقط في الأوقات التي تسمح بها معلمته الأساسية أو الحاضنة بحيث يتفادى بها غيابه عن حصص المواد الرئيسية أو أوقات الراحة والوجبات. والجدير بالذكر، أن الباحثة شخص غريب على طفلك، مما قد يشعره بعدم الراحة في البداية وسيتطلب منه بعض الوقت لتقبلها والتعاون معها. فيما عدا ذلك، أؤكد لكم بأنه لا يوجد أي مخاطر معروفة لمشاركة طفلكم في هذه الدراسة. أما في حال رفض الطفل المشاركة، بالرغم من موافقة والديه، فإنه سيتم ايقاف جميع خطوات البحث تلقائياً.

أرجو الاحتفاظ بصفحة 1 و 2 من هذا المستند لديكم للرجوع إليها عند الحاجة، ثم تعبئة البيانات في الصفحات 3 و 4 "موافقة مشفوعة بالعلم" وإعادتها مع طفلك لمعلمته أو الحاضنة في أسرع وقت ممكن.

ما هي المنافع المتوقعة من مشاركة طفلي في البحث؟

إن جميع المعلومات التي سيتم جمعها من الأطفال المشاركين في الدراسة، ستساعد المختصين من فهم تدرجات التطور الطبيعي للغة اللفظية عند الأطفال العرب كما أن نتائج البحث النهائية قد تساهم في توفير خدمات تشخيصية وعلاجية أفضل للأطفال المصابين بصعوبات في النطق.

ماذا سيعرف الآخرون عني وعن طفلي بعد المشاركة في هذه الدراسة؟

إن جميع المعلومات الشخصية التي يتم جمعها عن الأطفال أو عائلاتهم ستبقى سرية ولن يطلع عليها أي شخص فيما عدى الباحثة نفسها. كما أصول التسجيلات ونتائج البحث ستعطى رقما رمزياً بدلا من أسماء الأطفال حتى لا يمكن التعرف عليهم بها. والجدير بالذكر أن جميع المستندات والتسجيلات ستحفظ في مكان تخزين محمي بكلمة مرور سرية في جامعة نيوكاسل أبون تاين بحيث لا يمكن لأي كان الاطلاع عليها خارج فريق البحث: الأخصائية نورا العجروش والمشرفتان الأكاديميتان غادة خطاب و كرستينا ماكّين.

ماذا سيحدث لنتائج الدراسة؟

إن جميع المعلومات والتسجلات ستستخدم لما وافقتم عليه في خطاب "الموافقة المشفوعة بالعلم" فقط. بعد جمع الملعلومات والتسجيلات المطلوبة، سيتم تحليل إجابات الأطفال كلٍ على حدة لاستكشاف مراحل تطور اللغة اللفظية في كل مرحلة عمرية والتي ستكتب وتسلم ضمن رسالة الدكتوراة للباحثة في مجال علم التخاطب في جامعة نيوكاسل أبون تاين في بريطانيا. هذا بالإضافة أن نتائج البحث النهائية قد تنشر في المقالات العلمية.

ما الجهة المنظمة لهذه الدراسة؟

قسم علوم التخاطب في كلية علوم التعليم والتواصل واللغات في جامعة نيوكاسل أبون تاين في بريطانيا بالتعاون مع كلية الصحة وعلوم التأهيل بجامعة الأميرة نورة بنت عبدالرحمن للبنات في الرياض.

إذن، ما هو المطلوب الآن؟

إذا لم يكن لديكم مانع من مشاركة طفلكم في هذه الدراسة، أرجو تعبيئة البيانات المطلوبة والإجابة على كافة الأسئلة في الصفحة التالية "الموافقة المشفوعة بالعلم" وإعادتها للمعلمة أو الحاضنة الأساسية لطفلك في أسرع وقت ممكن. أما إذا كان لديكم أي استفسارات أو أسئلة عن هذه الدراسة، الرجاء التواصل مع الباحثة مباشرة عبر البريد الالكتروني Noura.al-ajroush@newcastle.ac.uk أو بالاتصال على رقم 0554477503 خلال ساعات العمل الرسمية من 8 صباحاً وحتى 2 ظهراً أو بالتواصل مع أحدى مشرفاتها الأكاديميات بالجامعة: د. غادة خطاب (بالعربية أو الانجليزية) بريد الكتروني: ghada.khattab@newcastle.ac.uk أو الهاتف: 6583 208(191)44+ أو د. كرستينا ماكّين (بالانجليزية فقط) بريد الكتروني: Cristina.mckean@ncl.ac.uk أو الهاتف: 6528 208(191)44+

إن تعاونكم معنا ومشاركتكم في هذه الدراسة هو محل تقديرنا ولكم منا جزيل الشكر.

الأخصائية/الباحثة

نورا بنت أحمد العجروش

أرجو الاحتفاظ بصفحة 1 و 2 من هذا المستند لديكم للرجوع إليها عند الحاجة، ثم تعبئة البيانات في الصفحات 3 و 4 "موافقة مشفوعة بالعلم" وإعادتها مع طفلك لمعلمته أو الحاضنة في أسرع وقت ممكن.

Appendix-C:

Invitation to participate in a Research Study: Consent Form (English and Arabic)

Research in Understanding How Young Arabic Children Learn to Speak

Newcastle University

I have read and understood the attached research information sheets of the study titled above, and I give my consent to the following (You can choose to consent to any of the following):

I give my consent for my child to participate and to be VIDEO recorded for the purposes of this study _______________ ☐ ***Yes*** ☐ ***No***

I give my consent for my child to participate and to be AUDIO recorded for the purposes of this study _______________ ☐ ***Yes*** ☐ ***No***

If you have agreed on your child's participation in this study, kindly take a few more minutes to answer the following questions:

1.	Are you and your spouse originally Saudi and raised in the central region of Saudi Arabia?	☐ **Yes**	☐ **No**
2.	Is Arabic the mother tongue of both you and your spouse?	☐ **Yes**	☐ **No**
3.	Is Arabic your child's first language?	☐ **Yes**	☐ **No**
4.	Is Arabic the primary language used at home?	☐ **Yes**	☐ **No**
5.	Do you have any concerns about your child's speech or language abilities, hearing or visual ability to identify printed pictures?	☐ **Yes**	☐ **No**
6.	Do you have a domestic helper (i.e.: nanny, driver, or cleaning lady) who does not speak Arabic fluently?	☐ **Yes**	☐ **No**

7. How much time daily does your child spend with your domestic helper?
☐ **less than one hour** ☐ **1-3 hours** ☐ **4-6 hours** ☐ **more than 6 hours**

8. How frequently do you use other languages to communicate with individuals in your household (family members and domestic workers)?
☐ **Always** ☐ **Often** ☐ **Rarely** ☐ **Never**

9. What is your child's birth date: ____**/**____**/ 20**___ **G** or ____**/**____**/143**__ **H**

10. What is the highest level of formal education for you and your spouse?

Mother:	☐None	☐ Elementary/ secondary	☐ High school	☐ Bachelor's degree	☐ Postgraduate
Father:	☐None	☐ Elementary/ secondary	☐ High school	☐ Bachelor's degree	☐ Postgraduate

Please hold on to Information sheets of this document with you for future reference and kindly return consent form "last page" with your child to be given to his teacher as soon as possible.

11. On average, what is your family's monthly income?

☐ **less than 10,000 SR**	☐ **20,000-29,000 SR**	☐ **40,000-49,000 SR**
☐ **10,000-19,000 SR**	☐ **30,000-39,000 SR**	☐ **More than 50,000 SR**

12. Where is your home located?

☐ **North of Riyadh:** Arrabeei, Almalga, Almorooj, Alworood, Almorsalat.. etc..
☐ **South of Riyadh:** Ashifa, Alaziziyah, Manfooha.. etc.
☐ **East of Riyadh:** Alrowadah, Annaseem, Alqadisyah, Alhamra, Arrabwah.. etc.
☐ **West of Riyadh:** Alderiyah, Irqa, Albadee'ah, Olisha.. etc.
☐ **Centre of Riyadh:** Almoraba'a, Almalaz, Alwizarat, Alma'athar.. etc.

Since the study depends heavily on stages of age-related acquisition of speech development, exact birth-date is crucial to ensure reliable results. If you don't remember the exact birth date of your child, please send a copy of his/her birth certificate or tick below to give permission for the researcher to access school records to obtain this information.

☐ ***I agree to have the researcher "Noura AlAjroush" access my child's school records for the sole purpose of obtaining my child's exact birth date.***

We aim to use the findings of this study to help us to identify and treat children with speech difficulties. To do this, we may present our findings at conferences or to Speech Pathologists in training. Using short clips of recordings can help this process. Please let us know whether you would be happy for us to use any anonymous recordings of your child in this way. Please note, this is not an essential part of this study. Your child can still participate in the study even if you decline this request.

I give my consent for the recordings of my child to be used for teaching or presentation purposes ________________________ ☐***Yes*** ☐ ***No***

Because data collection is time-consuming and costly, we would also like to ask your permission to securely keep the recordings of your child for future research and analysis outside the scope of this study. Please note that this request is not related to the research in hand and that your child can still participate in this study even if you deny us this request.

I give my consent for the recordings of my child to be securely saved and used for future research purposes ______________________ ☐***Yes*** ☐ ***No***

At the end, I would like to thank you for your time and cooperation and remind you to make sure you sign this consent form and return it to the researcher/teacher as soon as possible. And if do not mind to be contacted by the researcher for any enquiries or future research purposes, please provide your contact information below.

Participant's name: _______________ **Parent's name**: _________________________

Date: ___/___/ ________ **Signature:** __________________________________

Home or Mobile no. ____________ **Email:** ____________________________________

Please hold on to Information sheets of this document with you for future reference and kindly return consent form "last page" with your child to be given to his teacher as soon as possible.

موافقة مشوعة بالعلم

أنا والد/والدة الطفل/الطفلة ________________________________ في مدرسة/حضانة
________________ في الصف ______________ أؤكد بأنني قد اطلعت واستوعبت جميع المعلومات المرفقة للدراسة المذكورة أعلاه وعليه فإنني:

☐ نعم ☐ لا **أوافق على مشاركة طفلي في هذه الدراسة باستخدام التسجيل المرئي (فيديو) لطفلي أثناء جلسة خطوات البحث.**

☐ نعم ☐ لا **أوافق على مشاركة طفلي في هذه الدراسة باستخدام التسجيل الصوتي فقط لطفلي أثناء جلسة خطوات البحث.**

في حال ترحيبكم بمشاركة طفلك في هذه الدراسة، أرجو التكرم بالإجابة على الأسئلة التالية:

1. هل والدا الطفل سعوديا الأصل والمنشأ ومن المنطقة الوسطى؟ ☐ **نعم** ☐ **لا**
2. هل اللغة العربية هي اللغة الأم لكلا الوالدين؟ ☐ **نعم** ☐ **لا**
3. هل اللغة العربية هي اللغة الأولى التي تعلمها طفلك؟ ☐ **نعم** ☐ **لا**
4. هل اللغة العربية هي اللغة السائدة بين أفراد الأسرة؟ ☐ **نعم** ☐ **لا**
5. هل يعاني طفلك من تأخر لغوي أو مشاكل في السمع أو مشاكل في البصر قد تعوق قدرته على التعرّف على الصور المطبوعة؟ ☐ **نعم** ☐ **لا**
6. هل لديكم عمالة منزلية (سائق أو مربية أو خادمة) لا يتحدثون العربية بطلاقة؟ ☐ **نعم** ☐ **لا**
7. كم ساعة يقضيها طفلك يومياً مع الأفراد العاملين لديكم؟
   ☐ **أقل من ساعة** ☐ **1-3 ساعات** ☐ **4-6 ساعات** ☐ **أكثر من 6 ساعات**
8. ما مدى استخدام أفراد الأسرة للغات أخرى في التواصل بشكل يومي مع بعضهم البعض أو مع العاملين المنزليين؟
   ☐ **دائماً** ☐ **كثيراً** ☐ **نادراً** ☐ **أبداً: لا تستخدم لغات أخرى**
9. ماهي وظيفة أم الطفل:
   ☐ **ربة منزل** ☐ **تعمل من المنزل (مثال: مترجمة)** ☐ **موظفة بدوام جزئي (2-3 أيام بالأسبوع فقط)**
   ☐ **موظفة بدوام كامل (ينتهي قبل الساعة 2 ظهراً)** ☐ **موظفة بدوام كامل (ينتهي بعد الساعة 2 ظهراً)**
10. ما هو المستوى التعليمي لـ:
   الأم: ☐ **أمّي أو بدون شهادات** ☐ **ابتدائي أو متوسطة** ☐ **ثانوي** ☐ **جامعي** ☐ **دراسات عليا**
   الأب: ☐ **أمّي أو بدون شهادات** ☐ **ابتدائي أو متوسطة** ☐ **ثانوي** ☐ **جامعي** ☐ **دراسات عليا**
11. ما هو متوسط الدخل الشهري للأسرة؟
   ☐ **أقل من 10 آلاف ريال** ☐ **10،000-19،000 ريال** ☐ **20،000-29،000 ريال**
   ☐ **30،000-39،000 ريال** ☐ **40،000-49،000 ريال** ☐ **أكثر من 50،000 ريال شهرياً**

أرجو الحفاظ على صفحة 1 و 2 من هذا المستند لديكم للرجوع إليها عند الحاجة، ثم تعبئة البيانات في الصفحات 3 و 4 "موافقة مشفوعة بالعلم" وإعادتها مع طفلك لمعلمته أو الحاضنة في أسرع وقت ممكن.

12. في أي منطقة يقع منزلكم؟

- ☐ **شمال الرياض، مثال:** الربيع – الملقا – المروج – الورود – المرسلات... إلخ
- ☐ **جنوب الرياض، مثال:** الشفاء – منفوحة – العزيزية... إلخ
- ☐ **وسط الرياض، مثال:** المربع – الملز – الوزارات – المعذر... إلخ
- ☐ **شرق الرياض، مثال:** الروضة – الربوة – النسيم – الحمراء –القادسية... إلخ
- ☐ **غرب الرياض، مثال:** الدرعية – البديعة – عليشة... إلخ

13. ما هو تاريخ ميلاد طفلك؟

____/____/__143 هـ   أو   ____/____/____20 م

بما أن هذه الدراسة تعتمد بشكل كبير على ربط المهارات اللغوية اللفظية وتطورها بعمر الطفل، فإن صحة تاريخ ميلاد الطفل مهم جداً لضمان مصداقية نتائج البحث. في حال عدم تذكرك لميلاد طفلك، أرجو ارسال صورة من شهادة الميلاد أو دفتر العائلة أو للسماح للأخصائية (بالإشارة أدناه) بالاطلاع على ملف الطفل المدرسي للحصول على هذه المعلومة بشكل دقيق.

☐ **أوافق على منح الباحثة "نورا بنت أحمد العجروش" أحقية الاطلاع على ملف طفلي المدرسي لغرض الحصول على تاريخ ميلادة من الأوراق الثبوتية.**

إن الهدف الأساسي من هذه الدراسة هو مساعدة الأطفال المصابين بصعوبات في النطق، فإننا نصبو لنشر نتائج الدراسة في المؤتمرات العلمية واستخدامها في تعليم الطالبات والأخصائيات تحت التدريب. إن استخدام بعض المقاطع القصيرة من هذه التسجيلات سيساعد كثيراً في توضيح المعلومة بشكل أشمل ولهذا نود أن نعرف مدى ترحيبكم باستخدامها (بدون ذكر اسم الطفل أو مدرسته) لغرض العرض أو التدريب أوالتعليم. والجدير بالذكر ترحيبكم أو رفضكم لاستخدام تسجيلات طفلكم ليس أساسياً لمشاركته في الدراسة.

☐ **نعم** ☐ **لا** **أوافق على استخدام التسجيلات الصوتية أو المرئية لطفلي لغرض التدريب أو التعليم في المؤتمرات أوالمؤسسات التعليمية المختلفة.**

وأخيراً، إن مرحلة تجميع المعلومات والتسجيلات اللازمة لأي بحث مكلفة جداً وتتطلب عدد من الإجراءات المعقدة والتي تستمر عادة لعدة أشهر. ولهذا نود أن نطلب إذنكم لحفظ التسجيل الخاص بطفلكم والذي قمتم شاكرين بالترحيب به لغرض المشاركة في هذه الدراسة للاستفادة منه في أبحاث أخرى مستقبلية. أرجو ملاحظة أن هذا الطلب لا يتعلق بهذا البحث، حيث يمكنكم رفضه مع استمرار مشاركة الطفل في الدراسة الحالية.

☐ **نعم** ☐ **لا** **أوافق على حفظ واستخدام التسجيلات الصوتية أو المرئية لطفلي في أبحاث أخرى.**

وفي النهاية، أشكر لكم تعاونكم معنا لانجاح هذه الدراسة. كما أود تذكيركم بتعبئة كامل البيانات في هذه النموذج وإعادتها للباحثة/المدرسة في أسرع وقت ممكن. كما أرجو منكم التكرم بإضافة معلوماتكم الشخصية للتواصل في حال وجود أي أستفسارات أو أسئلة تخص طفلكم أو لغرض المشاركة في مزيد من الأبحاث.

اسم الوالد/الوالدة: ____________________________________

التاريخ: ____/____/________

التوقيع: ______________

هاتف رقم: __________________

بريد الكتروني:______________________________________

أرجو الحفاظ على صفحة 1 و 2 من هذا المستند لديكم للرجوع إليها عند الحاجة، ثم تعبئة البيانات في الصفحات 3 و 4 "موافقة مشفوعة بالعلم" وإعادتها مع طفلك لمعلمته أو الحاضنة في أسرع وقت ممكن.

4

Appendix-D: Study Protocol

صباح الخير.. الحين أنا و أنت بنلعب سوى بالصور.. مستعد؟ وكل مرة تقول لي واسمع صوتك.. بأعطيك ستيكر تجمعها وتأخذها لك البيت، ,إذا خلصنا، بأعطيك هدية كمان.. اتفقنا؟ بأوريك صورة وبأسألك سؤال عنها وتعلمني.. طيب؟ ياالله نبدأ:

مثال-1: أيش هذا؟

Stimulus in English	***Target word IPA***	***English meaning***	***Target word***	***Stimulus in Arabic***
What is this?	/mu.kaʕ.ʕa.baːt/	Blocks	مكعبات	1- إيش هذه؟
What is this?	/tɪl.fɪz.juːn/	Television	تلفزيون	2- إيش هذا؟
This is an apple and this is ……?	/kɪ.mɪθ.ra/	Pear	كمثرى	3- هذه تفاحة وهذه......................؟
This is a circle, this is a square, What is this?	/mu.θal.laθ/	Triangle	مثلث	4- هذه دائرة، وهذا مربع... إيش هذا؟
What is this?	/θal.la.d͡ʒa/	Fridge	ثلاجة	5- إيش هذه؟
When we had guests, this boy was very naughty and he was making faces. Not anymore, now he is being ……………?	/mu.ʔad.dab/	Polite	مؤدب	6- لما رحنا عند الضيوف، كان هذا الولد شقي مرة، بس الحين صار.........؟
What is this?	/ma.ka.ruː.na/	Pasta	مكرونة	7- إيش هذه؟
It is bed time, what is he doing with the duvet?	/jit.ɣatˤ.tˤaː/	Covers (v)	يتغطّى	8- جاء وقت النوم، إيش يسوي الولد باللحاف؟
What is this?	/sɪd͡ʒ.d͡ʒaː.da/	Prayer mat	سجادة	9- إيش هذه؟
What is this?	/ɣas.sa.la/	Washing machine	غسّالة	10- إيش هذه؟
Where are the student and teacher?	/mad.ra.sa/	at school	في المدرسة	11- شوف هذا المعلم وهذول الأطفال، وينهم؟
What is this?	/mɪɣ.sa.la/	Basin	مغسلة	12- إيش هذه؟

Stimulus in English	*Target word IPA*	*English Meaning*	*Target word*	*Stimulus in Arabic*
These are hand, and these are feet, what are these?	/ʕju:n/	Eyes	عيون	13- هذه رجول، وهذه يدين وهذه.......؟
Can name these animals for me?	/kalb/ /gɪrd/ /ħsˤa:n/ /xa.ru:f/	Dog Monkey Horse Sheep	كلب قرد حصان خروف	14- تعرف تسمي لي هذه الحيوانات؟
Where do you want me to put this ugly toy? Here or ………………	/hna:k/	There	هناك	15- وين تبيني أحط هذه اللعلبة الشينة؟ هنا و إلا ....
This is a Thob, and this is a…………..	/ʃma:ɣ/	Traditional Saudi clothing for men worn in the head.	شماغ	16- هذا ثوب وهذا ....؟
What is this?	/flu:s/	Money	فلوس	17- إيش هذه؟
This is a nose, and this is hair, do you know what this is? (pointing to body parts)	/wʌd͡ʒh/	face	وجه	18- هذا خشم، وهذا شعر، تعرف أيش هذا؟
This is a boy and this is ………. How many boys are there in this photo?	/bɪnt/ /wa.ħɪd/	Girl One	بنت واحد	19- هذا ولد، وهذه.................؟ كم ولد فيه بالصورة؟
This is glass of juice, what is in the other two glasses?	/ħa.li:b/ /θald͡ʒ /	Milk Ice	حليب ثلج	20- هذا الكاس فيه عصير، وهذا فيه..........؟ وهذا فيه إيش؟
What is this?	/xubz/	Bread	خبز	21- إيش هذا؟
What is this?	/ʃams/	Sun	شمس	22- إيش هذه؟
What is this? What do we use it for?	/sa.ʕa/ /wʌgt/	Hand watch Time	ساعة وقت	23- إيش هذه؟ إيش نشوف بالساعة؟

What can you see in this picture?	/ʕasˤ.fu:r/ /ʕɪʃ/ or /ʕuʃ/ /be:ðˤ/	Bird Nest Eggs	عصفور عش بيض	24- تقدر تقول لي وش فيه في هذه الصورة؟
What is this?	/rɪz/	Rice	رز	25- إيش هذا؟
What is the man trying to say?	/laʔ/	No	لأ	26- إيش يقول الرجال؟
This guy is leaving, but this one is………………?	/d͡ʒa:j/	He is going.	جاي	24- هذا الرجال رايح وهذا.............؟
What do the butcher do with sheep to get its meat?	/jað.baħ/	Slaughter	يذبح	25- إيش يسوي الجزار بالخروف عشان نأخذ لحمه؟
What is this? And what are these?	/fur.ʃa/ /ʔas.naːn/	Brush Teeth	فرشة أسنان	26- إيش هذه؟ وإيش هذه؟
This is a yellow car, What colour is this one? What about this other car? And this one?	/ʔaħ.mar/ /ʔaz.rag/ /ʔax.ðˤar/	Red Blue Green	أحمر أزرق أخضر	27- هذه السيارة لونها أصفر، وهذه إيش لونها؟ وهذه إيش لونها؟ وهذه إيش لونها؟
What is this? What is he doing ?	/bi:t.za/ /ja:.xɪð/	Pizza He takes a piece.	بيتزا يأخذ قطعة	28- إيش هذه؟ طيب، إيش يسوي الرجال؟
What are these?	/bɪs.kɔ:t/	Biscuits	بسكوت	29- إيش هذا؟
What is this?	/dab.du:b/	Teddy bear	دبدوب	30- إيش هذا؟
What is this room? Ok, now tell me where is the oven as you point at it?	/matˤ.bax/ /ha.ða/	Kitchen This is it.	مطبخ هذا	31- إيش هذا؟ طيب تقدر تقول لي وين الفرن؟
What is this?	/bat.tˤa/	Duck	بطة	32- إيش هذه؟
These are insects we see around, this is a fly, but that is this? And what is this?	/sˤar.sˤu:r/ /nam.la/	Cockroach Ant	صرصور نملة	33- هذه حشرات نشوفها حولنا. هذه ذبانة، تقدر تقول لي وش اسم هذه؟ طيب وهذه؟

What is this?	/d͡ʒaw.wa:l/	Mobile phone	جوال	34- إيش هذا؟
What is this?	/da.rad͡ʒ/	Stairs	درج	35- إيش هذا؟
This boy lost his ball, he is feeling ……….. What is the other boy doing?	/zaʕ.la:n/ /jaðˤ.ħak/	Sad Laughing	زعلان يضحك	36- هذا الولد ضاعت كورته، عشان كذا هو........... طيب وهذا الولد وش يسوي؟
This is dog is small, this one is bigger. But what about this one, is a little big or ………… big	/mar.ra:/	very	مرّة	37- هذا الكلب صغيرة وهذا أكبر وكذا كبير شوي وإلا كبير.........
Who is he?	/dʊk.tu:r/	Doctor	دكتور	38- مين هذا؟
What is this?	/ðˤɪf.daʕ/	Frog	ضفدع	39- إيش هذا؟
What is this?	/ðu.ra/	Corn	ذرة	40- إيش هذا؟
Allah Akbar, Allah Akbar.. (Reciting Athan).. what just happened?	/ʔʌð.ðan/	He called for prayer.	أذّن	41- الله أكبر الله أكبر.. أشهد أن لا إله إلا الله.. وش صار الحين؟
What is this?	/qa.lam/	Pen	قلم	42- إيش هذا؟
What is this?	/ʃa:.hɪ/	Tea	شاهي	43- أيش هذا؟
What is this?	/gah.wa/	Coffee	قهوة	44- إيش هذا؟
This is honey, what do we usually eat it with on breakfast?	/gɪʃ.tˤa/	Cream	قشطة	45- هذا عسل، نأكله بالفطور مع إيش؟..............
What is this?	/laj.mu:n/	Lemon	ليمون	46- إيش هذا؟
What is this?	/mɪ.gʌsˤ/	Scissors	مقص	47- أيش هذا؟
What is the boy doing?	/jnɪtˤ/	Jump	ينط	48- وش يسوي الولد؟
What is this?	/tˤaw.la/	Table	طاولة	49- إيش هذه؟
What is this?	/ʃan.tˤa/	Handbag	شنطة	50- إيش هذه؟
What is the boy doing?	/jal.bas/	Put them on.	يلبس الجزمة	51- إيش يسوي الولد؟
Now, we are finished.. Can you please open this box to get you reward?	/mag.dar/	I can't	ما أقدر	52- الحين خلاص خلصنا.. أبيك تفتح هذه العلبة عشان أعطيك الهدية.

Appendix-E: PN Stimulus targets, meaning, and syllabic structure

	IPA word	English meaning	Syllabic structure	Sounds targeted	Positions targeted
1	/ʕju:n/	Eyes	CCVVC	ʕj n	SIWI SFWF
2	/ħsˤa:n/	A horse	CCVVC	ħsˤ n	SIWI SFWF
3	/hna:k/	There	CCVVC	hn k	SIWI SFWF
4	/ʃma:ɣ/	Traditional Saudi clothing worn on head for men.	CCVVC	ʃm ɣ	SIWI SFWF
5	/flu:s/	Money	CCVVC	fl s	SIWI SFWF
6	/jnitˤ/	He jumps	CCVC	jn tˤ	SIWI SFWF
7	/wʌd͡ʒh/	Face	CVCC	w d͡ʒh	SIWI SFWF
8	/kalb/	Dog	CVCC	k lb	SIWI SFWF
9	/bɪnt/	Girl	CVCC	b -nt	SIWI SFWF
10	/θald͡ʒ /	Ice	CVCC	θ -ld͡ʒ	SIWI SFWF
11	/xubz/	Bread	CVCC	x -bz	SIWI SFWF
12	/gɪrd/	Monkey	CVCC	g ɾd	SIWI SFWF
13	/ʃams/	Sun	CVCC	ʃ ms	SIWI SFWF
14	/wʌgt/	Time	CVCC	w gt	SIWI SFWF
15	/ʕɪʃ/ or /ʕuʃ/	Nest	CVC	ʕ ʃ	SIWI SFWF
16	/be:ðˤ/	Eggs	CVVC	b ðˤ	SIWI SFWF
17	/rɪz/	Rice	CVC	r z	SIWI SFWF
18	/laʔ/	No	CVC	l ʔ	SIWI SFWF
19	/d͡ʒa:j/	He is coming.	CVVC	d͡ʒ j	SIWI SFWF
20	/jað.baħ/	Slaughter	CVC.CVC	j ð b ħ	SIWI SFWW SIWW SFWF
21	/ʔas.na:n/	Teeth	CVC.CVC	ʔ S	SIWI SFWW

				n	SIWW, SFWF
22	/ʔaħ.maɾ/	Red	CVC.CVC	ʔ ħ/ m ɾ	SIWI SFWW SIWW SFWF
23	/ʔax.ðˤaɾ/	Green	CVC.CVC	ʔ x ðˤ ɾ	SIWI SFWW SIWW SFWF
24	/ʔaz.ɾag/	Blue	CVC.CVC	ʔ z ɾ g	SIWI SFWW SIWW SFWF
25	/batˤ.tˤa:/	Duck	CVC.CV	b tˤ	SIWI SFWW, SIWW
26	/bi:t.za/	Pizza	CVVC.CV	b t z	SIWI SFWW SIWW
27	/bɪs.kɔ:t/	Biscuits	CVC.CVVC	b s k t	SIWI SFWW SIWW SFWF
28	/dab.du:b/	Teddy bear	CVC.CVVC	d b	SIWI, SIWW SFWW, SFWF
29	/matˤ.bax/	Kitchen	CVC.CVC	m tˤ b x	SIWI SFWW SIWW SFWF
30	/fur.ʃa/	A brush	CVC.CV	f ɾ ʃ	SIWI SFWW SIWW
31	/ħa.li:b/	milk	CV.CVVC	ħ l b	SIWI SIWW SFWF
32	/nam.la/	An ant	CVC.CV	n m l	SIWI SFWW SIWW]
33	/d͡ʒaw.wa:l/	Mobile phone	CVC.CVVC	d͡ʒ w l	SIWI SFWW,SI WW SFWF
34	/da.ɾad͡ʒ/	Stairs	CV.CVC	d ɾ d͡ʒ	SIWI SIWW SFWF
35	/jal.bas/	He is wearing	CVC.CVC	j	SIWI

				l b s	SFWW SIWW SFWF
36	/jaðˤ.ħak/	He laughs	CVC.CVC	j ðˤ ħ k	SIWI SFWW SIWW SFWF
37	/wa.ħɪd/	One	CV.CVC	w ħ d	SIWI SIWW SFWF
38	/mag.daɾ/	I can't	CVC.CVC	m g d ɾ	SIWI SFWW SIWW SFWF
39	/mar.ra:/	very	CVC.CVV	m r	SIWI SFWW, SIWW
40	/ja:.xɪð/	He takes	CVV.CVC	j x ð	SIWI SIWW SFWF
41	/dʊk.tu:r/	Doctor	CVC.CVVC	d k t ɾ	SIWI SFWW SIWW SFWF
42	/ðˤɪf.daʕ/	Frog	CVC.CVC	ðˤ f d ʕ	SIWI SFWW SIWW SFWF
43	/ðu.ra/	Corn	CV.CV	ð ɾ	SIWI SIWW
44	/ʔʌð.ðan/	He called for prayer.	CVC.CVC	ʔ ð n	SIWI SFWW,SI WW SFWF
45	/ha.ða/	this	CV.CV	h ð	SIWI SIWW
46	/qa.lam/	Pen	CV.CVC	q l m	SIWI SIWW SFWF
47	/ʃa:.hɪ/	Tea	CVV.CV	ʃ h	SIWI SIWW
48	/ʕasˤ.fu:r/	A bird	CVC.CVVC	ʕ sˤ f ɾ	SIWI SFWW SIWW SFWW
49	/laj.mu:n/	Lemon	CVC.CVVC	l j m n	SIWI SFWW SIWW SFWF

50	/gah.wa/	Coffee	CVC.CV	g h w	SIWI SFWW SIWW
51	/gɪʃ.tˤa/	Cream	CVC.CV	g ʃ tˤ	SIWI SFWW SIWW
52	/sˤar.sˤu:r/	Cockroach	CVC.CVVC	sˤ r	SIWI, SIWW SFWW, SFWF
53	/mɪ.gʌsˤ/	Scissors	CV.CVC	m g sˤ	SIWI SIWW SFWF
54	/tˤaw.la/	Table	CVC.CV	tˤ w l	SIWI SFWW SIWW
55	/ʃan.tˤa/	Purse	CVC.CV	ʃ n tˤ	SIWI SFWW SIWW
56	/zaʕ.la:n/	He is sad.	CVC.CVVC	z ʕ l n	SIWI SFWW SIWW SFWF
57	/sa.ʕa/	Clock	CV.CV	s ʕ	SIWI SIWW
58	/xa.ru:f/	Sheep	CV.CVVC	x r f	SIWI SIWW SFWF
59	/ɣas.sa.la/	Washing machine	CVC.CV.CV	ɣ s l	SIWI SFWW, SIWW SIWW
60	/mɪɣ.sa.la/	Basin	CVC.CV.CV	m ɣ s l	SIWI SFWW SIWW SIWW
61	/mad.ra.sa/	School	CVC.CV.CV	m d r s	SIWI SFWW SIWW SIWW
62	/sɪd͡ʒ.d͡ʒa:.da/	Prayer mat	CVC.CVV.CV	s d͡ʒ d	SIWI SFWW,SI WW SIWW
63	/tɪl.fɪz.ju:n/	Television	CVC.CVC.CV VC	t l f z j	SIWI SFWW SIWW SFWW SIWW

				n	SFWF
64	/kɪ.mɪθ.ɾa/	Pear	CV.CVC.CV	k m θ ɾ	SIWI SIWW SFWW SIWW
65	/mu.θal.laθ/	Triangle	CV.CVC.CVC	m θ l	SIWI SIWW, SFWF SFW W, SIWW
66	/θal.la.d͡ʒa/	Fridge	CVC.CV.CV	θ l d͡ʒ	SIWI SFWW, SIWW SIWW
67	/mu.ʔad.dab/	Polite-Male	CV.CVC.CVC	m ʔ d b	SIWI SIWW SFWW, SIWW SFWF
68	/jit.ɣatˤ.tˤaː/	He is covering	CV.CVC.CVV	J t ɣ tˤ	SIWI SFWW SIWW SIWW, SFWW
69	/mu.kaʕ.ʕa.ba:t/	Blocks	CV.CVC.CV.CVVC	m k ʕ b t	SIWI SIWW SFWW, SIWW SIWW SFWF
70	/ma.ka.ru:.na/	Pasta	CV.CV.CVV.CV	m k ɾ n	SIWI SIWW SIWW SIWW

Appendix-F:

Proof of License

(accurate as of March 24, 2015)

Dreamstime LLC
1616 Westgate Circle
Brentwood, TN 37027
United States

Customer name: Noura Alajroush

Location: Riyadh, Saudi Arabia

Address: 12 Alfustuq St, Altaawon

Phone: 0096655447XXX

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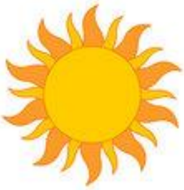
	21182363	Colored Cars	Jpegwiz Dreamstime.com	03/22/2015 06:38 PM	Large	Royalty Free
	7072519	Building lego blocks	Aprescindere Dreamstime.com	03/22/2015 06:38 PM	Max	Royalty Free
	2333296	Sheep	Isselee Dreamstime.com	03/22/2015 06:38 PM	Max	Royalty Free
	44208485	Penne	Norgal Dreamstime.com	03/22/2015 06:38 PM	Max	Royalty Free
	37164657	Biscuits in a white background	Tatsuya Otsuka Dreamstime.com	03/21/2015 06:26 PM	Max	Royalty Free
	44275478	Biscuits on white background	Mkos83 Dreamstime.com	03/21/2015 06:26 PM	Max	Royalty Free
	11786356	Baby Sumatran Orangutan against white background	Isselee Dreamstime.com	03/21/2015 06:26 PM	Max	Royalty Free
	48567529	Cooked rice in a white plate	Sommai Sommai Dreamstime.com	03/21/2015 06:26 PM	Max	Royalty Free

	43740694	Bird (Vinous - breasted Starling) isolated on whit	Tharvron Posri Dreamstime.com	03/23/2015 03:13 PM	Max	Royalty Free
	12260512	Child hands	Riderofthestorm Dreamstime.com	03/23/2015 03:13 PM	Max	Royalty Free
	27678828	Baby feet	Rangizzz Dreamstime.com	03/23/2015 03:13 PM	Max	Royalty Free
	13753854	Bird's Nest with Eggs	Matthew Benoit Dreamstime.com	03/22/2015 06:38 PM	Max	Royalty Free
	14595548	Sun logo	Dreamzdesigner Dreamstime.com	03/22/2015 06:38 PM	Max	Royalty Free
	19608492	Beagle dog isolated on white background.	Nejron Dreamstime.com	03/22/2015 06:38 PM	Max	Royalty Free
	27984845	Stack of pita bread	Ramzi Hachicho Dreamstime.com	03/22/2015 06:38 PM	Max	Royalty Free
	28018194	Luxury wrist watch in gold color isolated on white	Alexandr Mitiuc Dreamstime.com	03/22/2015 06:38 PM	Max	Royalty Free
	20136155	Arabic Coffee	Mahmoud Rahhal Dreamstime.com	03/22/2015 06:38 PM	Max	Royalty Free

	45013521	Statue of green frog on the white background	Yurakp Dreamstime.com	03/22/2015 06:38 PM	Max	Royalty Free
	49233107	Dark blue female handbag isolated on white backgro	Ontzet Dreamstime.com	03/21/2015 06:26 PM	Max	Royalty Free
	45194068	Male hand picking pizza slice	Elisanth Dreamstime.com	03/21/2015 06:26 PM	Max	Royalty Free
	4299931	Doctor isolated on white background	Forestpath Dreamstime.com	03/21/2015 06:26 PM	Max	Royalty Free
	43816656	Full glass of orange juice on white background	Nopparat Jaikla Dreamstime.com	03/21/2015 06:26 PM	Max	Royalty Free
	30099011	Glass of fresh milk isolated on white background	Hyrman Dreamstime.com	03/21/2015 06:26 PM	Max	Royalty Free
	31780856	Washing machine	Andrey Armyagov Dreamstime.com	03/21/2015 06:26 PM	Max	Royalty Free
	46686363	White washing sink	Yudesign Dreamstime.com	03/21/2015 06:26 PM	Max	Royalty Free

	15736852	Teacher in classroom with his little student	Zurijeta Dreamstime.com	03/21/2015 06:26 PM	Max	Royalty Free
	49829266	Muslims Prayer Mat or Carpet	Shariqkhan Dreamstime.com	03/21/2015 06:26 PM	Extralarge	Royalty Free
	37426378	Washing sink with ceramic base	Tairen10 Dreamstime.com	03/20/2015 03:00 PM	Max	Royalty Free
	15197805	Naughty boy making faces	Pipa100 Dreamstime.com	03/20/2015 03:00 PM	Max	Royalty Free
	15197814	Naughty little boy	Pipa100 Dreamstime.com	03/20/2015 03:00 PM	Max	Royalty Free
	33513425	Scissor	Michel Bussieres Dreamstime.com	03/18/2015 01:52 PM	Max	Royalty Free
	1972058	Corn on the cob	Marlee Dreamstime.com	03/18/2015 01:52 PM	Max	Royalty Free
	49205190	Bay horse isolated on white background	Alexia Khruscheva Dreamstime.com	03/18/2015 01:52 PM	Max	Royalty Free

	26249593	Close up cockroach on white background	Somchai Somsanitangkul Dreamstime.com	03/18/2015 01:52 PM	Max	Royalty Free
	47660118	Glass of Real Ice isolated on white background	Wichien Tepsuttinun Dreamstime.com	03/18/2015 01:52 PM	Max	Royalty Free
	11608541	Healthy teeth	Kurhan Dreamstime.com	03/24/2015 05:03 PM	Max	Royalty Free
	50068400	Laughing little boy	Atikinka Dreamstime.com	03/24/2015 04:13 PM	Max	Royalty Free
	10329116	Sad	Marina Dyakonova Dreamstime.com	03/24/2015 04:03 PM	Max	Royalty Free
	13128029	Glass cup of tea with teaspoon isolated	Valery2007 Dreamstime.com	03/24/2015 03:52 PM	Max	Royalty Free
	51072764	Cute african american little boy jump isolated on	Lopolo Dreamstime.com	03/24/2015 03:51 PM	Max	Royalty Free
	27422024	Happy kids boy and girls eating ice cream isolated	Oksun70 Dreamstime.com	03/24/2015 03:51 PM	Max	Royalty Free

	2514268	Peeled Banana	Todd Taulman Dreamstime.com	03/24/2015 03:51 PM	Max	Royalty Free
	1556966	A yellow rubber duck isolated on a white backgroun	Alexander Paterov Dreamstime.com	03/23/2015 03:21 PM	Large	Royalty Free
	6314769	Two green eyes	Inga Nielsen Dreamstime.com	03/23/2015 03:21 PM	Large	Royalty Free
	20642933	Luxury Modern Kitchen	Michael Higginson Dreamstime.com	03/23/2015 03:21 PM	Max	Royalty Free
	71956	Fly 1	Joao Estevao Andrade De Freitas Dreamstime.com	03/23/2015 03:13 PM	Max	Royalty Free
	22068739	Kaymak on a bread	Ukrphoto Dreamstime.com	03/23/2015 03:13 PM	Max	Royalty Free
	22098493	Lemon	Jason Cheng Dreamstime.com	03/23/2015 03:13 PM	Max	Royalty Free
	40677685	Toy teddy bear	Tirrasa Dreamstime.com	03/23/2015 03:13 PM	Max	Royalty Free

	23570649	Two door white refrigerator	Piotr Pawinski Dreamstime.com	03/23/2015 03:13 PM	Max	Royalty Free
	21005722	Big Dog Small Dog	Erik Lam Dreamstime.com	03/23/2015 03:13 PM	Max	Royalty Free
	10524208	Raw lamb meat	Mchudo Dreamstime.com	03/23/2015 03:13 PM	Max	Royalty Free
	36796257	Kandura and Ghutrah are usually worn by men in Ara	Sophiejames Dreamstime.com	03/23/2015 03:13 PM	Max	Royalty Free

Appendix-G:

Thank you letter (English and Arabic)

Dear parents of ________________________

First, I would like to take this opportunity to thank you for allowing your child to take part in the current study which aims to investigate the specifics of phonological development in Arabic speaking children. This letter confirms that your child's participation has been recorded only using the manner you have consented to on ___/___/______ at ______ am/pm and the session lasted ______ minutes. Rest assured that all identifying information has been removed from all recordings before they have been saved in a password protected location.

In the next phase and after gathering enough participants, all children's recordings will be reviewed individually and then analyzed. It is worth mentioning that the expected period of completion of this study is four years. Upon completion of this study, a summary of the research findings will be printed and distributed to the participating schools and to the parents of the participating children.

At the end, I would like to remind you that I will be more than happy to receive your inquiries regarding this study via e-mail n.al-ajroush@newcastle.ac.uk or by via a phone call or text on: 00554477503

Your cooperation and participation in this study is appreciated.

The researcher,
Noura bint Ahmed Al Ajroush

والدي الطفل/ الطفلة ________________________________

السلام عليكم ورحمة الله وبركاته...   أمّا بعد

في البداية أود أن أشكر لكم تعاونكم معنا وقبولكم مشاركة طفلكم/طفلتكم في هذه الدراسة والتي تهدف إلى فهم كيفية تطور المهارات اللفظية عند الأطفال الناطقين باللغة العربية. وبهذا أود إبلاغكم بأنه تم تسجيل مشاركة طفلكم/طفلتكم في هذا البحث بتاريخ ___/___/_______هـ في تمام الساعة ___________ وقد استغرقت الجلسة _______ دقيقة.

كما أود أن أؤكد أن مشاركة طفلكم/طفلتكم تم تسجيلها بالوسيلة التي وافقتم عليها فقط وتم حفظها بشكل آمن في مكان تخزين محمي بكلمة مرور سرية وذلك بعد إزالة جميع المعلومات الشخصية والتي يمكن بها التعرف على هوية الطفل/الطفلة. في المرحلة القادمة من هذه الرسالة وبعد جمع عدد كاف من المشتركين، ستتم مراجعة جميع تسجيلات الأطفال كل على حدة ومن ثم تحليل النتائج. والجدير بالذكر أن المدة الزمنية المتوقعة لاستكمال هذه الدراسة هو أربع سنوات من تاريخه. عند استكمال هذه الدراسة، ستتم طباعة نشرة موجزة لنتائج البحث وسيتم توزيعها على المدارس المشاركة وأهالي الأطفال المشاركين.

وفي النهاية، أود التنويه بأنه يسعدني استقبال استفساراتكم فيما يخص هذه الدراسة عبر البريد الاكتروني

N.Al-Ajroush@Newcaste.ac.uk أو بالأتصال على رقم: 00554477503

إن مشاركتكم في نجاح هذا البحث وتعاونكم معنا هو محل تقديرنا واهتمامنا.

الباحثة،

نورا بنت أحمد العجروش

Appendix-H:

Consonantal and Extended IPA symbols used in transcriptions

Tables H.1, H.2. and H.3 lists all vowel, consonantal and extended diacritics IPA symbols used in the narrow transcription of the data in this study.

Table H.1:

Vowel IPA symbols used in data transcription

Symbol	Description
i	high front unrounded vowel
ɪ	near-close near-front high unrounded vowel
e	tense mid front unrounded vowel
ɛ	Open mid-front unrounded vowel
æ	near open front unrounded lax vowel
a	lowest-front unrounded vowel
ɨ	Close high-central unrounded vowel
ʉ	Close high central rounded vowel
ɘ	Close mid-central unrounded vowel
ɵ	Close mid-central rounded vowel
ə	mid central lax vowel “schwa”
ɚ	rhotacized schwa
ɜ	Open mid-central unrounded vowel
ɞ	Open mid-central rounded vowel
ɐ	Near-open central vowel
u	high back rounded vowel
ʊ	near-close near-back rounded lax vowel
o	mid back rounded tense vowel
ʌ	Open Mid-back unrounded vowel
ɔ	open mid-back rounded lax vowel
ɑ	open low back unrounded vowel
ɒ	open low back rounded vowel

Table H.2

Consonantal IPA symbols used in data transcription

Symbol	Description	Symbol	Description
ʔ	voiceless glottal plosive	ʃ	voiceless postalveolar fricative
b	voiced bilabial plosive	t͡ʃ	voiceless postalveolar affricate
p	voiceless bilabial plosive	sˤ	emphatic/pharyngealized voiceless alveolar fricative
β	voiced bilabial fricative	tˤ	emphatic/pharyngealized voiceless alveolar plosive
t	voiceless alveolar plosive	ðˤ	emphatic/pharyngealized voiced inter-dental fricative
θ	voiceless dental fricative	ʕ	voiced pharyngeal fricative
d͡ʒ	voiced alveolar affricate	ɣ	voiced velar fricative
ʒ	voiced palate-alveolar fricative	f	voiceless labiodental fricative
ç	voiceless palatal fricative	v	voiced labiodental fricative
ħ	voiceless pharyngeal fricative	g	voiced velar plosive
x	voiceless velar fricative	q	voiceless uvular plosive
d	voiced alveolar plosive	k	voiceless velar plosive
ð	voiced inter-dental fricative	l	voiced alveolar lateral liquid
lˤ	emphatic/pharyngealized alveolar lateral liquid	ɫ	velarized voiced alveolar lateral liquid
z	voiced alveolar fricative	m	voiced bilabial nasal
zˤ	emphatic/pharyngealized voiced alveolar fricative	n	voiced alveolar nasal
s	voiceless alveolar fricative	ŋ	voiced velar nasal
t͡s	voiceless alveolar affricate	h	voiceless glottal fricative
ɸ	voiceless bilabial fricative	ɦ	voiced glottal fricative
ʋ	labio-dental voiced approximant	w	voiced labial-velar glide
ɺ	voiced alveolar lateral flap	j	voiced palatal glide
r	voiced alveolar trill	ɽ	voiced retroflex flap
ɾ	voiced alveolar tap	ɹ	voiced (post)alveolar liquid

Table H.3

List of Extended IPA diacritic symbols used in data transcription

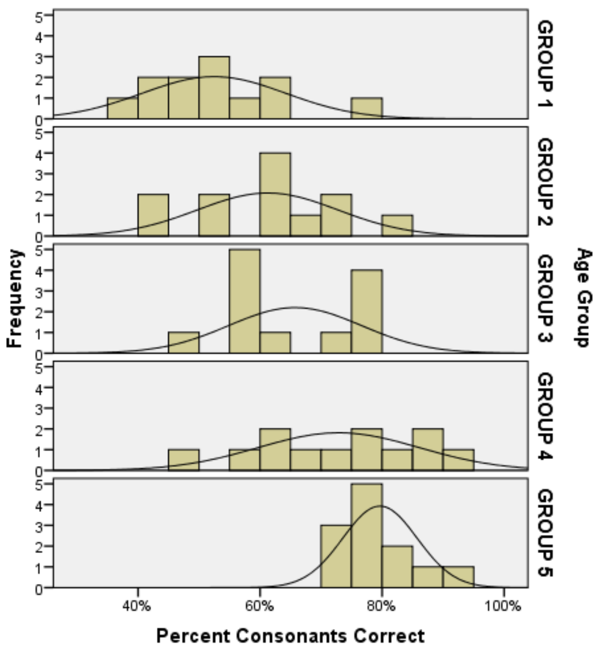
Symbol	Description	Use to indicate
ˈ	primary stress	syllables with primary stress
ˌ	secondary stress	syllables with secondary stress
ː	long	long vowels
ˑ	half-long	half-long vowels and consonants
˘	extra-short	extra-short vowels
˜	nasal	nasality in non-nasal sounds
˚	devoiced	loss of voicing
̬	voiced	insertion of voicing quality
ʳ	rhotacized	rhotic quality
ʰ	aspirated	audible aspiration
ʷ	labialized	rounded/labialized quality
ʲ	palatalized	palatalized sound quality
̟	advanced	advanced place of articulation
̠	retracted	retracted place of articulation
̚	unreleased	no audible release
̞	lowered	lowered place of articulation/ also used for weak articulation
ʼ	ejective	ejecting quality, often of plosives
̼	linguolabial	the usage of tongue and lips as place of articulation
̰	creaky voice	creaky voice quality of vowels
̤	breathy voice	breathy voice quality of vowels
̪	dental	the usage of front teeth in articulation
͈	strong articulation	strong but not long articulation of consonants in the absence of gemination
͉	weak articulation	weak contact of articulators
ˤ	pharyngealized	place of articulation retracted to pharynx
ˀ	glottal	place of articulation retracted to glottis
͊	denasal	loss of nasality
͋	Nasal escape	excess and audible nasal release

Appendix-I:

PCC Normality Test

		Shapiro-Wilk		
	Age Group	Statistic	df	Sig.
Percent Consonants Correct	Group 1	.905	12	.185
	Group 2	.958	12	.762
	Group 3	.883	12	.096
	Group 4	.965	12	.857
	Group 5	.934	12	.427

Key: PCC = Percent Consonants Correct



Appendix-J:

PCC manner of articulation groups - Normality Test

		Shapiro-Wilk		
	Age Group	**Statistic**	**df**	**Sig.**
PCC Stops	Group 1	.952	9	.710
	Group 2	.912	11	.258
	Group 3	.927	12	.353
	Group 4	.920	12	.285
	Group 5	.942	12	.525
PCC Fricatives	Group 1	.898	9	.243
	Group 2	.955	11	.707
	Group 3	.914	12	.237
	Group 4	.950	12	.644
	Group 5	.965	12	.858
PCC Nasals	Group 1	.975	9	.931
	Group 2	.957	11	.728
	Group 3	.935	12	.441
	Group 4	.863	12	.053
	Group 5	.940	12	.501
PCC Affricates	Group 1	.390	9	**.000****
	Group 2	.856	11	.052
	Group 3	.899	12	.153
	Group 4	.882	12	.093
	Group 5	.951	12	.655
PCC Tap	Group 1	.868	9	.116
	Group 2	.878	11	.099
	Group 3	.893	12	.128
	Group 4	.799	12	**.009****
	Group 5	.935	12	.440
PCC Trill	Group 1	.672	9	**.001****
	Group 2	.915	11	.278
	Group 3	.974	12	.949
	Group 4	.926	12	.344
	Group 5	.890	12	.117
PCC Laterals	Group 1	.954	9	.733
	Group 2	.898	11	.173
	Group 3	.936	12	.444
	Group 4	.956	12	.723
	Group 5	.864	12	.055
PCC Approximants	Group 1	.914	9	.343
	Group 2	.947	11	.610
	Group 3	.945	12	.566
	Group 4	.843	12	**.030***
	Group 5	.963	12	.822
PCC Emphatics	Group 1	.556	9	**.000****
	Group 2	.848	11	**.040***
	Group 3	.847	12	**.033***
	Group 4	.829	12	**.021***
	Group 5	.977	12	.970

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: PCC = Percent Consonants Correct

Appendix-K:

PN vs SPON PCC Normality Test:

		Shapiro-Wilk		
	Age Group	Statistic	df	Sig.
PN PCC	GROUP 1	.924	12	.323
	GROUP 2	.982	12	.991
	GROUP 3	.905	12	.183
	GROUP 4	.976	12	.963
	GROUP 5	.976	12	.963
SPON PCC	GROUP 1	.937	12	.461
	GROUP 2	.971	12	.925
	GROUP 3	.899	12	.153
	GROUP 4	.947	12	.592
	GROUP 5	.938	12	.475

Key: PN = Picture Naming, SPON = Spontaneous, PCC = Percent Consonants Correct.

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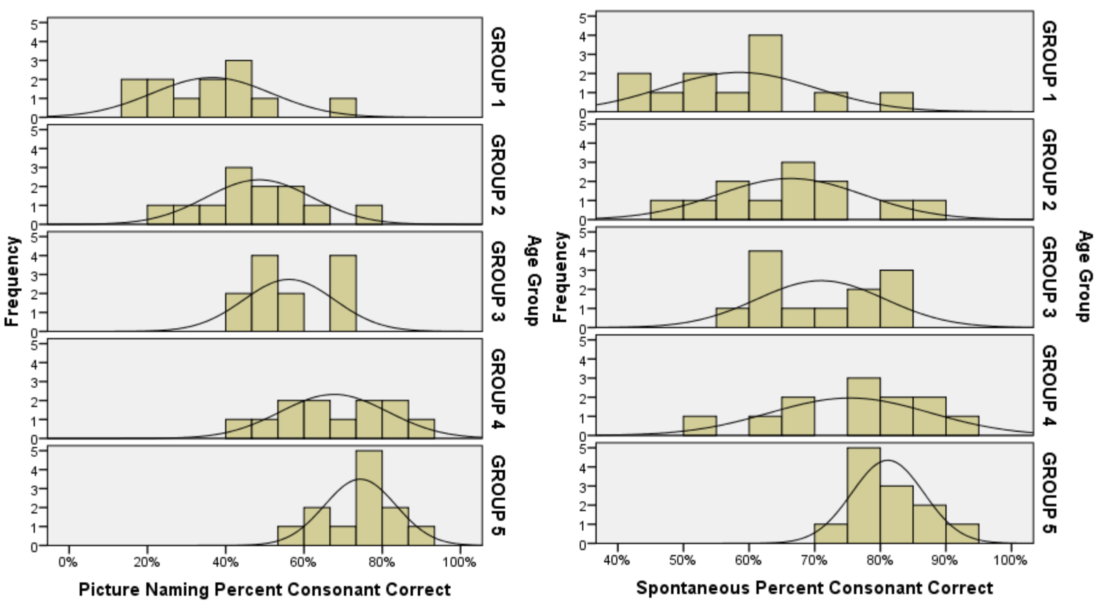


Appendix-L:

a. *PN vs. SPON PCC: Levene's Test of Equality of Error Variances*

Within Subjects Effect	F	df1	df2	Sig.
PN PCC	.760	9	50	.653
SPON PCC	1.525	9	50	.165

Key: PN = Picture Naming, SPON = Spontaneoush, PCC = Percent Consonants Correct.

b. *PN vs. SPON PCC: Mauchly's Test of Sphericity*

					Epsilon		
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
PN vs SPON PCC	1.000	.000	0	.	1.000	1.000	1.000

Key: PN = Picture Naming, SPON = Spontaneous, PCC = Percent Consonants Correct.

Appendix-M:

PCC Post Hoc Test between Age-Groups

(I) Age Group	(J) Age Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
GROUP 1	GROUP 2	-9.9675	4.30261	.157	-22.1431	2.2081
	GROUP 3	-16.1200*	4.30261	.004	-28.2956	-3.9444
	GROUP 4	-24.0742*	4.30261	.000	-36.2497	-11.8986
	GROUP 5	-30.3117*	4.30261	.000	-42.4872	-18.1361
GROUP 2	GROUP 1	9.9675	4.30261	.157	-2.2081	22.1431
	GROUP 3	-6.1525	4.30261	.612	-18.3281	6.0231
	GROUP 4	-14.1067*	4.30261	.016	-26.2822	-1.9311
	GROUP 5	-20.3442*	4.30261	.000	-32.5197	-8.1686
GROUP 3	GROUP 1	16.1200*	4.30261	.004	3.9444	28.2956
	GROUP 2	6.1525	4.30261	.612	-6.0231	18.3281
	GROUP 4	-7.9542	4.30261	.358	-20.1297	4.2214
	GROUP 5	-14.1917*	4.30261	.015	-26.3672	-2.0161
GROUP 4	GROUP 1	24.0742*	4.30261	.000	11.8986	36.2497
	GROUP 2	14.1067*	4.30261	.016	1.9311	26.2822
	GROUP 3	7.9542	4.30261	.358	-4.2214	20.1297
	GROUP 5	-6.2375	4.30261	.599	-18.4131	5.9381
GROUP 5	GROUP 1	30.3117*	4.30261	.000	18.1361	42.4872
	GROUP 2	20.3442*	4.30261	.000	8.1686	32.5197
	GROUP 3	14.1917*	4.30261	.015	2.0161	26.3672
	GROUP 4	6.2375	4.30261	.599	-5.9381	18.4131

Key: PCC = Percent Consonants Correct.

Appendix-N:

*Speech-Task*Age-Group Interaction of PCC: Mauchly's Test of Sphericity*

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
G1 PN vs SPON PCC	1.000	.000	0	.	1.000	1.000	1.000
G2 PN vs SPON PCC	1.000	.000	0	.	1.000	1.000	1.000
G3 PN vs SPON PCC	1.000	.000	0	.	1.000	1.000	1.000
G4 PN vs SPON PCC	1.000	.000	0	.	1.000	1.000	1.000
G5 PN vs SPON PCC	.000	.000	0	.	1.000	1.000	1.000

Key: PN = Picture Naming, SPON = Spontaneous, PCC = Percent Consonants Correct.

Appendix-O:

Positional PCC Normality Test

	Age Group	Shapiro-Wilk		
		Statistic	df	Sig.
Syllable-Initial Word-Initial PCC	GROUP 1	.967	12	.877
	GROUP 2	.959	12	.768
	GROUP 3	.909	12	.206
	GROUP 4	.939	12	.488
	GROUP 5	.958	12	.753
Syllable-Initial Within-Word PCC	GROUP 1	.967	12	.877
	GROUP 2	.979	12	.980
	GROUP 3	.902	12	.169
	GROUP 4	.945	12	.566
	GROUP 5	.960	12	.791
Syllable-Final Within-Word PCC	GROUP 1	.789	12	.007**
	GROUP 2	.919	12	.274
	GROUP 3	.921	12	.295
	GROUP 4	.956	12	.722
	GROUP 5	.929	12	.366
Syllable Final Word-Final PCC	GROUP 1	.960	12	.779
	GROUP 2	.927	12	.354
	GROUP 3	.919	12	.280
	GROUP 4	.979	12	.978
	GROUP 5	.977	12	.966

*. The mean difference is significant at the .01 level.
Key: PCC = Percent Consonants Correct.

Appendix-P:

Mauchly's Test of Sphericity in Positional PCC

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Syllable/Word Position	.753	13.814	5	.017	.831	1.000	.333

Key: PCC = Percent Consonants Correct.

Appendix-Q:

*Syllable/Word Position*Age-Group Interaction of Positional PCC: Mauchly's Test of Sphericity*

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
G1 Positional PCC	.039	31.486	5	.000**	.552	.638	.333
G2 Positional PCC	.396	9.012	5	.110	.606	.720	.333
G3 Positional PCC	.283	12.256	5	.032*	.619	.739	.333
G4 Positional PCC	.648	4.222	5	.520	.766	.980	.333
G5 Positional PCC	.205	15.412	5	.009**	.633	.761	.333

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: PCC = Percent Consonants Correct.

Appendix-R:

*PCC Medial and Coda Consonants*Age-Group Interaction of Positional PCC: Mauchly's Test of Sphericity*

Within Subjects Effect	Age Groups	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
						Greenhouse-Geisser	Huynh-Feldt	Lower-bound
SIWW vs. SFWW	G1	1.000	.000	0	.	1.000	1.000	1.000
	G2	1.000	.000	0	.	1.000	1.000	1.000
	G3	1.000	.000	0	.	1.000	1.000	1.000
	G4	1.000	.000	0	.	1.000	1.000	1.000
	G5	1.000	.000	0	.	1.000	1.000	1.000
SFWW vs. SFWF	G1	1.000	.000	0	.	1.000	1.000	1.000
	G2	1.000	.000	0	.	1.000	1.000	1.000
	G3	1.000	.000	0	.	1.000	1.000	1.000
	G4	1.000	.000	0	.	1.000	1.000	1.000
	G5	1.000	.000	0	.	1.000	1.000	1.000

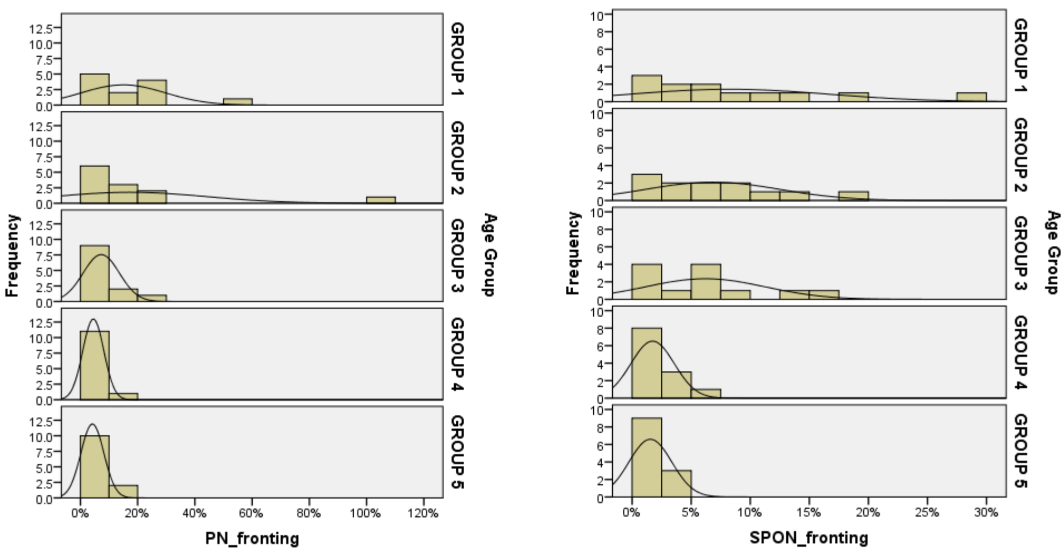
Key: PCC = Percent Consonants Correct, SIWW= Syllable Initial Within-Word, SFWW= Syllable Final Within-Word.

Appendix-S:

Velar-Fronting Errors: Normality Test

		Shapiro-Wilk		
	Age Group	Statistic	df	Sig.
PN velar fronting	GROUP 1	.873	12	.072
	GROUP 2	.558	12	.000*
	GROUP 3	.916	12	.252
	GROUP 4	.912	12	.228
	GROUP 5	.798	12	.009*
SPON velar fronting	GROUP 1	.873	12	.071
	GROUP 2	.942	12	.527
	GROUP 3	.879	12	.085
	GROUP 4	.876	12	.078
	GROUP 5	.800	12	.009*

*. The mean difference is significant at the .01 level.
Key: PN = Picture Naming, SPON = Spontaneous.



Key: PN = Picture Naming, SPON = Spontaneous.

Appendix-T:

Velar-Fronting Errors: Mauchly's Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b] Greenhouse-Geisser	Huynh-Feldt	Lower-bound
PN vs SPON Fronting	1.000	.000	0	.	1.000	1.000	1.000

Key: PN = Picture Naming, SPON = Spontaneous.

Appendix-U:

Velar-Fronting post Hoc Test:

(I) Age Group	(J) Age Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
GROUP 1	GROUP 2	-.4496	3.27451	1.000	-9.7158	8.8167
	GROUP 3	4.8658	3.27451	.576	-4.4004	14.1321
	GROUP 4	8.4750	3.27451	.088	-.7912	17.7412
	GROUP 5	8.7313	3.27451	.074	-.5350	17.9975
GROUP 2	GROUP 1	.4496	3.27451	1.000	-8.8167	9.7158
	GROUP 3	5.3154	3.27451	.490	-3.9508	14.5817
	GROUP 4	8.9246	3.27451	.064	-.3417	18.1908
	GROUP 5	9.1808	3.27451	.053	-.0854	18.4471
GROUP 3	GROUP 1	-4.8658	3.27451	.576	-14.1321	4.4004
	GROUP 2	-5.3154	3.27451	.490	-14.5817	3.9508
	GROUP 4	3.6092	3.27451	.805	-5.6571	12.8754
	GROUP 5	3.8654	3.27451	.762	-5.4008	13.1317
GROUP 4	GROUP 1	-8.4750	3.27451	.088	-17.7412	.7912
	GROUP 2	-8.9246	3.27451	.064	-18.1908	.3417
	GROUP 3	-3.6092	3.27451	.805	-12.8754	5.6571
	GROUP 5	.2563	3.27451	1.000	-9.0100	9.5225
GROUP 5	GROUP 1	-8.7313	3.27451	.074	-17.9975	.5350
	GROUP 2	-9.1808	3.27451	.053	-18.4471	.0854
	GROUP 3	-3.8654	3.27451	.762	-13.1317	5.4008
	GROUP 4	-.2563	3.27451	1.000	-9.5225	9.0100

Appendix-V:

Positional Velar-Fronting Errors: Normality Test

		Shapiro-Wilk		
	Age Group	Statistic	df	Sig.
SIWI velar fronting	GROUP 1	.935	12	.442
	GROUP 2	.857	12	.045*
	GROUP 3	.782	12	.006**
	GROUP 4	.813	12	.013*
	GROUP 5	.876	12	.078
SIWW velar fronting	GROUP 1	.906	12	.190
	GROUP 2	.899	12	.152
	GROUP 3	.898	12	.149
	GROUP 4	.823	12	.017*
	GROUP 5	.921	12	.291
SFWW velar fronting	GROUP 1	.964	12	.833
	GROUP 2	.859	12	.047*
	GROUP 3	.812	12	.013*
	GROUP 4	.754	12	.003**
	GROUP 5	.911	12	.220
SFWF velar fronting	GROUP 1	.839	12	.027*
	GROUP 2	.901	12	.163
	GROUP 3	.879	12	.084
	GROUP 4	.847	12	.033*
	GROUP 5	.878	12	.084

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: SIWI = Syllable-Initial Word-Initial, SIWW, Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

Appendix-W:

Difference in Velar-Fronting Errors between Several Syllable/word positions: Wilcoxon Signed Ranks Test

Syllable/word Positions compared	Reference	N	Mean Rank	Sum of Ranks
SIWW velar fronting - SIWI velar fronting	Negative Ranks	15[a]	24.33	365.00
	Positive Ranks	37[b]	27.38	1013.00
	Ties	8[c]		
	Total	60		
SFWW velar fronting - SIWW velar fronting	Negative Ranks	12[d]	24.67	296.00
	Positive Ranks	43[e]	28.93	1244.00
	Ties	5[f]		
	Total	60		
SFWF velar fronting - SFWW velar fronting	Negative Ranks	39[g]	28.28	1103.00
	Positive Ranks	14[h]	23.43	328.00
	Ties	7[i]		
	Total	60		
SFWF velar fronting - SIWI velar fronting	Negative Ranks	20[j]	31.03	620.50
	Positive Ranks	35[k]	26.27	919.50
	Ties	5[l]		
	Total	60		

a. Syllable-final word-final fronting < Syllable-initial word-initial fronting
b. Syllable-final word-final fronting > Syllable-initial word-initial fronting
c. Syllable-final word-final fronting = Syllable-initial word-initial fronting
d. Syllable-Initial Within-word fronting < Syllable-initial word-initial fronting
e. Syllable-Initial Within-word fronting > Syllable-initial word-initial fronting
f. Syllable-Initial Within-word fronting = Syllable-initial word-initial fronting
g. Syllable-final within-word fronting < Syllable-Initial Within-word fronting
h. Syllable-final within-word fronting > Syllable-Initial Within-word fronting
i. Syllable-final within-word fronting = Syllable-Initial Within-word fronting
j. Syllable-final word-final fronting < Syllable-final within-word fronting
k. Syllable-final word-final fronting > Syllable-final within-word fronting
l. Syllable-final word-final fronting = Syllable-final within-word fronting

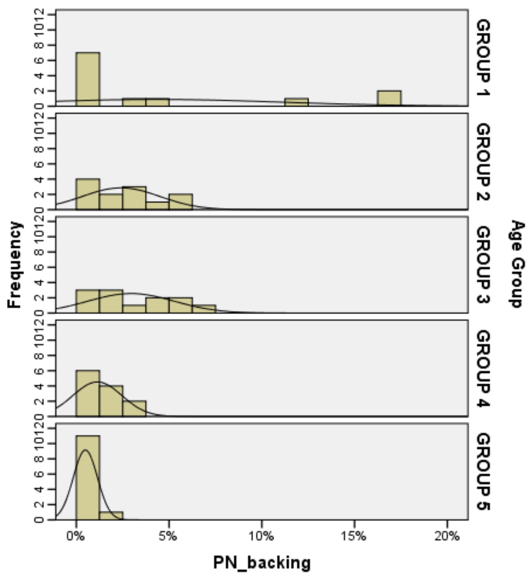
Key: SIWI = Syllable-Initial Word-Initial, SIWW, Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

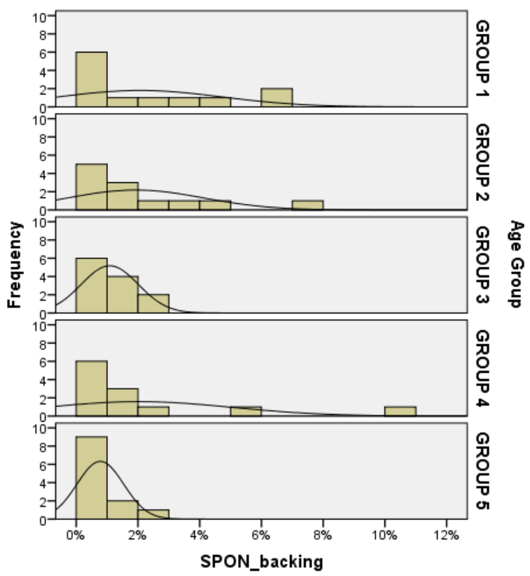
Appendix-X:

Coronal Backing Errors: Normality Test

	Age Group	Shapiro-Wilk		
		Statistic	df	Sig.
PN Coronal Backing	GROUP 1	.681	12	.001**
	GROUP 2	.904	12	.180
	GROUP 3	.929	12	.365
	GROUP 4	.812	12	.013*
	GROUP 5	.759	12	.003**
SPON Coronal Backing	GROUP 1	.784	12	.006**
	GROUP 2	.829	12	.021**
	GROUP 3	.917	12	.264
	GROUP 4	.702	12	.001**
	GROUP 5	.876	12	.078

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: PN = Picture Naming, SPON = Spontaneous.





Key: PN = Picture Naming, SPON = Spontaneous.

Appendix-Y:

The Effect of Age-Group on the Occurrence of Coronal Backing in Two Speech Samples: Kruskal-Wallis Test

	Age Group	N	Mean Rank	Chi-Square	df	Sig.
PN coronal backing	GROUP 1	12	30.63	8.874	4	.064
	GROUP 2	12	35.42			
	GROUP 3	12	39.04			
	GROUP 4	12	26.50			
	GROUP 5	12	20.92			
	Total	60				
SPON coronal backing	GROUP 1	12	30.42	1.748	4	.782
	GROUP 2	12	34.63			
	GROUP 3	12	30.46			
	GROUP 4	12	31.50			
	GROUP 5	12	25.50			
	Total	60				

Key: PN = Picture Naming, SPON = Spontaneous.

There was no significant difference between Age-Group in the occurrence of coronal backing in PN sample: $\chi^2(4, N = 60) = 8.874$, $p = .064$. Similarly, there was no significant difference between Age-Group in the occurrence of coronal backing in SPON sample: $\chi^2(4, N = 60) = 1.748$, $p = .782$

Appendix-Z:

The Effect of Gender on the Occurrence of Coronal Backing in Two Speech Samples: Mann-Whitney Test

	Gender	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Z	Sig. (2-tailed)
PN Coronal Backing	Female	30	28.22	846.50	381.500	-1.062	.288
	Male	30	32.78	983.50			
	Total	60					
SPON Coronal Backing	Female	30	29.58	887.50	422.500	-.413	.679
	Male	30	31.42	942.50			
	Total	60					

Key: PN = Picture Naming, SPON = Spontaneous.

Appendix-AA:

Positional Backing Errors: Normality Test

		Shapiro-Wilk		
	Age Group	Statistic	df	Sig.
SIWI Coronal Backing	GROUP 1	.784	12	.006**
	GROUP 2	.829	12	.021*
	GROUP 3	.917	12	.264
	GROUP 4	.702	12	.001**
	GROUP 5	.876	12	.078
SIWW Coronal Backing	GROUP 1	.851	12	.038*
	GROUP 2	.849	12	.036*
	GROUP 3	.843	12	.030*
	GROUP 4	.829	12	.021*
	GROUP 5	.677	12	.001**
SFWW Coronal Backing	GROUP 1	.830	12	.021*
	GROUP 2	.726	12	.002*
	GROUP 3	.863	12	.053
	GROUP 4	.627	12	.000**
	GROUP 5	.805	12	.011*
SFWF Coronal Backing	GROUP 1	.827	12	.019*
	GROUP 2	.857	12	.045*
	GROUP 3	.918	12	.270
	GROUP 4	.835	12	.024*
	GROUP 5	.666	12	.000**

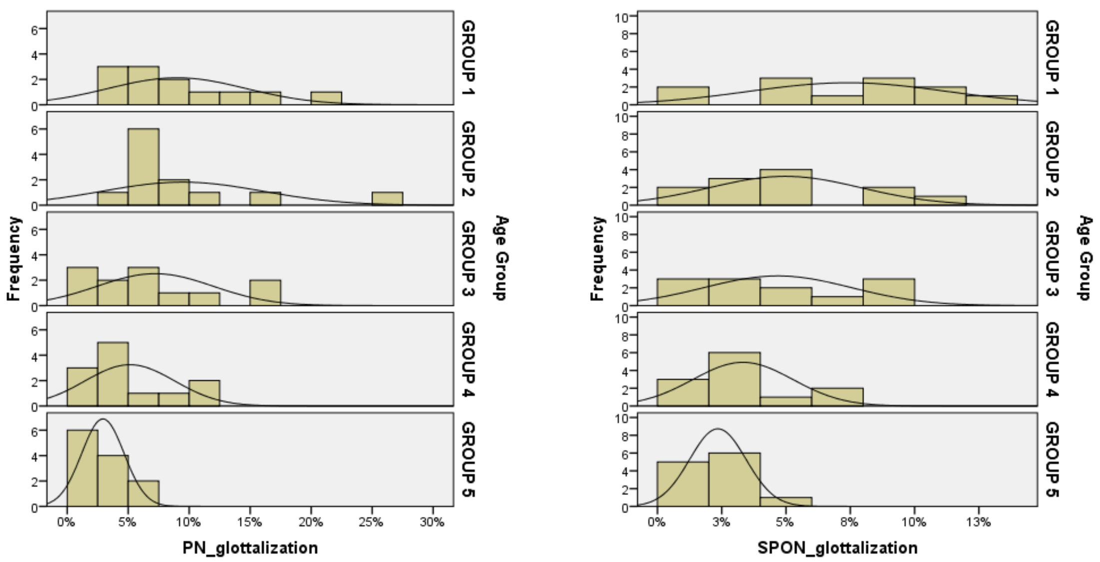
*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: SIWI = Syllable-Initial Word-Initial, SIWW, Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

Appendix-AB:

Glottalization Errors: Normality Test

	Age Group	Shapiro-Wilk		
		Statistic	df	Sig.
PN Glottalization	GROUP 1	.895	12	.135
	GROUP 2	.690	12	.001**
	GROUP 3	.877	12	.079
	GROUP 4	.855	12	.043*
	GROUP 5	.874	12	.074
SPON Glottalization	GROUP 1	.929	12	.369
	GROUP 2	.901	12	.165
	GROUP 3	.885	12	.102
	GROUP 4	.869	12	.063
	GROUP 5	.966	12	.862

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: PN = Picture Naming, SPON = Spontaneous.



Key: PN = Picture Naming, SPON = Spontaneous.

Appendix-AC

Glottalization Errors: Mauchly's Test of Sphericity

					Epsilon[b]		
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
PN vs SPON Glottalization	1.000	.000	0	.	1.000	1.000	1.000

Key: PN = Picture Naming, SPON = Spontaneous.

Appendix-AD:

Glottalization Errors Post-Hoc Test:

(I) Age Group	(J) Age Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
GROUP 1	GROUP 2	.9913	1.39784	.953	-2.9644	4.9469
	GROUP 3	2.2575	1.39784	.495	-1.6981	6.2131
	GROUP 4	3.9713*	1.39784	.049	.0156	7.9269
	GROUP 5	5.5617*	1.39784	.002	1.6060	9.5173
GROUP 2	GROUP 1	-.9913	1.39784	.953	-4.9469	2.9644
	GROUP 3	1.2663	1.39784	.893	-2.6894	5.2219
	GROUP 4	2.9800	1.39784	.223	-.9756	6.9356
	GROUP 5	4.5704*	1.39784	.016	.6148	8.5260
GROUP 3	GROUP 1	-2.2575	1.39784	.495	-6.2131	1.6981
	GROUP 2	-1.2663	1.39784	.893	-5.2219	2.6894
	GROUP 4	1.7137	1.39784	.736	-2.2419	5.6694
	GROUP 5	3.3042	1.39784	.142	-.6515	7.2598
GROUP 4	GROUP 1	-3.9713*	1.39784	.049	-7.9269	-.0156
	GROUP 2	-2.9800	1.39784	.223	-6.9356	.9756
	GROUP 3	-1.7137	1.39784	.736	-5.6694	2.2419
	GROUP 5	1.5904	1.39784	.786	-2.3652	5.5460
GROUP 5	GROUP 1	-5.5617*	1.39784	.002	-9.5173	-1.6060
	GROUP 2	-4.5704*	1.39784	.016	-8.5260	-.6148
	GROUP 3	-3.3042	1.39784	.142	-7.2598	.6515
	GROUP 4	-1.5904	1.39784	.786	-5.5460	2.3652

Based on observed means.
The error term is Mean Square (Error) = 11.724.
*. The mean difference is significant at the .05 level.

Appendix-AE:

Positional Glottalization Errors: Normality Test

		Shapiro-Wilk		
	Age Group	Statistic	df	Sig.
SIWI Glottalization	GROUP 1	.554	12	.000**
	GROUP 2	.780	12	.006**
	GROUP 3	.809	12	.012*
	GROUP 4	.793	12	.008**
	GROUP 5	.821	12	.016*
SIWW Glottalization	GROUP 1	.703	12	.001**
	GROUP 2	.711	12	.001**
	GROUP 3	.814	12	.014*
	GROUP 4	.539	12	.000**
	GROUP 5	.756	12	.003**
SFWW Glottalization	GROUP 1	.487	12	.000**
	GROUP 2	.719	12	.001**
	GROUP 3	.646	12	.000**
	GROUP 4	.612	12	.000**
	GROUP 5	.648	12	.000**
SFWF Glottalization	GROUP 1	.807	12	.011*
	GROUP 2	.717	12	.001**
	GROUP 3	.896	12	.142
	GROUP 4	.696	12	.001**
	GROUP 5	.815	12	.014*

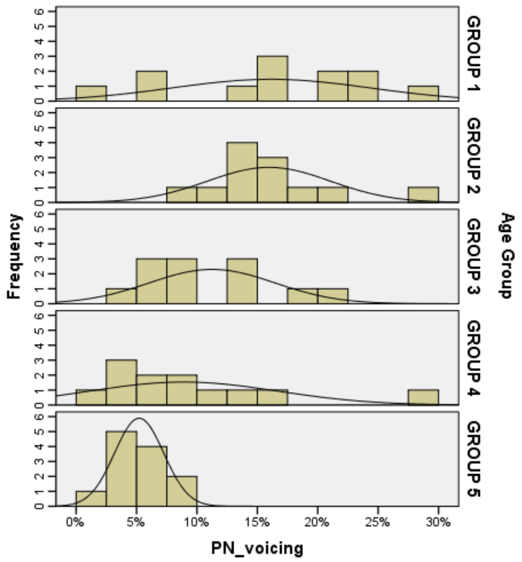
*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: SIWI = Syllable-Initial Word-Initial, SIWW, Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

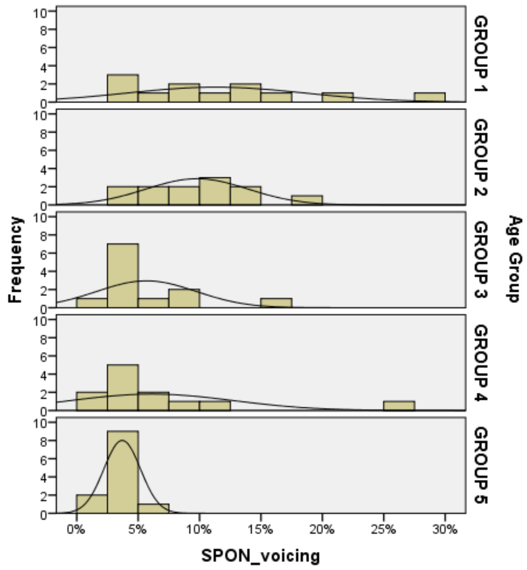
Appendix-AF:

Voicing Errors: Normality Test

		Shapiro-Wilk		
	Age Group	Statistic	df	Sig.
PN Voicing	GROUP 1	.949	12	.616
	GROUP 2	.882	12	.093
	GROUP 3	.925	12	.330
	GROUP 4	.795	12	.008**
	GROUP 5	.960	12	.790
SPON Voicing	GROUP 1	.903	12	.174
	GROUP 2	.960	12	.784
	GROUP 3	.839	12	.027*
	GROUP 4	.622	12	.000**
	GROUP 5	.955	12	.706

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: PN = Picture Naming, SPON = Spontaneous.





Key: PN = Picture Naming, SPON = Spontaneous.

Appendix-AG:

Voicing Errors: Mauchly's Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
PN vs SPON Voicing	1.000	.000	0	.	1.000	1.000	1.000

Key: PN = Picture Naming, SPON = Spontaneous.

Appendix-AH:

Voicing Errors Post-Hoc Test:

(I) Age Group	(J) Age Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
GROUP 1	GROUP 2	.8529	1.95344	.992	-4.6749	6.3808
	GROUP 3	5.2625	1.95344	.069	-.2653	10.7903
	GROUP 4	6.2325*	1.95344	.020	.7047	11.7603
	GROUP 5	9.2704*	1.95344	.000	3.7426	14.7983
GROUP 2	GROUP 1	-.8529	1.95344	.992	-6.3808	4.6749
	GROUP 3	4.4096	1.95344	.176	-1.1183	9.9374
	GROUP 4	5.3796	1.95344	.060	-.1483	10.9074
	GROUP 5	8.4175*	1.95344	.001	2.8897	13.9453
GROUP 3	GROUP 1	-5.2625	1.95344	.069	-10.7903	.2653
	GROUP 2	-4.4096	1.95344	.176	-9.9374	1.1183
	GROUP 4	.9700	1.95344	.987	-4.5578	6.4978
	GROUP 5	4.0079	1.95344	.257	-1.5199	9.5358
GROUP 4	GROUP 1	-6.2325*	1.95344	.020	-11.7603	-.7047
	GROUP 2	-5.3796	1.95344	.060	-10.9074	.1483
	GROUP 3	-.9700	1.95344	.987	-6.4978	4.5578
	GROUP 5	3.0379	1.95344	.532	-2.4899	8.5658
GROUP 5	GROUP 1	-9.2704*	1.95344	.000	-14.7983	-3.7426
	GROUP 2	-8.4175*	1.95344	.001	-13.9453	-2.8897
	GROUP 3	-4.0079	1.95344	.257	-9.5358	1.5199
	GROUP 4	-3.0379	1.95344	.532	-8.5658	2.4899

Based on observed means.
The error term is Mean Square (Error) = 22.895.
*. The mean difference is significant at the .05 level.

Appendix-AI:

Positional Voicing Errors: Normality Test

		Shapiro-Wilk		
	Age Group	Statistic	df	Sig.
SIWI Voicing	GROUP 1	.889	12	.114
	GROUP 2	.978	12	.976
	GROUP 3	.846	12	.032*
	GROUP 4	.640	12	.000**
	GROUP 5	.906	12	.190
SIWW Voicing	GROUP 1	.887	12	.108
	GROUP 2	.942	12	.520
	GROUP 3	.835	12	.024*
	GROUP 4	.685	12	.001**
	GROUP 5	.900	12	.159
SFWW Voicing	GROUP 1	.955	12	.706
	GROUP 2	.940	12	.494
	GROUP 3	.767	12	.004**
	GROUP 4	.611	12	.000**
	GROUP 5	.982	12	.991
SFWF Voicing	GROUP 1	.908	12	.200
	GROUP 2	.939	12	.486
	GROUP 3	.783	12	.006**
	GROUP 4	.589	12	.000**
	GROUP 5	.956	12	.725

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: SIWI = Syllable-Initial Word-Initial, SIWW, Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

Appendix-AJ:

Difference in Positional Voicing Errors: Wilcoxon Signed Ranks Test

Syllable/word Positions compared	Reference	N	Mean Rank	Sum of Ranks
SIWW voicing - SIWI voicing	Negative Ranks	13[a]	19.31	251.00
	Positive Ranks	47[b]	33.60	1579.00
	Ties	0[c]		
	Total	60		
SFWW voicing - SIWW voicing	Negative Ranks	11[d]	18.09	199.00
	Positive Ranks	49[e]	33.29	1631.00
	Ties	0[f]		
	Total	60		
SFWF voicing - SFWW voicing	Negative Ranks	48[g]	33.77	1621.00
	Positive Ranks	12[h]	17.42	209.00
	Ties	0[i]		
	Total	60		
SFWF voicing - SIWI voicing	Negative Ranks	17[j]	25.47	433.00
	Positive Ranks	43[k]	32.49	1397.00
	Ties	0[l]		
	Total	60		

a. SFWF voicing < SIWI voicing
b. SFWF voicing > SIWI voicing
c. SFWF voicing = SIWI voicing
d. SIWW voicing < SIWI voicing
e. SIWW voicing > SIWI voicing
f. SIWW voicing = SIWI voicing
g. SFWW voicing < SIWW voicing
h. SFWW voicing > SIWW voicing
i. SFWW voicing = SIWW voicing
j. SFWF voicing < SFWW voicing
k. SFWF voicing > SFWW voicing
l. SFWF voicing = SFWW voicing

Key: SIWI = Syllable-Initial Word-Initial, SIWW, Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

Appendix-AK:

Devoicing Errors: Normality Test

Age Group		Shapiro-Wilk		
		Statistic	df	Sig.
PN Devoicing	GROUP 1	.921	12	.297
	GROUP 2	.953	12	.687
	GROUP 3	.953	12	.679
	GROUP 4	.968	12	.891
	GROUP 5	.868	12	.062
SPON Devoicing	GROUP 1	.900	12	.158
	GROUP 2	.971	12	.923
	GROUP 3	.865	12	.057
	GROUP 4	.907	12	.193
	GROUP 5	.973	12	.943

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: PN = Picture Naming, SPON = Spontaneous.

Appendix-AL:

a. *Devoicing Errors: Mauchly's Test of Sphericity*

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
PN vs SPON Devoicing	1.000	.000	0	.	1.000	1.000	1.000

Key: PN = Picture Naming, SPON = Spontaneous.

b. *Devoicing Errors Speech-Task*Age interaction: Mauchly's Test of Sphericity*

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
G1 PN vs SPON Devoicing	1.000	.000	0	.	1.000	1.000	1.000
G2 PN vs SPON Devoicing	1.000	.000	0	.	1.000	1.000	1.000
G3 PN vs SPON Devoicing	1.000	.000	0	.	1.000	1.000	1.000
G4 PN vs SPON Devoicing	1.000	.000	0	.	1.000	1.000	1.000
G5 PN vs SPON Devoicing	1.000	.000	0	.	1.000	1.000	1.000

Key: PN = Picture Naming, SPON = Spontaneous.

Appendix-AM:

Devoicing Errors Post-Hoc Test:

(I) Age Group	(J) Age Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
GROUP 1	GROUP 2	.8642	2.35860	.996	-5.8102	7.5385
	GROUP 3	3.2996	2.35860	.631	-3.3748	9.9740
	GROUP 4	8.0525*	2.35860	.011	1.3781	14.7269
	GROUP 5	7.2558*	2.35860	.027	.5815	13.9302
GROUP 2	GROUP 1	-.8642	2.35860	.996	-7.5385	5.8102
	GROUP 3	2.4354	2.35860	.839	-4.2390	9.1098
	GROUP 4	7.1883*	2.35860	.029	.5140	13.8627
	GROUP 5	6.3917	2.35860	.067	-.2827	13.0660
GROUP 3	GROUP 1	-3.2996	2.35860	.631	-9.9740	3.3748
	GROUP 2	-2.4354	2.35860	.839	-9.1098	4.2390
	GROUP 4	4.7529	2.35860	.274	-1.9215	11.4273
	GROUP 5	3.9563	2.35860	.457	-2.7181	10.6306
GROUP 4	GROUP 1	-8.0525*	2.35860	.011	-14.7269	-1.3781
	GROUP 2	-7.1883*	2.35860	.029	-13.8627	-.5140
	GROUP 3	-4.7529	2.35860	.274	-11.4273	1.9215
	GROUP 5	-.7967	2.35860	.997	-7.4710	5.8777
GROUP 5	GROUP 1	-7.2558*	2.35860	.027	-13.9302	-.5815
	GROUP 2	-6.3917	2.35860	.067	-13.0660	.2827
	GROUP 3	-3.9563	2.35860	.457	-10.6306	2.7181
	GROUP 4	.7967	2.35860	.997	-5.8777	7.4710

Based on observed means.
The error term is Mean Square (Error) = 33.378.
*. The mean difference is significant at the .05 level.

Appendix-AN:

Positional Devoicing Errors: Normality Test

		Shapiro-Wilk		
	Age Group	Statistic	df	Sig.
SIWI Devoicing	GROUP 1	.941	12	.507
	GROUP 2	.964	12	.834
	GROUP 3	.902	12	.167
	GROUP 4	.805	12	.011*
	GROUP 5	.976	12	.965
SIWW Devoicing	GROUP 1	.946	12	.573
	GROUP 2	.914	12	.238
	GROUP 3	.961	12	.791
	GROUP 4	.899	12	.153
	GROUP 5	.956	12	.727
SFWW Devoicing	GROUP 1	.811	12	.013*
	GROUP 2	.875	12	.077
	GROUP 3	.829	12	.021*
	GROUP 4	.777	12	.005**
	GROUP 5	.756	12	.003**
SFWF Devoicing	GROUP 1	.972	12	.927
	GROUP 2	.957	12	.741
	GROUP 3	.932	12	.403
	GROUP 4	.943	12	.542
	GROUP 5	.955	12	.713

*. The mean difference is significant at the .05 level.

**. The mean difference is significant at the .01 level.

Key: SIWI = Syllable-Initial Word-Initial, SIWW, Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

Appendix-AO:

Difference in Positional Devoicing Errors: Wilcoxon Signed Ranks Test

Syllable/word Positions compared	Reference	N	Mean Rank	Sum of Ranks
SIWW devoicing - SIWI devoicing	Negative Ranks	36[a]	29.96	1078.50
	Positive Ranks	24[b]	31.31	751.50
	Ties	0[c]		
	Total	60		
SFWW devoicing - SIWW devoicing	Negative Ranks	36[d]	32.36	1165.00
	Positive Ranks	24[e]	27.71	665.00
	Ties	0[f]		
	Total	60		
SFWF devoicing - SFWW devoicing	Negative Ranks	26[g]	29.02	754.50
	Positive Ranks	34[h]	31.63	1075.50
	Ties	0[i]		
	Total	60		
SFWF devoicing - SIWI devoicing	Negative Ranks	27[j]	34.80	939.50
	Positive Ranks	33[k]	26.98	890.50
	Ties	0[l]		
	Total	60		

a. SFWF Devoicing < SIWI Devoicing
b. SFWF Devoicing > SIWI Devoicing
c. SFWF Devoicing = SIWI Devoicing
d. SIWW Devoicing < SIWI Devoicing
e. SIWW Devoicing > SIWI Devoicing
f. SIWW Devoicing = SIWI Devoicing
g. SFWW Devoicing < SIWW Devoicing
h. SFWW Devoicing > SIWW Devoicing
i. SFWW Devoicing = SIWW Devoicing
j. SFWF Devoicing < SFWW Devoicing
k. SFWF Devoicing > SFWW Devoicing
l. SFWF Devoicing = SFWW Devoicing

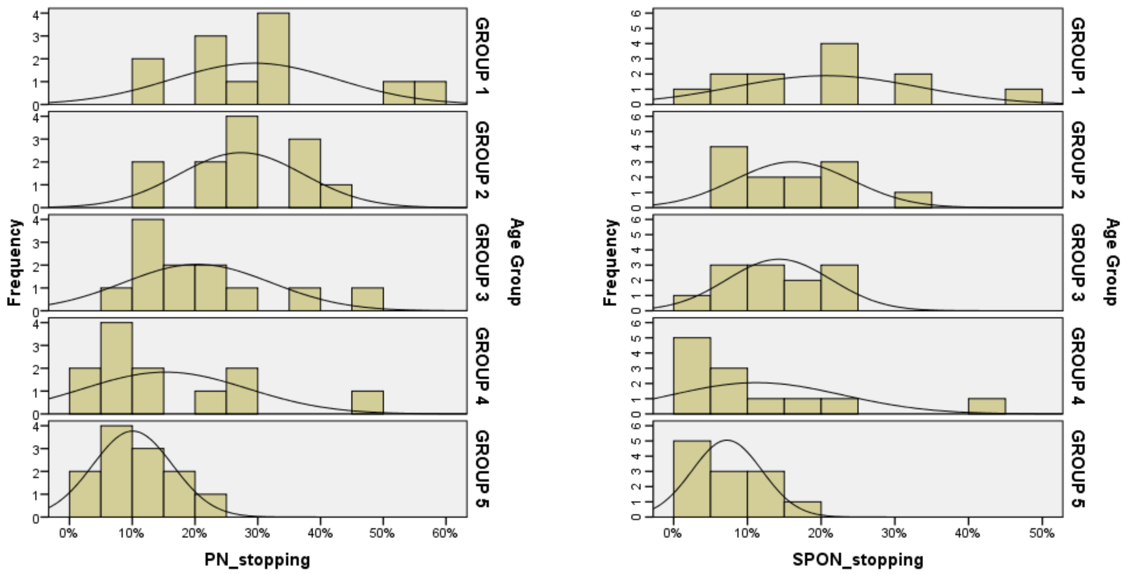
Key: SIWI = Syllable-Initial Word-Initial, SIWW, Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

Appendix-AP

Fricative Stopping: Normality Test

Age Group		Shapiro-Wilk		
		Statistic	df	Sig.
PN Fricative Stopping	GROUP 1	.920	12	.290
	GROUP 2	.965	12	.847
	GROUP 3	.869	12	.063
	GROUP 4	.848	12	.034*
	GROUP 5	.897	12	.147
SPON Fricative Stopping	GROUP 1	.952	12	.661
	GROUP 2	.933	12	.414
	GROUP 3	.932	12	.401
	GROUP 4	.792	12	.008**
	GROUP 5	.899	12	.153

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: PN = Picture Naming, SPON = Spontaneous.



Key: PN = Picture Naming, SPON = Spontaneous.

Appendix-AQ:

Fricative Stopping: Mauchly's Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b] Greenhouse-Geisser	Huynh-Feldt	Lower-bound
PN vs SPON Fricative Stopping	1.000	.000	0	.	1.000	1.000	1.000

Key: PN = Picture Naming, SPON = Spontaneous.

Appendix-AR:

Fricative Stopping Errors Post-Hoc Test:

(I) Age Group	(J) Age Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
GROUP 1	GROUP 2	3.2992	3.72835	.901	-7.2513	13.8497
	GROUP 3	7.7392	3.72835	.247	-2.8113	18.2897
	GROUP 4	11.7821*	3.72835	.022	1.2316	22.3326
	GROUP 5	16.4104*	3.72835	.001	5.8599	26.9609
GROUP 2	GROUP 1	-3.2992	3.72835	.901	-13.8497	7.2513
	GROUP 3	4.4400	3.72835	.757	-6.1105	14.9905
	GROUP 4	8.4829	3.72835	.170	-2.0676	19.0334
	GROUP 5	13.1113*	3.72835	.008	2.5607	23.6618
GROUP 3	GROUP 1	-7.7392	3.72835	.247	-18.2897	2.8113
	GROUP 2	-4.4400	3.72835	.757	-14.9905	6.1105
	GROUP 4	4.0429	3.72835	.814	-6.5076	14.5934
	GROUP 5	8.6712	3.72835	.154	-1.8793	19.2218
GROUP 4	GROUP 1	-11.7821*	3.72835	.022	-22.3326	-1.2316
	GROUP 2	-8.4829	3.72835	.170	-19.0334	2.0676
	GROUP 3	-4.0429	3.72835	.814	-14.5934	6.5076
	GROUP 5	4.6283	3.72835	.727	-5.9222	15.1788
GROUP 5	GROUP 1	-16.4104*	3.72835	.001	-26.9609	-5.8599
	GROUP 2	-13.1113*	3.72835	.008	-23.6618	-2.5607
	GROUP 3	-8.6712	3.72835	.154	-19.2218	1.8793
	GROUP 4	-4.6283	3.72835	.727	-15.1788	5.9222

Based on observed means.
The error term is Mean Square (Error) = 83.403.
*. The mean difference is significant at the .05 level.

Appendix-AS:

Positional Fricative Stopping Errors: Normality Test

		Shapiro-Wilk		
	Age Group	Statistic	df	Sig.
SIWI Fricative Stopping	GROUP 1	.904	12	.179
	GROUP 2	.964	12	.844
	GROUP 3	.904	12	.176
	GROUP 4	.697	12	.001**
	GROUP 5	.784	12	.006**
SIWW Fricative Stopping	GROUP 1	.851	12	.038*
	GROUP 2	.925	12	.330
	GROUP 3	.950	12	.632
	GROUP 4	.803	12	.010*
	GROUP 5	.849	12	.035*
SFWW Fricative Stopping	GROUP 1	.868	12	.061
	GROUP 2	.919	12	.277
	GROUP 3	.925	12	.328
	GROUP 4	.696	12	.001**
	GROUP 5	.802	12	.010*
SFWF Fricative Stopping	GROUP 1	.880	12	.088
	GROUP 2	.959	12	.763
	GROUP 3	.842	12	.029*
	GROUP 4	.839	12	.027*
	GROUP 5	.901	12	.163

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: SIWI = Syllable-Initial Word-Initial, SIWW, Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

Appendix-AT:

Difference in Positional Fricative Stopping Errors: Wilcoxon Signed Ranks Test

Syllable/word Positions compared	Reference	N	Mean Rank	Sum of Ranks
SIWW Fricative stopping - SIWI Fricative stopping	Negative Ranks	9[a]	6.33	57.00
	Positive Ranks	3[b]	7.00	21.00
	Ties	0[c]		
	Total	12		
SFWW Fricative stopping - SIWW Fricative stopping	Negative Ranks	2[d]	7.00	14.00
	Positive Ranks	10[e]	6.40	64.00
	Ties	0[f]		
	Total	12		
SFWF Fricative stopping - SFWW Fricative stopping	Negative Ranks	10[g]	6.60	66.00
	Positive Ranks	2[h]	6.00	12.00
	Ties	0[i]		
	Total	12		
SFWF Fricative stopping - SIWI Fricative stopping	Negative Ranks	10[j]	6.60	66.00
	Positive Ranks	2[k]	6.00	12.00
	Ties	0[l]		
	Total	12		

a. SIWW stopping < SIWI stopping
b. SIWW stopping > SIWI stopping
c. SIWW stopping = SIWI stopping
d. SFWW stopping < SIWW stopping
e. SFWW stopping > SIWW stopping
f. SFWW stopping = SIWW stopping
g. SFWF stopping < SFWW stopping
h. SFWF stopping > SFWW stopping
i. SFWF stopping = SFWW stopping
j. SFWF stopping < SIWI stopping
k. SFWF stopping > SIWI stopping
l. SFWF stopping = SIWI stopping

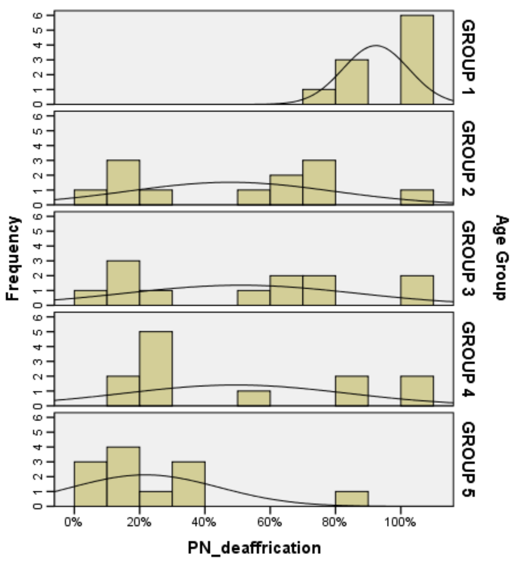
Key: SIWI = Syllable-Initial Word-Initial, SIWW, Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

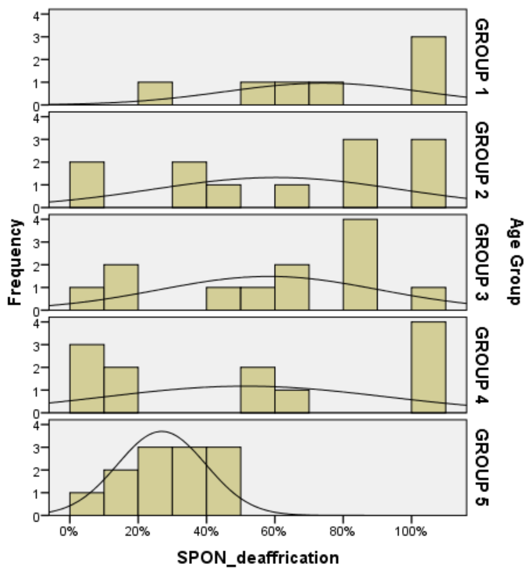
Appendix-AU:

Deaffrication Errors: Normality Testing

Age Group		Shapiro-Wilk		
		Statistic	df	Sig.
PN Deaffrication	GROUP 1	.704	6	.007**
	GROUP 2	.928	12	.362
	GROUP 3	.912	12	.224
	GROUP 4	.816	12	.014*
	GROUP 5	.828	12	.020*
SPON Deaffrication	GROUP 1	.931	6	.586
	GROUP 2	.898	12	.148
	GROUP 3	.927	12	.346
	GROUP 4	.807	12	.011**
	GROUP 5	.923	12	.308

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: PN = Picture Naming, SPON = Spontaneous.





Key: PN = Picture Naming, SPON = Spontaneous.

Appendix-AV:

Deaffrication Errors: Levene's [a] *Test of Equality of Error Variances*

	F	df1	df2	Sig.
PN deaffrication	1.730	9	44	.111
SPON deaffrication	4.245	9	44	.001**

Key: PN = Picture Naming, SPON = Spontaneous.

Appendix-AW:

Positional Deaffrication Errors: Normality Test

		Shapiro-Wilk		
	Age Group	Statistic	df	Sig.
SIWI Deaffrication	GROUP 1	.862	6	.196
	GROUP 2	.845	8	.084
	GROUP 3	.921	9	.397
	GROUP 4	.855	12	.043*
	GROUP 5	.797	11	.008**
SIWW Deaffrication	GROUP 1	.795	6	.053
	GROUP 2	.948	8	.691
	GROUP 3	.890	9	.200
	GROUP 4	.862	12	.051
	GROUP 5	.970	11	.888
SFWW Deaffrication	GROUP 1	.928	6	.564
	GROUP 2	.802	8	.030*
	GROUP 3	.896	9	.229
	GROUP 4	.856	12	.044*
	GROUP 5	.941	11	.529
SFWF Deaffrication	GROUP 1	.783	6	.041*
	GROUP 2	.862	8	.125
	GROUP 3	.870	9	.123
	GROUP 4	.808	12	.011*
	GROUP 5	.868	11	.074

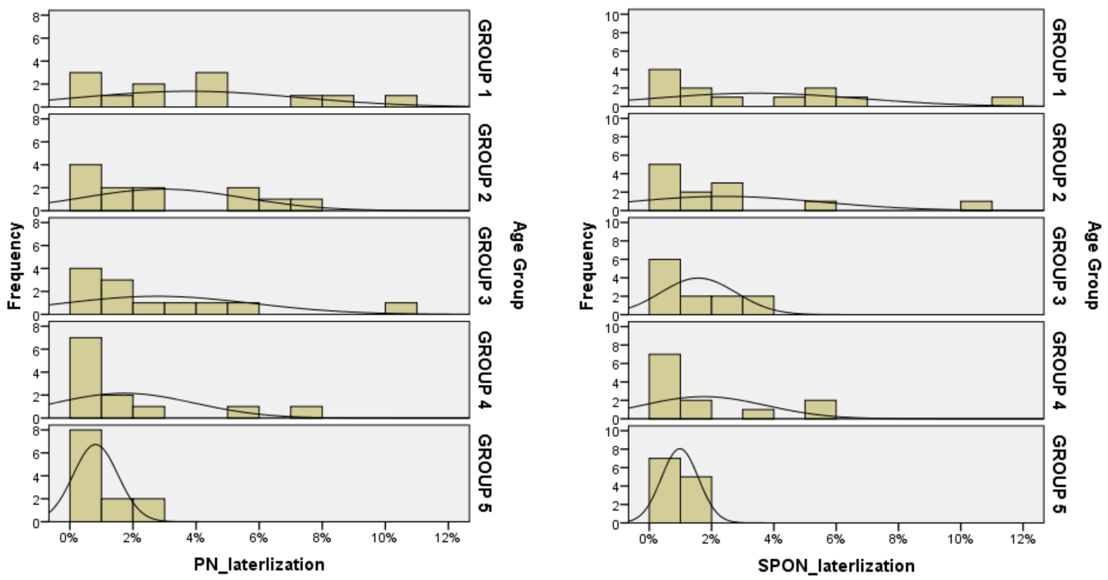
*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: SIWI = Syllable-Initial Word-Initial, SIWW, Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

Appendix-AX:

Lateralization Errors: Normality Test

Age Group		Shapiro-Wilk		
		Statistic	df	Sig.
PN Lateralization	GROUP 1	.910	12	.212
	GROUP 2	.869	12	.064
	GROUP 3	.758	12	.003*
	GROUP 4	.706	12	.001*
	GROUP 5	.873	12	.071
SPON Lateralization	GROUP 1	.867	12	.061
	GROUP 2	.712	12	.001*
	GROUP 3	.865	12	.056
	GROUP 4	.747	12	.002*
	GROUP 5	.872	12	.070

*. The mean difference is significant at the .01 level.
Key: PN = Picture Naming, SPON = Spontaneous.



Key: PN = Picture Naming, SPON = Spontaneous.

Appendix-AY:

Lateralization Errors: Mauchly's Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b] Greenhouse-Geisser	Huynh-Feldt	Lower-bound
PN vs SPON Lateralization	1.000	.000	0	.	1.000	1.000	1.000

Key: PN = Picture Naming, SPON = Spontaneous.

Appendix-AZ:

Positional Lateralization Errors: Normality Test

		Shapiro-Wilk		
	Age Group	Statistic	df	Sig.
SIWI Lateralization	GROUP 1	.800	12	.009**
	GROUP 2	.822	12	.017*
	GROUP 3	.772	12	.005**
	GROUP 4	.694	12	.001**
	GROUP 5	.881	12	.090
SIWW Lateralization	GROUP 1	.666	12	.000**
	GROUP 2	.747	12	.002**
	GROUP 3	.835	12	.024*
	GROUP 4	.774	12	.005**
	GROUP 5	.898	12	.151
SFWW Lateralization	GROUP 1	.799	12	.009**
	GROUP 2	.787	12	.007**
	GROUP 3	.911	12	.221
	GROUP 4	.706	12	.001**
	GROUP 5	.939	12	.487
SFWF Lateralization	GROUP 1	.827	12	.019*
	GROUP 2	.729	12	.002**
	GROUP 3	.860	12	.049*
	GROUP 4	.715	12	.001**
	GROUP 5	.914	12	.240

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: SIWI = Syllable-Initial Word-Initial, SIWW, Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

Appendix-BA:

Difference in Positional Lateralization Errors: Wilcoxon Signed Ranks Test

Syllable/word Positions compared	Reference	N	Mean Rank	Sum of Ranks
SIWW - SIWI Lateralization	Negative Ranks	2[a]	1.50	3.00
	Positive Ranks	9[b]	7.00	63.00
	Ties	1[c]		
	Total	12		
SFWW - SIWW Lateralization	Negative Ranks	2[d]	2.00	4.00
	Positive Ranks	10[e]	7.40	74.00
	Ties	0[f]		
	Total	12		
SFWF - SFWW Lateralization	Negative Ranks	9[g]	8.00	72.00
	Positive Ranks	3[h]	2.00	6.00
	Ties	0[i]		
	Total	12		
SFWF - SIWI Lateralization	Negative Ranks	3[j]	2.00	6.00
	Positive Ranks	9[k]	8.00	72.00
	Ties	0[l]		
	Total	12		

a. SFWF Lateralization < SIWI Lateralization
b. SFWF Lateralization > SIWI Lateralization
c. SFWF Lateralization = SIWI Lateralization
d. SIWW Lateralization < SIWI Lateralization
e. SIWW Lateralization > SIWI Lateralization
f. SIWW Lateralization = SIWI Lateralization
g. SFWW Lateralization < SIWW Lateralization
h. SFWW Lateralization > SIWW Lateralization
i. SFWW Lateralization = SIWW Lateralization
j. SFWF Lateralization < SFWW Lateralization
k. SFWF Lateralization > SFWW Lateralization
l. SFWF Lateralization = SFWW Lateralization

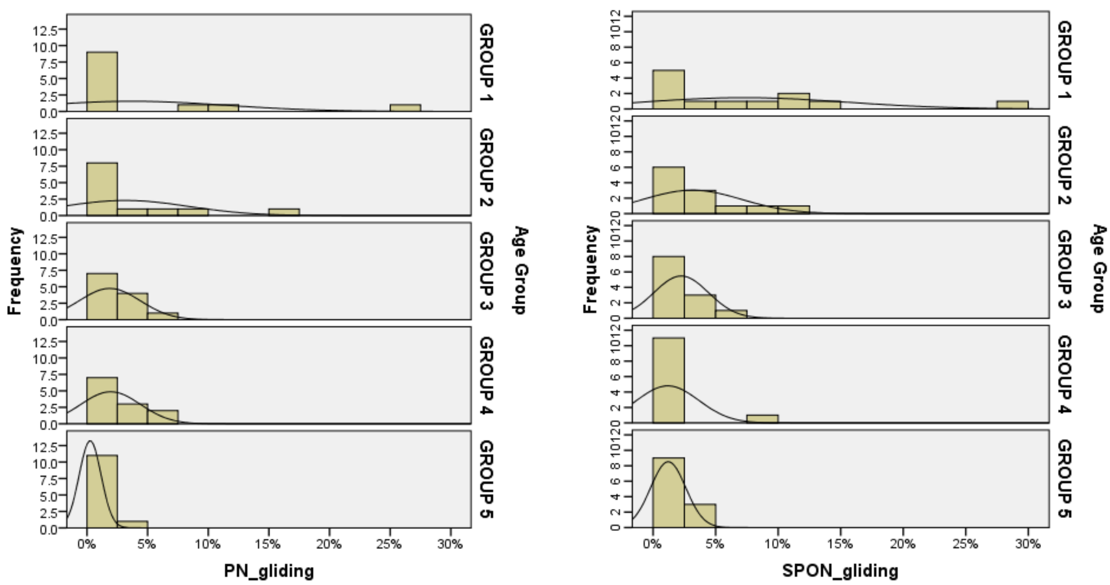
Key: SIWI = Syllable-Initial Word-Initial, SIWW, Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

Appendix-BB:

Liquid Gliding/Vocalization Errors: Normality Test

Age Group		Shapiro-Wilk		
		Statistic	df	Sig.
PN gliding/vocalization	GROUP 1	.575	12	.000**
	GROUP 2	.695	12	.001**
	GROUP 3	.752	12	.003**
	GROUP 4	.796	12	.008**
	GROUP 5	.327	12	.000**
SPON gliding/vocalization	GROUP 1	.814	12	.014*
	GROUP 2	.804	12	.010**
	GROUP 3	.887	12	.107
	GROUP 4	.522	12	.000**
	GROUP 5	.834	12	.023*

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: PN = Picture Naming, SPON = Spontaneous.



Key: PN = Picture Naming, SPON = Spontaneous.

Appendix-BC:

Non-parametric test result Gliding/vocalization Errors:

a. Within subjects: Wilcoxon related samples test

Descriptive Statistics

	N	Mean	Std. Deviation	Min	Max	Percentiles 25th	50th (Median)	75th
SPON gliding	60	2.9995	4.78662	.00	28.57	.0000	1.4300	3.0675
PN gliding	60	2.1968	4.49350	.00	25.00	.0000	.0000	3.3700

Key: PN = Picture Naming, SPON = Spontaneous.

Wilcoxon Related Samples Test

		N	Mean Rank	Sum of Ranks	Z	Sig. (2-tailed)
PN – SPON gliding	Negative Ranks	29[a]	20.74	601.50	-.948[e]	.343
	Positive Ranks	16[b]	27.09	433.50		
	Ties	15[c]				
	Total	60				

a. PN gliding < SPON gliding
b. PN gliding > SPON gliding
c. PN gliding = SPON gliding
e. Based on positive ranks.
Key: PN = Picture Naming, SPON = Spontaneous.

There is no significant different in the occurrence of gliding/vocalization errors between the two Speech tasks: PN vs. SPON (z = .948, *N* – Ties = 45, *p* = .343, two-tailed)

b. Between subjects factor: Age-Group: Kruskal-Wallis Test

Descriptive Statistics

						Percentiles		
	N	Mean	Std. Deviation	Min	Max	25th	50th (Median)	75th
PN gliding	60	2.1968	4.49350	.00	25.00	.0000	.0000	3.3700
SPON gliding	60	2.9995	4.78662	.00	28.57	.0000	1.4300	3.0675

Key: PN = Picture Naming, SPON = Spontaneous.

Kruskal-Wallis Test

	PN gliding/vocalization Errors		SPON gliding/vocalization Errors	
Age Group	N	Mean Rank	N	Mean Rank
GROUP 1	12	29.88	12	42.13
GROUP 2	12	33.42	12	31.83
GROUP 3	12	32.88	12	32.88
GROUP 4	12	33.83	12	21.04
GROUP 5	12	22.50	12	24.63
Total	60		60	
Chi-Square	5.012		11.030	
df	4		4	
Asymp. Sig.	.286		.026*	

*. The mean difference is significant at the .05 level.
Key: PN = Picture Naming, SPON = Spontaneous.

For the PN sample, there was no significant effect of Age-Group: $\chi^2(4, N = 60) = 5.012$, $p = .286$. However, for the SPON sample, there was a significant effect of Age-Group: $\chi^2(4, N = 60) = 11.030$, $p = .026$.

c. Between subjects factor: Gender (Mann-Whitney Test)

	Gender	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Z	Sig. (2-tailed)
PN gliding	Female	30	29.37	881.00	416.000	-.599	.549
	Male	30	31.63	949.00			
	Total	60					
SPON gliding	Female	30	27.05	811.50	346.500	-1.569	.117
	Male	30	33.95	1018.50			
	Total	60					

Key: PN = Picture Naming, SPON = Spontaneous.

There is no statistical difference between female and male participants in the occurrence of gliding/vocalization errors in PN sample: (U = 416.000, N_1 = 30, N_2 = 30, p = .549, two-tailed). Similarly, is no statistical difference between female and male participants in the occurrence of gliding errors in SPON sample: (U = 346.500, N_1 = 30, N_2 = 30, p = .117, two-tailed).

Appendix-BD:

Gliding/Vocalization Errors: Mauchly's Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
PN vs SPON Gliding/vocalization	1.000	.000	0	.	1.000	1.000	1.000

Key: PN = Picture Naming, SPON = Spontaneous.

Appendix-BE:

Liquid Gliding/Vocalization Errors Post-Hoc Test:

(I) Age Group	(J) Age Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
GROUP 1	GROUP 2	2.3379	1.41827	.474	-1.6755	6.3513
	GROUP 3	3.4292	1.41827	.127	-.5843	7.4426
	GROUP 4	3.9271	1.41827	.058	-.0863	7.9405
	GROUP 5	4.7546*	1.41827	.013	.7412	8.7680
GROUP 2	GROUP 1	-2.3379	1.41827	.474	-6.3513	1.6755
	GROUP 3	1.0913	1.41827	.938	-2.9222	5.1047
	GROUP 4	1.5892	1.41827	.795	-2.4243	5.6026
	GROUP 5	2.4167	1.41827	.441	-1.5968	6.4301
GROUP 3	GROUP 1	-3.4292	1.41827	.127	-7.4426	.5843
	GROUP 2	-1.0913	1.41827	.938	-5.1047	2.9222
	GROUP 4	.4979	1.41827	.997	-3.5155	4.5113
	GROUP 5	1.3254	1.41827	.882	-2.6880	5.3388
GROUP 4	GROUP 1	-3.9271	1.41827	.058	-7.9405	.0863
	GROUP 2	-1.5892	1.41827	.795	-5.6026	2.4243
	GROUP 3	-.4979	1.41827	.997	-4.5113	3.5155
	GROUP 5	.8275	1.41827	.977	-3.1859	4.8409
GROUP 5	GROUP 1	-4.7546*	1.41827	.013	-8.7680	-.7412
	GROUP 2	-2.4167	1.41827	.441	-6.4301	1.5968
	GROUP 3	-1.3254	1.41827	.882	-5.3388	2.6880
	GROUP 4	-.8275	1.41827	.977	-4.8409	3.1859

Based on observed means.
The error term is Mean Square (Error) = 12.069.
*. The mean difference is significant at the .05 level.

Appendix-BF:

Positional Liquid Gliding/vocalization: Normality Test

	Age Group	Shapiro-Wilk		
		Statistic	df	Sig.
SIWI Liquid Gliding/vocalization	GROUP 1	.554	12	.000**
	GROUP 2	.780	12	.006**
	GROUP 3	.809	12	.012*
	GROUP 4	.793	12	.008**
	GROUP 5	.821	12	.016*
SIWW Liquid Gliding/vocalization	GROUP 1	.703	12	.001**
	GROUP 2	.711	12	.001**
	GROUP 3	.814	12	.014*
	GROUP 4	.539	12	.000**
	GROUP 5	.756	12	.003**
SFWW Liquid Gliding/vocalization	GROUP 1	.487	12	.000**
	GROUP 2	.719	12	.001**
	GROUP 3	.646	12	.000**
	GROUP 4	.612	12	.000**
	GROUP 5	.648	12	.000**
SFWF Liquid Gliding/vocalization	GROUP 1	.807	12	.011*
	GROUP 2	.717	12	.001**
	GROUP 3	.896	12	.142
	GROUP 4	.696	12	.001**
	GROUP 5	.815	12	.014*

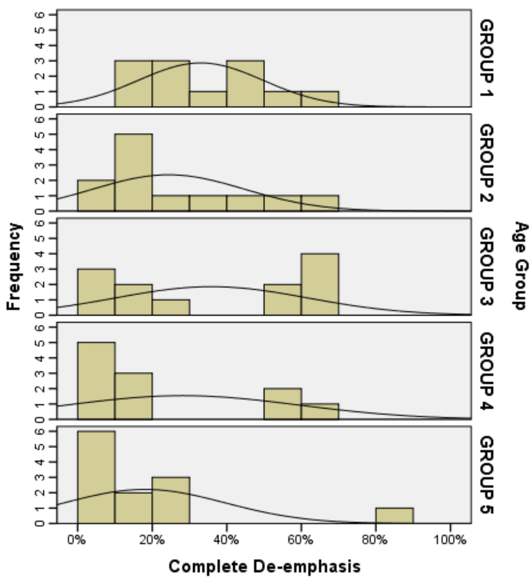
*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: SIWI = Syllable-Initial Word-Initial, SIWW, Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

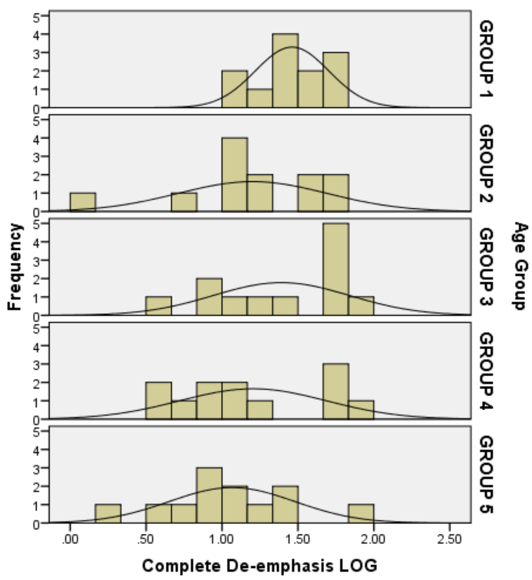
Appendix-BG

Complete De-Emphasis Errors: Normality Test

		Shapiro-Wilk		
	Age Group	Statistic	df	Sig.
Complete De-Emphasis	GROUP 1	.938	12	.467
	GROUP 2	.861	12	.050
	GROUP 3	.853	12	.040*
	GROUP 4	.774	12	.005**
	GROUP 5	.628	12	.000**
Complete De-Emphasis after LOG conversion	GROUP 1	.955	12	.714
	GROUP 2	.895	12	.136
	GROUP 3	.873	12	.071
	GROUP 4	.905	12	.182
	GROUP 5	.969	12	.899

*. The mean is significant at the .05 level.
**. The mean is significant at the .01 level.
Key: LOG = Logerithmic.





Key: LOG = Logerithmic.

Appendix-BH:

De-Emphasis Errors in Two Speech Samples: Normality Test

		Shapiro-Wilk		
	Age Group	Statistic	df	Sig.
PN De-Emphasis	GROUP 1	.938	12	.477
	GROUP 2	.892	12	.124
	GROUP 3	.940	12	.498
	GROUP 4	.812	12	.013**
	GROUP 5	.700	12	.001**
SPON De-Emphasis	GROUP 1	.963	12	.828
	GROUP 2	.845	12	.032
	GROUP 3	.855	12	.042*
	GROUP 4	.790	12	.007**
	GROUP 5	.690	12	.001**
PN De-Emphasis (SQURT)	GROUP 1	.867	12	.060
	GROUP 2	.933	12	.408
	GROUP 3	.945	12	.560
	GROUP 4	.875	12	.076
	GROUP 5	.888	12	.112
SPON De-Emphasis (SQURT)	GROUP 1	.888	12	.112
	GROUP 2	.931	12	.387
	GROUP 3	.934	12	.430
	GROUP 4	.880	12	.088
	GROUP 5	.946	12	.573

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: PN = Picture Naming, SPON = Spontaneous, SQURT= Squared.

Appendix-BI:

a. *De-Emphasis Errors: Mauchly's Test of Sphericity*

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
PN vs SPON De-Emphasis	1.000	.000	0	.	1.000	1.000	1.000

Key: PN = Picture Naming, SPON = Spontaneous.

b. *De-Emphasis Errors in Two Speech Samples: Levene's Test of Equality of Error Variances*

SQURT transformed De-Emphasis Errors	F	df1	df2	Sig.
PN De-Emphasis	1.933	9	50	.068
SPON De-Emphasis	.826	9	50	.595

Key: PN = Picture Naming, SPON = Spontaneous, SQURT= Squared.

Appendix-BJ:

Positional De-Emphasis Errors: Normality Test

	Age Group	Shapiro-Wilk		
		Statistic	df	Sig.
SIWI De-emphasis	GROUP 1	.906	8	.329
	GROUP 2	.639	9	.000**
	GROUP 3	.921	12	.298
	GROUP 4	.912	11	.260
	GROUP 5	.695	12	.001**
SIWW De-emphasis	GROUP 1	.866	8	.137
	GROUP 2	.848	9	.070
	GROUP 3	.926	12	.341
	GROUP 4	.781	11	.005**
	GROUP 5	.659	12	.000**
SFWW De-emphasis	GROUP 1	.971	8	.905
	GROUP 2	.828	9	.043*
	GROUP 3	.922	12	.301
	GROUP 4	.854	11	.048*
	GROUP 5	.710	12	.001**
SFWF De-emphasis	GROUP 1	.917	8	.410
	GROUP 2	.809	9	.026*
	GROUP 3	.761	12	.003**
	GROUP 4	.863	11	.063
	GROUP 5	.826	12	.019*

Key: SIWI = Syllable-Initial Word-Initial, SIWW, Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

Appendix-BK:

Difference in Positional De-emphasis Errors: Wilcoxon Signed Ranks Test

Syllable/word Positions compared	Reference	N	Mean Rank	Sum of Ranks
SFWF De-emphasis – SIWI De-emphasis	Negative Ranks	12[a]	15.71	188.50
	Positive Ranks	34[b]	26.25	892.50
	Ties	6[c]		
	Total	52		
SIWW De-emphasis – SIWI De-emphasis	Negative Ranks	18[d]	25.22	454.00
	Positive Ranks	36[e]	28.64	1031.00
	Ties	6[f]		
	Total	60		
SFWW De-emphasis – SIWW De-emphasis	Negative Ranks	32[g]	27.91	893.00
	Positive Ranks	22[h]	26.91	592.00
	Ties	3[i]		
	Total	57		
SFWF De-emphasis - SFWW De-emphasis	Negative Ranks	13[j]	20.00	260.00
	Positive Ranks	34[k]	25.53	868.00
	Ties	5[l]		
	Total	52		

a. SFWF De-emphasis < SIWI De-emphasis
b. SFWF De-emphasis > SIWI De-emphasis
c. SFWF De-emphasis = SIWI De-emphasis
d. SIWW De-emphasis < SIWI De-emphasis
e. SIWW De-emphasis > SIWI De-emphasis
f. SIWW De-emphasis = SIWI De-emphasis
g. SFWW De-emphasis < SIWW De-emphasis
h. SFWW De-emphasis > SIWW De-emphasis
i. SFWW De-emphasis = SIWW De-emphasis
j. SFWF De-emphasis < SFWW De-emphasis
k. SFWF De-emphasis > SFWW De-emphasis
l. SFWF De-emphasis = SFWW De-emphasis

Key: SIWI = Syllable-Initial Word-Initial, SIWW, Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

Appendix-BL:

a. *Positional Token Frequency of High and Less Frequent Emphatics: Normality Test*

Token Frequency	Positions	Kolmogorov-Smirnov		
		Statistic	df	Sig.
High Frequency Emphatics	SIWI	.105	60	.099
	SIWW	.160	60	.001**
	SFWW	.127	60	.018*
	SFWF	.140	60	.005**
Low Frequency Emphatics	SIWI	.423	60	.000**
	SIWW	.219	60	.000**
	SFWW	.223	60	.000**
	SFWF	.314	60	.000**

Key: SIWI = Syllable-Initial Word-Initial, SIWW, Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

b. *Positional De-Emphasis Errors of High and Low Token Frequency Emphatic Consonants: Normality Test*

De-emphasis of	Positions	Kolmogorov-Smirnov: df>50 Shapiro-Wilk: df<50		
		Statistic	df	Sig.
High Frequency Emphatics	SIWI	.200	60	.000**
	SIWW	.174	60	.000**
	SFWW	.175	57	.000**
	SFWF	.185	52	.000**
Low Frequency Emphatics	SIWI	.780	14	.003**
	SIWW	.192	54	.000**
	SFWW	.272	44	.000**
	SFWF	.338	25	.000**

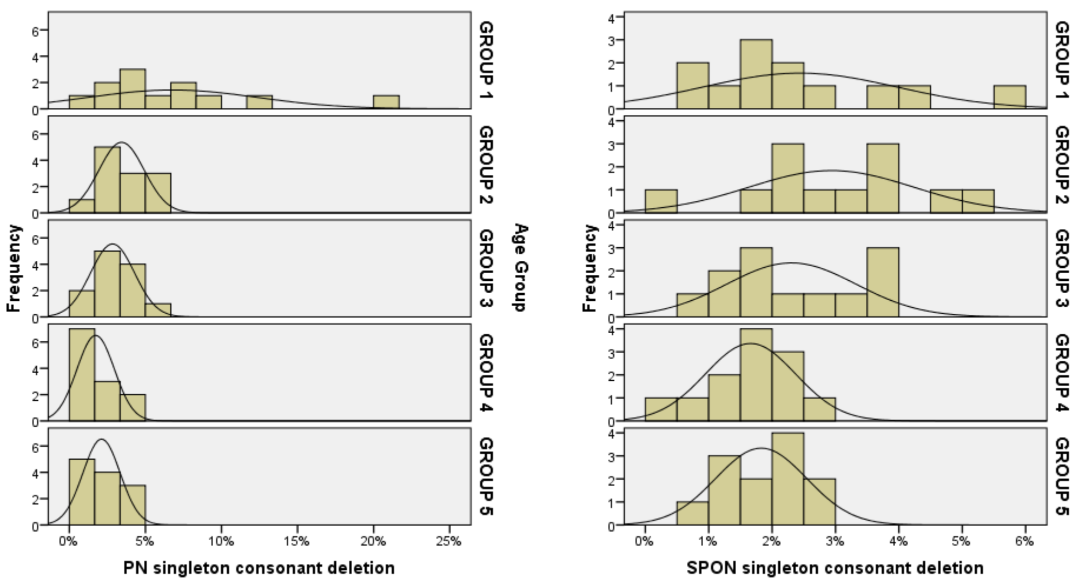
Key: SIWI = Syllable-Initial Word-Initial, SIWW, Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

Appendix-BM:

SCD Errors: Normality Test

Age Group		Shapiro-Wilk		
		Statistic	df	Sig.
PN SCD	GROUP 1	.830	12	.021*
	GROUP 2	.980	12	.983
	GROUP 3	.968	12	.884
	GROUP 4	.932	12	.406
	GROUP 5	.954	12	.699
SPON SCD	GROUP 1	.893	12	.130
	GROUP 2	.981	12	.988
	GROUP 3	.928	12	.361
	GROUP 4	.981	12	.989
	GROUP 5	.970	12	.914

*. The mean difference is significant at the .05 level.
Key: PN = Picture Naming, SPON = Spontaneous, SCD= Singleton Consonant Deletion.



Key: PN = Picture Naming, SPON = Spontaneous.

Appendix-BN:

SCD Errors: Mauchly's Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
PN vs SPON SCD	1.000	.000	0	.	1.000	1.000	1.000

Key: PN = Picture Naming, SPON = Spontaneous, SCD= Singleton Consonant Deletion.

Appendix-BO:

Positional SCD: Normality test after data transformation.

		Shapiro-Wilk Positional SCD			Shapiro-Wilk Positional SCD-LOG		
	Age Group	Statistic	df	Sig.	Statistic	df	Sig.
SIWI SCD	GROUP 1	.913	12	.236	.948	5	.722
	GROUP 2	.919	12	.274	.958	9	.772
	GROUP 3	.781	12	.006**	.981	8	.968
	GROUP 4	.822	12	.017*	.965	5	.839
	GROUP 5	.851	12	.037*	.974	6	.918
SIWW SCD	GROUP 1	.743	12	.002**	.936	5	.638
	GROUP 2	.749	12	.003**	.877	9	.146
	GROUP 3	.943	12	.533	.979	8	.958
	GROUP 4	.873	12	.072	.922	5	.540
	GROUP 5	.887	12	.108	.958	6	.804
SFWW SCD	GROUP 1	.798	12	.009**	.916	5	.508
	GROUP 2	.872	12	.070	.903	9	.267
	GROUP 3	.945	12	.564	.844	8	.082
	GROUP 4	.924	12	.321	.927	5	.574
	GROUP 5	.932	12	.401	.928	6	.564
SFWF SCD	GROUP 1	.947	12	.592	.849	5	.192
	GROUP 2	.867	12	.059	.870	9	.122
	GROUP 3	.918	12	.271	.938	8	.588
	GROUP 4	.955	12	.716	.907	5	.447
	GROUP 5	.901	12	.163	.900	6	.373

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: SIWI = Syllable-Initial Word-Initial, SIWW, Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final, SCD= Singleton Consonant Deletion.

Appendix-BP:

a. *Positional SCD Errors: Mauchly's Test of Sphericity*

					Epsilon		
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
PN vs SPON Lateralization	.802	4.800	5	.441	.875	1.000	.333

Key: PN = Picture Naming, SPON = Spontaneous.

b. *Positional SCD Errors: Levene's* [a] *Test of Equality of Error Variances*

LOG transformed Positional SCD	F	df1	df2	Sig.
SIWI SCD LOG	1.401	9	23	.245
SIWW SCD LOG	1.606	9	23	.172
SFWW SCD LOG	1.420	9	23	.237
SFWF SCD LOG	1.052	9	23	.432

Key: PN = Picture Naming, SPON = Spontaneous, LOG = Logerithmic.

Appendix-BQ:

Positional SCD: Tests of Within-Subjects Contrasts

Source	Positional SCD	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
positional SCD	SIWI vs. SIWW	.302	1	.302	2.673	.116	.104
	SIWW vs. SFWW	31.368	1	31.368	256.329	.000**	.918
	SFWW vs. SFWF	.832	1	.832	12.166	.002**	.346
positional SCD * Age-Group	SIWI vs. SIWW	.155	4	.039	.343	.846	.056
	SIWW vs. SFWW	.346	4	.087	.707	.595	.109
	SFWW vs. SFWF	1.116	4	.279	4.079	.012*	.415
positional SCD* Gender	SIWI vs. SIWW	.353	1	.353	3.123	.090	.120
	SIWW vs. SFWW	.002	1	.002	.013	.911	.001
	SFWW vs. SFWF	.127	1	.127	1.856	.186	.075
positional SCD* Age-Group* Gender	SIWI vs. SIWW	.581	4	.145	1.286	.304	.183
	SIWW vs. SFWW	.132	4	.033	.269	.895	.045
	SFWW vs. SFWF	.218	4	.055	.797	.539	.122
Error (positional SCD)	SIWI vs. SIWW	2.598	23	.113			
	SIWW vs. SFWW	2.815	23	.122			
	SFWW vs. SFWF	1.574	23	.068			

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: SCD= Singleton Consonant Deletion, SIWI = Syllable-Initial Word-Initial, SIWW, Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

Appendix-BR:

*Positional SCD Errors: SFWW vs. SFWF*Age interaction: Mauchly's Test of Sphericity*

Within Subjects Effect: SFWW vs SFWF	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
G1	1.000	.000	0	.	1.000	1.000	1.000
G2	1.000	.000	0	.	1.000	1.000	1.000
G3	1.000	.000	0	.	1.000	1.000	1.000
G4	1.000	.000	0	.	1.000	1.000	1.000
G5	1.000	.000	0	.	1.000	1.000	1.000

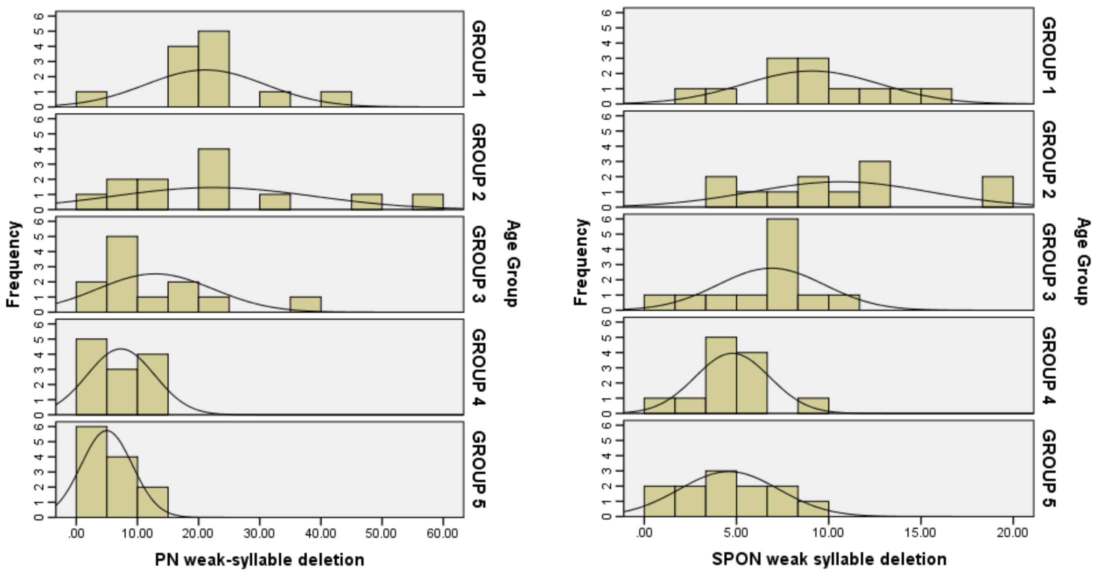
Key: SCD= Singleton Consonant Deletion, SIWW, Syllable-Initial Within-Word, SFWW= Syllable-Final Within-Word.

Appendix-BS:

WSD Normality Test

	Age Group	Shapiro-Wilk		
		Statistic	df	Sig.
PN WSD	GROUP 1	.869	12	.064
	GROUP 2	.929	12	.375
	GROUP 3	.795	12	.008**
	GROUP 4	.891	12	.120
	GROUP 5	.881	12	.090
SPON WSD	GROUP 1	.979	12	.981
	GROUP 2	.922	12	.300
	GROUP 3	.922	12	.300
	GROUP 4	.949	12	.617
	GROUP 5	.974	12	.946

**. The mean difference is significant at the .01 level.
Key: PN = Picture Naming, SPON = Spontaneous, WSD = Weak-Syllable Deletion.



Key: PN = Picture Naming, SPON = Spontaneous.

Appendix-BT:

a. *WSD Errors in Two Speech Samples: Mauchly's Test of Sphericity*

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b] Greenhouse-Geisser	Huynh-Feldt	Lower-bound
WSD in PN vs. SPON	1.000	.000	0	.	1.000	1.000	1.000

Key: PN = Picture Naming, SPON = Spontaneous, WSD = Weak-Syllable Deletion.

b. *WSD PN vs. SPON*Age interaction: Mauchly's Test of Sphericity*

Within Subjects Effect SFWW vs SFWF	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon Greenhouse-Geisser	Huynh-Feldt	Lower-bound
G1	1.000	.000	0	.	1.000	1.000	1.000
G2	1.000	.000	0	.	1.000	1.000	1.000
G3	1.000	.000	0	.	1.000	1.000	1.000
G4	1.000	.000	0	.	1.000	1.000	1.000
G5	1.000	.000	0	.	1.000	1.000	1.000

Key: PN = Picture Naming, SPON = Spontaneous, WSD = Weak-Syllable Deletion SFWW= Syllable-Final Within-Word, SFWF= Syllable-Final Word-Final.

Appendix-BU:

WSD Errors Post-Hoc Test:

(I) Age Group	(J) Age Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
GROUP 1	GROUP 2	-1.4029	2.34513	.975	-8.0392	5.2333
	GROUP 3	5.2108	2.34513	.189	-1.4254	11.8471
	GROUP 4	9.0746*	2.34513	.003	2.4383	15.7108
	GROUP 5	10.3179*	2.34513	.001	3.6817	16.9542
GROUP 2	GROUP 1	1.4029	2.34513	.975	-5.2333	8.0392
	GROUP 3	6.6137	2.34513	.051	-.0225	13.2500
	GROUP 4	10.4775*	2.34513	.000	3.8412	17.1138
	GROUP 5	11.7208*	2.34513	.000	5.0846	18.3571
GROUP 3	GROUP 1	-5.2108	2.34513	.189	-11.8471	1.4254
	GROUP 2	-6.6137	2.34513	.051	-13.2500	.0225
	GROUP 4	3.8638	2.34513	.475	-2.7725	10.5000
	GROUP 5	5.1071	2.34513	.205	-1.5292	11.7433
GROUP 4	GROUP 1	-9.0746*	2.34513	.003	-15.7108	-2.4383
	GROUP 2	-10.4775*	2.34513	.000	-17.1138	-3.8412
	GROUP 3	-3.8638	2.34513	.475	-10.5000	2.7725
	GROUP 5	1.2433	2.34513	.984	-5.3929	7.8796
GROUP 5	GROUP 1	-10.3179*	2.34513	.001	-16.9542	-3.6817
	GROUP 2	-11.7208*	2.34513	.000	-18.3571	-5.0846
	GROUP 3	-5.1071	2.34513	.205	-11.7433	1.5292
	GROUP 4	-1.2433	2.34513	.984	-7.8796	5.3929

Based on observed means.
The error term is Mean Square (Error) = 32.998.
*. The mean difference is significant at the .05 level.
Key: WSD = Weak-Syllable Deletion.

Appendix-BV:

Positional WSD: Normality tests

		Shapiro-Wilk Positional WSD		
	Age Group	Statistic	df	Sig.
Initial WSD	GROUP 1	.964	12	.843
	GROUP 2	.900	12	.161
	GROUP 3	.968	12	.890
	GROUP 4	.983	12	.994
	GROUP 5	.946	11	.597
Medial WSD	GROUP 1	.790	12	.007**
	GROUP 2	.923	12	.315
	GROUP 3	.928	12	.361
	GROUP 4	.965	12	.850
	GROUP 5	.937	11	.490
Final WSD	GROUP 1	.825	12	.018**
	GROUP 2	.863	12	.054
	GROUP 3	.799	12	.009**
	GROUP 4	.783	12	.006**
	GROUP 5	.830	11	.024*

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: WSD = Weak-Syllable Deletion.

Appendix-BW:

Positional WSD: Non-Parametric Test Results

a. Descriptive Statistics

						Percentiles		
	N	Mean	Std. Deviation	Min	Max	25th	50th (Median)	75th
Initial WSD	59	42.53	15.42	10.00	92.86	33.33	41.30	52.94
Medial WSD	59	52.85	14.81	.00	90.00	42.86	52.94	62.26
Final WSD	59	4.60	5.74	.00	20.00	.00	2.33	7.89

Key: WSD = Weak-Syllable Deletion.

b. Friedman's Test

Mean Rank	
Initial WSD	2.35
Medial WSD	2.62
Final WSD	1.03
Test Statistics	
N	59
Chi-Square	86.606
df	2
Asymp. Sig.	.000*

*. The mean difference is significant at the .01 level.
Key: WSD = Weak-Syllable Deletion.

c. Positional WSD Wilcoxon Signed Ranks Test

		N	Mean Rank	Sum of Ranks
Medial WSD - Initial WSD	Negative Ranks	20[a]	22.35	447.00
	Positive Ranks	36[b]	31.92	1149.00
	Ties	3[c]		
	Total	59		
Final WSD - Medial WSD	Negative Ranks	58[d]	30.50	1769.00
	Positive Ranks	1[e]	1.00	1.00
	Ties	0[f]		
	Total	59		
Final WSD - Initial WSD	Negative Ranks	57[g]	29.00	1653.00
	Positive Ranks	0[h]	.00	.00
	Ties	2[i]		
	Total	59		

a. Medial WSD < Initial WSD
b. Medial WSD > Initial WSD
c. Medial WSD = Initial WSD
d. Final WSD < Medial WSD
e. Final WSD > Medial WSD
f. Final WSD = Medial WSD
g. Final WSD < Initial WSD
h. Final WSD > Initial WSD

Key: WSD = Weak-Syllable Deletion.

Appendix-BX:

Positional WSD Errors: Mauchly's Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Positional WSD	.324	54.030	2	.000	.597	.716	.500

Key: WSD = Weak-Syllable Deletion.

Appendix-BY:

Positional WSD: Tests of Within-Subjects Contrasts

Source	Positional WSD	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Positional WSD	Initial WSD vs. Medial WSD	6406.517	1	6406.517	6.292	.015*	.114
	Medial WSD vs. Final WSD	137065.788	1	137065.788	457.066	.000**	.903
Positional WSD * Age-Group	Initial WSD vs. Medial WSD	110.264	4	27.566	.027	.999	.002
	Medial WSD vs. Final WSD	237.919	4	59.480	.198	.938	.016
Positional WSD * Gender	Initial WSD vs. Medial WSD	195.926	1	195.926	.192	.663	.004
	Medial WSD vs. Final WSD	84.984	1	84.984	.283	.597	.006
Positional WSD * Age-Group * Gender	Initial WSD vs. Medial WSD	978.720	4	244.680	.240	.914	.019
	Medial WSD vs. Final WSD	465.747	4	116.437	.388	.816	.031
Error (Positional WSD)	Initial WSD vs. Medial WSD	49888.910	49	1018.141			
	Medial WSD vs. Final WSD	14694.221	49	299.882			

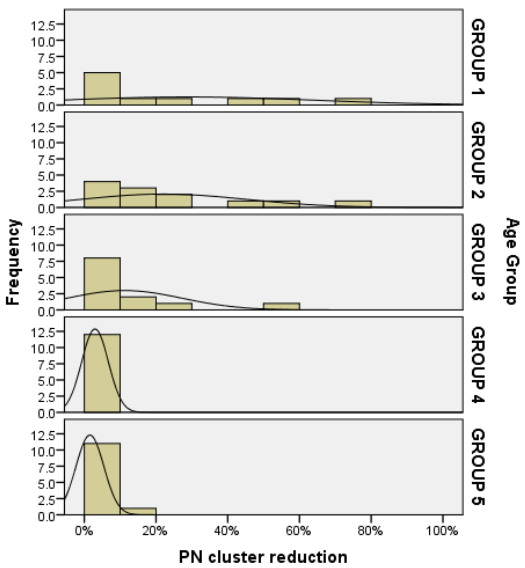
*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: WSD = Weak-Syllable Deletion

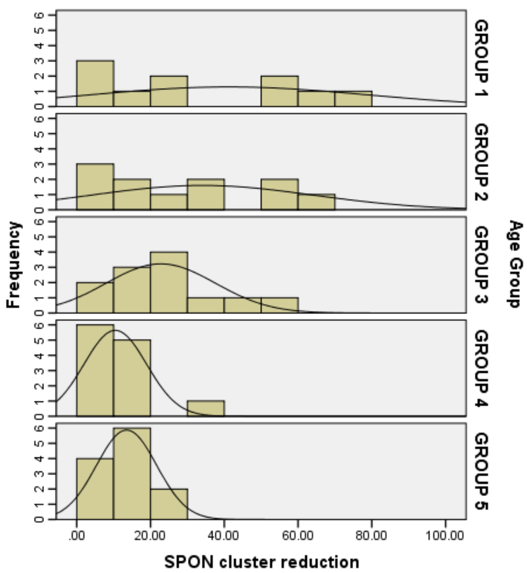
Appendix-BZ:

CR Normality Test

Age Group		Shapiro-Wilk		
		Statistic	df	Sig.
PN CR	GROUP 1	.821	11	.018*
	GROUP 2	.870	12	.065
	GROUP 3	.743	12	.002**
	GROUP 4	.683	12	.001**
	GROUP 5	.479	12	.000**
SPON CR	GROUP 1	.913	11	.262
	GROUP 2	.924	12	.325
	GROUP 3	.977	12	.968
	GROUP 4	.891	12	.121
	GROUP 5	.948	12	.613

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: CR= Cluster Reduction, PN = Picture Naming, SPON = Spontaneous.





Key: PN = Picture Naming, SPON = Spontaneous.

Appendix-CA:

a. CR in Two Speech Samples: Wilcoxon Signed Ranks Test

		N	Mean Rank	Sum of Ranks
SPON CR - PN CR	Negative Ranks	9[a]	31.56	284.00
	Positive Ranks	44[b]	26.07	1147.00
	Ties	6[c]		
	Total	59		

a. SPON CR < PN CR
b. SPON CR > PN CR
c. SPON CR = PN CR
Key: CR= Cluster Reduction, PN = Picture Naming, SPON = Spontaneous.

b. The Effect of Gender on the Occurrence of CR in Two Speech Samples: Mann-Whitney Test

	Gender	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Z	Sig. (2-tailed)
PN CR	Female	29	28.17	817.00	382.500	-.856	.392
	Male	30	31.77	953.00			
	Total	59					
SPON CR	Female	30	30.38	911.50	446.500	-.052	.959
	Male	30	30.62	918.50			
	Total	60					

Key: CR= Cluster Reduction, PN = Picture Naming, SPON = Spontaneous.

Appendix-CB:

CR Errors: Mauchly's Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
CR in Two speech samples	1.000	.000	0	.	1.000	1.000	1.000

Key: CR= Cluster Reduction.

Appendix-CC:

CR Errors Post-Hoc Test:

(I) Age Group	(J) Age Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
GROUP 1	GROUP 2	4.2014	6.89990	.973	-15.3387	23.7415
	GROUP 3	15.2593	6.89990	.193	-4.2808	34.7994
	GROUP 4	25.5289*	6.89990	.005	5.9888	45.0690
	GROUP 5	24.7089*	6.89990	.007	5.1688	44.2490
GROUP 2	GROUP 1	-4.2014	6.89990	.973	-23.7415	15.3387
	GROUP 3	11.0579	6.74823	.481	-8.0527	30.1685
	GROUP 4	21.3275*	6.74823	.022	2.2169	40.4381
	GROUP 5	20.5075*	6.74823	.030	1.3969	39.6181
GROUP 3	GROUP 1	-15.2593	6.89990	.193	-34.7994	4.2808
	GROUP 2	-11.0579	6.74823	.481	-30.1685	8.0527
	GROUP 4	10.2696	6.74823	.554	-8.8410	29.3802
	GROUP 5	9.4496	6.74823	.630	-9.6610	28.5602
GROUP 4	GROUP 1	-25.5289*	6.89990	.005	-45.0690	-5.9888
	GROUP 2	-21.3275*	6.74823	.022	-40.4381	-2.2169
	GROUP 3	-10.2696	6.74823	.554	-29.3802	8.8410
	GROUP 5	-.8200	6.74823	1.000	-19.9306	18.2906
GROUP 5	GROUP 1	-24.7089*	6.89990	.007	-44.2490	-5.1688
	GROUP 2	-20.5075*	6.74823	.030	-39.6181	-1.3969
	GROUP 3	-9.4496	6.74823	.630	-28.5602	9.6610
	GROUP 4	.8200	6.74823	1.000	-18.2906	19.9306

Based on observed means.
The error term is Mean Square (Error) = 273.232.
*. The mean difference is significant at the .05 level.
Key: CR= Cluster Reduction.

Appendix-CD:

Positional CR Normality Test

		Shapiro-Wilk Positional CR		
	Age Group	Statistic	df	Sig.
PN Word-Initial CR	GROUP 1	.769	11	.004**
	GROUP 2	.486	12	.000**
	GROUP 3	.669	12	.000**
	GROUP 4	.592	12	.000**
	GROUP 5	.327	12	.000**
PN Word-Final CR	GROUP 1	.726	11	.001**
	GROUP 2	.652	12	.000**
	GROUP 3	.650	12	.000**
	GROUP 4	.714	12	.001**
	GROUP 5	.327	12	.000**
SPON Word-Initial CR	GROUP 1	.841	11	.033*
	GROUP 2	.689	12	.001**
	GROUP 3	.757	12	.003**
	GROUP 4	.647	12	.000**
	GROUP 5	.861	12	.051
SPON Word-Final CR	GROUP 1	.740	11	.002**
	GROUP 2	.579	12	.000**
	GROUP 3	.614	12	.000**
	GROUP 4	.799	12	.009**
	GROUP 5	.849	12	.036*

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: CR= Cluster Reduction, PN= Picture Naming, SPON = Spontaneous.

Appendix-CE

Positional CR and Speech Sample Comparison: Wilcoxon Signed Ranks Test

Conditions compared		N	Mean Rank	Sum of Ranks
PN word-final CR – PN word-initial CR	Negative Ranks	7[a]	8.57	60.00
	Positive Ranks	21[b]	16.48	346.00
	Ties	31[c]		
	Total	59		
SPON word-final CR – SPON word-initial CR	Negative Ranks	27[d]	26.13	705.50
	Positive Ranks	18[e]	18.31	329.50
	Ties	15[f]		
	Total	60		
SPON word-initial CR – PN word-initial CR	Negative Ranks	6[g]	16.83	101.00
	Positive Ranks	37[h]	22.84	845.00
	Ties	16[i]		
	Total	59		
SPON word-final CR – PN word-final CR	Negative Ranks	18[j]	25.61	461.00
	Positive Ranks	24[k]	18.42	442.00
	Ties	17[l]		
	Total	59		

a. PN word-final CR < PN word-initial CR
b. PN word-final CR > PN word-initial CR
c. PN word-final CR = PN word-initial CR
d. SPON word-final CR < SPON word-initial CR
e. SPON word-final CR > SPON word-initial CR
f. SPON word-final CR = SPON word-initial CR
g. SPON word-initial CR < PN word-initial CR
h. SPON word-initial CR > PN word-initial CR
i. SPON word-initial CR = PN word-initial CR
j. SPON word-final CR < PN word-final CR
k. SPON word-final CR > PN word-final CR
l. SPON word-final CR = PN word-final CR

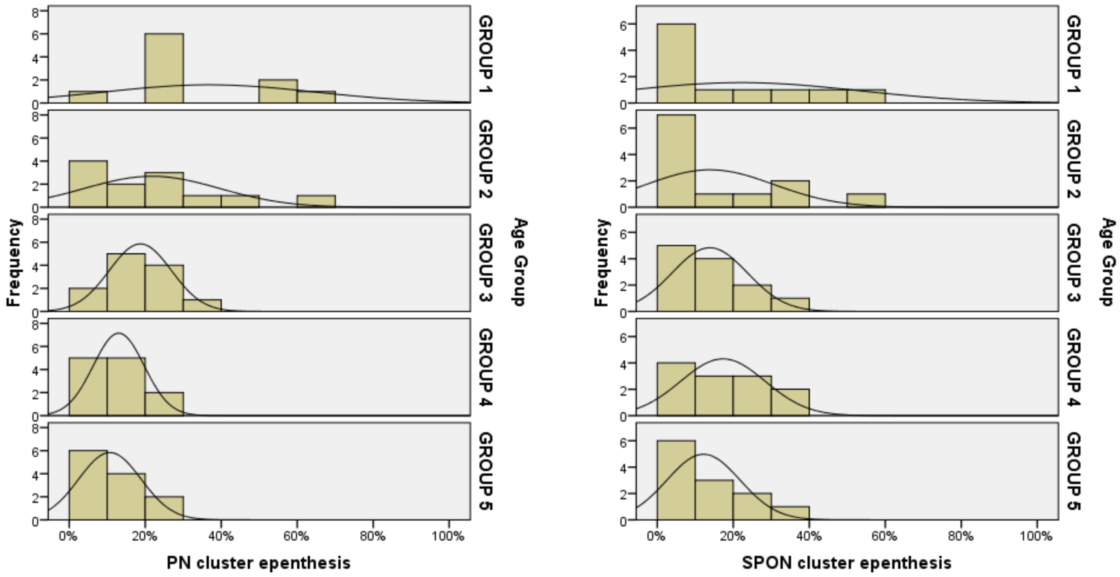
Key: CR= Cluster Reduction, PN = Picture Naming, SPON = Spontaneous.

Appendix-CF:

CE Normality Test

Age Group		Shapiro-Wilk		
		Statistic	df	Sig.
PN CE	GROUP 1	.867	11	.071
	GROUP 2	.826	12	.019*
	GROUP 3	.931	12	.390
	GROUP 4	.850	12	.037*
	GROUP 5	.931	12	.392
SPON CE	GROUP 1	.794	11	.008**
	GROUP 2	.827	12	.019*
	GROUP 3	.946	12	.581
	GROUP 4	.954	12	.694
	GROUP 5	.881	12	.090

*. The mean difference is significant at the .05 level.
**. The mean difference is significant at the .01 level.
Key: CE= Cluster Epenthesis, PN = Picture Naming, SPON = Spontaneous.



Key: PN = Picture Naming, SPON = Spontaneous.

Appendix-CG:

a. CE in Two Speech Samples: Wilcoxon Signed Ranks Test

		N	Mean Rank	Sum of Ranks
SPON CE - PN CE	Negative Ranks	34[a]	29.66	1008.50
	Positive Ranks	22[b]	26.70	587.50
	Ties	3[c]		
	Total	59		

a. SPON CE < PN CE
b. SPON CE > PN CE
c. SPON CE = PN CE
Key: CE= Cluster Epenthesis, PN = Picture Naming, SPON = Spontaneous.

b. The Effect of Gender on the Occurrence of CE in Two Speech Samples: Mann-Whitney Test

	Gender	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Z	Sig. (2-tailed)
PN CE	Female	29	32.33	937.50	367.500	-1.024	.306
	Male	30	27.75	832.50			
	Total	59					
SPON CE	Female	30	29.97	899.00	434.000	-.238	.812
	Male	30	31.03	931.00			
	Total	60					

Key: CE= Cluster Epenthesis, PN = Picture Naming, SPON = Spontaneous.

Appendix-CH:

CE Errors: Mauchly’s Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
CE in Two speech samples	1.000	.000	0	.	1.000	1.000	1.000

Key: CE= Cluster Epenthesis.

Appendix-CI:

CE Errors Post-Hoc Test:

(I) Age Group	(J) Age Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
GROUP 1	GROUP 2	12.6590	5.54593	.168	-3.0468	28.3647
	GROUP 3	14.2227	5.54593	.093	-1.4830	29.9285
	GROUP 4	15.3323	5.54593	.059	-.3734	31.0381
	GROUP 5	19.0523*	5.54593	.010	3.3466	34.7581
GROUP 2	GROUP 1	-12.6590	5.54593	.168	-28.3647	3.0468
	GROUP 3	1.5637	5.42403	.998	-13.7968	16.9243
	GROUP 4	2.6733	5.42403	.988	-12.6872	18.0339
	GROUP 5	6.3933	5.42403	.763	-8.9672	21.7539
GROUP 3	GROUP 1	-14.2227	5.54593	.093	-29.9285	1.4830
	GROUP 2	-1.5637	5.42403	.998	-16.9243	13.7968
	GROUP 4	1.1096	5.42403	1.000	-14.2509	16.4701
	GROUP 5	4.8296	5.42403	.899	-10.5309	20.1901
GROUP 4	GROUP 1	-15.3323	5.54593	.059	-31.0381	.3734
	GROUP 2	-2.6733	5.42403	.988	-18.0339	12.6872
	GROUP 3	-1.1096	5.42403	1.000	-16.4701	14.2509
	GROUP 5	3.7200	5.42403	.959	-11.6405	19.0805
GROUP 5	GROUP 1	-19.0523*	5.54593	.010	-34.7581	-3.3466
	GROUP 2	-6.3933	5.42403	.763	-21.7539	8.9672
	GROUP 3	-4.8296	5.42403	.899	-20.1901	10.5309
	GROUP 4	-3.7200	5.42403	.959	-19.0805	11.6405

Based on observed means.
The error term is Mean Square (Error) = 176.521.
*. The mean difference is significant at the .05 level.
Key: CE= Cluster Epenthesis.

Appendix-CJ:

Positional CE Normality Test

		Shapiro-Wilk Positional CE		
	Age Group	Statistic	df	Sig.
PN Word-Initial CE	GROUP 1	.935	11	.466
	GROUP 2	.864	12	.056
	GROUP 3	.763	12	.004**
	GROUP 4	.637	12	.000**
	GROUP 5	.903	12	.175
PN Word-Final CE	GROUP 1	.848	11	.040*
	GROUP 2	.718	12	.001**
	GROUP 3	.891	12	.121
	GROUP 4	.712	12	.001**
	GROUP 5	.853	12	.040*
SPON Word-Initial CE	GROUP 1	.721	11	.001**
	GROUP 2	.837	12	.026*
	GROUP 3	.888	12	.111
	GROUP 4	.787	12	.007**
	GROUP 5	.860	12	.049*
SPON Word-Final CE	GROUP 1	.465	11	.000**
	GROUP 2	.601	12	.000**
	GROUP 3	.505	12	.000**
	GROUP 4	.481	12	.000**
	GROUP 5	.736	12	.002**

*. The mean difference is significant at the .01 level.
Key: CE= Cluster Epenthesis, PN = Picture Naming, SPON = Spontaneous.

Appendix-CK:

Positional CE and Speech Sample Comparison: Wilcoxon Signed Ranks Test

Conditions compared		N	Mean Rank	Sum of Ranks
PN Word-Final CE - PN Word-Initial CE	Negative Ranks	36[a]	24.93	897.50
	Positive Ranks	11[b]	20.95	230.50
	Ties	12[c]		
	Total	59		
SPON Word-Initial CE - PN Word-Initial CE	Negative Ranks	26[d]	30.52	793.50
	Positive Ranks	27[e]	23.61	637.50
	Ties	6[f]		
	Total	59		
SPON Word-Final CE - PN Word-Final CE	Negative Ranks	29[g]	20.33	589.50
	Positive Ranks	10[h]	19.05	190.50
	Ties	20[i]		
	Total	59		
SPON Word-Final CE - SPON Word-Initial CE	Negative Ranks	33[j]	20.79	686.00
	Positive Ranks	7[k]	19.14	134.00
	Ties	20[l]		
	Total	60		

a. PN Word-Final CE < PN Word-Initial CE
b. PN Word-Final CE > PN Word-Initial CE
c. PN Word-Final CE = PN Word-Initial CE
d. SPON Word-Initial CE < PN Word-Initial CE
e. SPON Word-Initial CE > PN Word-Initial CE
f. SPON Word-Initial CE = PN Word-Initial CE
g. SPON Word-Final CE < PN Word-Final CE
h. SPON Word-Final CE > PN Word-Final CE
i. SPON Word-Final CE = PN Word-Final CE
j. SPON Word-Final CE < SPON Word-Initial CE
k. SPON Word-Final CE > SPON Word-Initial CE
l. SPON Word-Final CE = SPON Word-Initial CE

Key: CE= Cluster Epenthesis, PN = Picture Naming, SPON = Spontaneous.