Exploring Relationships between Phonological Awareness and Phonological Productive Abilities of Kindergarten-Aged Children

by

© Alyson Judd

A Thesis submitted to the

School of Graduate Studies

in partial fulfillment of the requirements for the degree of

Master of Arts

Department of Linguistics

Memorial University of Newfoundland

June 2018 St. John's, NL

Abstract

Numerous language acquisition studies have identified relationships between phonological awareness, which refers to a speaker's ability to identify and manipulate syllable constituents, and other developmental skills, including vocabulary, literacy, and future academic achievement. In contrast, fewer studies have explored the nature of the relationship between phonological awareness and phonological abilities measured through performance in speech production. In this thesis, I explore the nature of this relationship by using statistics to compare the performance of 26 children on three developmental tasks (Phoneme Isolation, Verbal Fluency, and Letter Naming) and two measures of phonological abilities in production (Picture Naming Task and Semi-Directed Narrative). I divide the participants into three separate speaker groups (children with suspected speech disorders, younger children with typical speech, and older children with typical speech). I identify the measures for which lower scores consistently pattern with the former two speaker groups, in comparison to the latter group, and I establish that less mature phonological systems may also influence performance on these assessments. I show that differences in behaviours observed among these speaker groups can most clearly be identified through 'marked' (i.e. complex) phonological contexts, as opposed to those that are 'unmarked' (i.e. simple). In addition to contributing research on the relationship between phonological awareness and phonological abilities in production, this study also provides evidence of the potential for phonological markedness as a principal consideration toward both the future development of phonological assessments and early diagnosis of phonological disorders.

Acknowledgements

Throughout the duration of this thesis, I have been fortunate to have a phenomenal support network of family and friends. I am very grateful to my parents and to my sister for their unwavering belief in me and my project, to my fellow graduate students and professors in the Department of Linguistics at Memorial University for their valuable insight and feedback, and to my transcriber, Chantal Lamarche, for her patience and diligence with phonological transcription. Thank you all for your encouragement and for helping me to persevere through the challenges of independent research!

I would like to express my gratitude to Dr. Catherine Penney for permitting me to use her data for my study and for introducing me to this area of research. Thank you to my supervisor, Dr. Yvan Rose, for providing me with the opportunity to pursue graduate studies, for refining my skills as a researcher, and for his guidance throughout this process. Finally, thank you to my reviewers, Dr. Carrie Dyck and Dr. Cynthia Core, for their positive and constructive feedback on my thesis.

Table of Contents

Appendices

List of Tables

List of Figures

Chapter 1: Introduction and Aims

Phonological awareness refers to an individual's dynamic knowledge of how sounds combine to create meaningful units of language (Ball 1993). This ability allows the experienced learner to dynamically separate words into individual phonemes and to manipulate the sounds within a word (Torgesen & Mathes 2000). Researchers have discovered developmental relationships between phonological awareness skills and other abilities, including vocabulary (Rvachew 2006; Linklater, O'Connor & Palardy 2009), phonological production errors (Mann & Foy 2007; Preston, Hull & Edwards 2013), letter naming (Blaiklock 2004), reading achievement (Adams 1990; Goswami & Bryant 1990; Moyle, Heilmann & Berman 2013), and future academic success (Anthony, Aghara, Solari, et al. 2011). Researchers have assessed phonological awareness in children using a variety of phoneme segmentation (Liberman et al. 1974; Muter et al. 1997), blending (Helfgott 1976), deletion (elision) (Bruce 1964; Rosner & Simon 1971), identification (Yopp 1988), and oddity tasks (Wagner et al. 1997; Runge & Watkins 2006). Some researchers have also incorporated rhyming production and identification tasks (Stanovich, Cunningham & Cramer 1984). However, while previous studies have examined correlations among these different abilities, there is a lack of research on the relationship between phonological awareness and phonological productive abilities. Therefore, we do not know what exact correlations there might be between these two areas of phonological performance.

My study provides a step toward addressing current needs for more information on the relationship between phonological awareness and phonological abilities in production. It also supplements previous studies by replicating comparisons of phonological awareness with verbal fluency and letter naming. In my thesis, I answer the following research questions:

1) Do significant correlations exist between measures of phonological awareness and measures of phonological productive abilities?
2) Does the performance of children with suspected speech disorders and younger children with typical speech differ from that of older children with typical speech patterns?
3) If the answer to 1) and/or 2) is yes, do these relationships provide insight into the connection between phonological representations and phonological abilities in production?

To establish whether relationships exist among these measures, I compiled data from 26 kindergarten-aged children on three developmental tasks: *Phoneme Isolation* (i.e. phonological awareness), *Verbal Fluency*, and *Letter Naming*. To assess phonological abilities in production, I analyzed the productions of 12 isolated words in a *Picture Naming Task*, as well as samples of continuous speech in a *Semi-Directed Narrative*. Once I obtained these scores, I conducted a comparative analysis of single correlations to determine which relationships were statistically significant.

In response to the research questions formulated above, I present evidence of the relationship between phonological awareness and phonological abilities in production. I argue that significant correlations between tasks that assess these abilities are indicative of shared phonological mechanisms. Furthermore, I use the performance of the suspected speech-disordered children and younger children with typical speech to substantiate that lower scores on the phonological tasks are attributable to immature or less developed phonological systems.

In the next chapter, I review previous studies that have examined relationships between phonological awareness and other developmental abilities.

Chapter 2: Background Literature

1. Introduction

In this chapter, I present an overview of previous research that has explored the relationships between phonological awareness and other developmental abilities. I primarily focus on studies relevant to the measures addressed in the current study. In addition, I discuss phonological awareness and literacy, given the large body of research devoted to establishing the nature of this relationship.

2. Phoneme Isolation and Related Developmental Abilities

I begin this section by discussing the optimal age range for assessing phonological awareness skills, in section 2.1. I then summarize research concerning phonological awareness and its relationship with literacy, verbal fluency, and phonological abilities in production, in sections 2.2, 2.3, and 2.4, respectively.

2.1 Importance of Age

Researchers have shown that children are often able to display language abilities before they are aware of these abilities (Fox & Routh 1975). For example, children may recognize the number of phonological components in a word before they can actively isolate and articulate them (Gombert 1992). For a developmental skill such as phonological awareness, this could be an important factor, as researchers may be able to elicit a target response from a young child, even if the child does not recognize the skill being assessed.

Age is an important element to consider in research on phonological awareness. Researchers must establish the minimum age at which children can be assessed for phonological awareness skills and the earliest age at which they can understand the task they must perform. For literacy purposes, the association between phonological awareness and reading becomes strongly correlated after second grade. It is therefore difficult to determine if phonological awareness skills are due to phonological representations or grapheme-phoneme relationships, and to what extent the combination of these two factors plays a role (Hogan, Catts & Little 2005).

It is important to observe the developmental trends of phonological awareness skills, particularly between three to seven years of age (Fowler 1991). Fox & Routh (1975) discovered that children improve the most on segmenting syllables into phonemes between the ages of three and four. Phoneme segmentation abilities continue to increase between the ages of six and seven, but at a much slower rate. Similarly, Alegria, Pignot & Morais (1982) show that, by the age of six, most children are consciously aware that words are divisible sequences of sounds. The results from the literature suggest that, depending on what measures and variables the researchers use, the estimation of the age at which phonological awareness abilities emerge and are mastered varies significantly (see Bruce 1964; Torgesen & Mathes 2000).

A large portion of research has focused on the relationship between phonological awareness and reading abilities. While my research does not concentrate specifically on this, it is important to consider literacy studies to establish the larger context of research on phonological awareness. I provide an overview of the literature on the relationship between phonological awareness and reading abilities in the following section.

2.2 Phonological Abilities and Literacy

Learning to read an alphabetic language, in which letters and letter combinations have some degree of correspondence with sounds, "requires access to a phonemic organization of lexical structures" (Fowler 1991, p. 106). Children must therefore learn that one letter can represent different sounds or that a group of alphabetic letters can correspond to a single sound (Adams

1990; Castiglioni-Spalten & Ehri 2003). Given that phonological awareness is essential in establishing grapheme-phoneme relationships, it is not surprising that this skill has shown moderate to strong correlations with respect to reading achievement (Zifcak 1981; Swanson et al. 2003). In contrast to this, learners of logographic languages, which are written with non-alphabetic symbols, do not rely as heavily on phonological awareness when learning to read. This is because logographic characters generally do not correspond to individual phonemes (Mann 1986; Read et al. 1986).

The phonological awareness task that appears to have the most predictive power for future reading achievement in alphabetic languages is segmentation at the phoneme level (Helfgott 1976; Muter et al. 1997; Nation & Hulme 1997). Conversely, rhyming and alliteration, two of the earliest phonological awareness skills to emerge (Chard & Dickson 1999; Torgesen & Mathes 2000), are not strong predictors of reading ability (Adams 1990; Blaiklock 2004; Moyle, Heilmann & Berman 2013). As children become more proficient at reading, the correlation with phonological awareness becomes increasingly linear. At this point, phonological awareness loses its predictive validity (Hogan, Catts & Little 2005).

Letter naming is also an important predictor of reading success. Calfee (1977) shows that kindergarten children who initially make more than five or six errors with letter naming are at risk of reading challenges. Letter naming *fluency*, not just accuracy, should also be considered, as it is a key part of the foundation for literacy (Kaminski & Good, III 1996; Muter et al. 1997). Researchers have also uncovered relationships between letter naming and phonological awareness, although the strength of this correlation decreases as children become more advanced readers (Blaiklock 2004; Hogan, Catts & Little 2005). Manolitsis & Tafa (2011) attribute letter knowledge to phonological awareness development in Greek children at the end of kindergarten. In addition, they suggest that letter-sound knowledge is more positively correlated with phonological awareness than knowledge of the letter name. One reason for this could be that letter naming tasks require access to phonological representations which are independent from words stored within the lexicon (Wagner & Torgesen 1987). Poor letter naming skills may also relate to weaker vocabulary, which can be caused by insufficient phonological representations (Mann & Foy 2003).

The relationship between letter naming and speech articulation is unclear, as correlations appear to range from poor to moderate, with varied statistical significance (Sutherland & Gillon 2007). Webster, Plante & Couvillion (1997) explored the relationship between letter naming and percentage consonants correct (PCC) using three measures: "longitudinal, age 3-6; precedent, age 4-6; and concurrent, age 5-6" (p. 369). They found significant correlations between letter naming and articulation accuracy in each measure, with the precedent showing the strongest correlation. In contrast, Mann & Foy (2003) found that articulatory errors negatively correlate, although weakly, with both letter naming proficiency and knowledge of letter-sound associations. These contradictory results may be in part attributable to the population and design of each study. For example, Webster, Plante & Couvillion (1997) include phonologically disordered children, whereas Mann & Foy (2003) do not identify any disordered children within their population.

2.3 Phonological Abilities and Verbal Fluency

Verbal fluency tasks are designed to assess both an individual's "lexical knowledge and semantic memory organization" (Ardila, Ostrosky−Solís & Bernal 2006, p. 326). Researchers use speed (Swanson et al. 2003), precision (Kuhn, Schwanenflugel & Meisinger 2010), and automaticity (McBride-Chang et al. 2012) of the target response to differentiate verbal fluency from other skills. The exact nature of the relationship between phonological awareness and verbal fluency is unclear, as a variety of social and linguistic factors are also involved (see Spere & Evans 2009).

According to Calfee (1977), verbal fluency is moderately correlated with phonological awareness, but Melby-Lervåg & Hulme (2010) found differences depending on the type of verbal fluency. The strength of the relationship between verbal fluency and phonological awareness may therefore depend on how verbal fluency is assessed.

Many verbal fluency and phonological awareness studies use rapid automatic naming of objects (see Kuhn, Schwanenflugel & Meisinger 2010; Cronin 2013), nonword repetitions (Edwards, Beckman & Munson 2004), and word recognition (McBride-Chang et al. 2012). Fewer studies, including Aguilar-Mediavilla et al. (2014) and Ardila, Ostrosky−Solís & Bernal (2006), use lexical retrieval methods that require the participant to respond without the use of a visual aid. Vandewalle et al. (2012) allowed children 20 seconds to provide as many words as they could think of within a given semantic category. They found that children with specific language impairment, regardless of reading ability, have significantly lower verbal fluency scores than their typically-developing peers. These results support the concept of the phonological system as a set of interdependent abilities: "(a) ease of forming new phonological representations, (b) accessibility of extant phonological representations, (c) precision of extant phonological representations as reflected in speech perception, and (d) precision of extant phonological representations as reflected in articulation accuracy" (Anthony et al. 2010, p. 971). Therefore, deficiencies in the phonological system should be reflected by performance on these four tasks.

2.4 Phonological Awareness and Phonological Abilities in Production

Fewer studies have examined the relationship between phonological awareness and phonological production in typically-developing children. Instead, many researchers have been concentrating on literacy since the early 1990s (Adams 1990; Goswami & Bryant 1990), or they have explored this relationship exclusively with individuals who have language impairment (see Thomas &

Sénéchal 2004). Difficulties in phonological awareness and articulatory control could indicate disordered phonological representations and may lead to future difficulties in reading and learning (Fowler 1991; Anthony, Aghara, Dunkelberger, et al. 2011). It is also possible that children may have difficulty with phonological awareness, but their phonological production may not be affected (Torgesen & Mathes 2000). Likewise, some children with speech impairments may not have deficient phonological representations (Sutherland & Gillon 2005), while others may struggle with phonological awareness tasks at the intrasyllabic level (Bird, Bishop & Freeman 1995). These findings should not be interpreted as the absence of a relationship between articulatory accuracy and phonological awareness. Instead, they may reflect the fundamental difference between knowledge of how words sound and explicit access to phonological representations (Adams 1990).

If individual differences in phonological awareness are related to the structure of phonological representations, there may be predictable phonological patterns in production. Foy & Mann (2001) found that the only phonological error made by readers was cluster simplification. Nonreaders exhibited errors including syllable and cluster reduction, as well as phoneme deletion and insertion. The correlations between error type and level of phonological awareness, however, were not significant. Similarly, Preston, Hull & Edwards (2013) found that more atypical speech sound errors, which are "substitutions and syllable structure errors that are not generally found in normal phonological development" (p. 174), are significantly predictive of poorer future phonological awareness ability. Other errors such as distortion, which are articulation errors on the phonetic level, are related to other future phonological problems, including low scores on the Goldman-Fristoe Test of Articulation - Second Edition (GFTA-2). Therefore, if language impairment is due to poor motor control, phonological awareness may not be significantly affected. If deficient phonological representations are the source of the problem, however, children may be at greater risk of developing problems with phonological awareness (see Gombert 1992 for additional discussion).

3. Interim Discussion

As we saw in the summary above, many researchers have established significant correlations between phonological awareness and alphabetic literacy. However, fewer studies have examined correlations between children's phonological productive abilities and phonological awareness, verbal fluency, and letter naming. The findings from these studies are generally inconclusive and, to my knowledge, not one study has incorporated results from all of these four types of assessments. My research offers an opportunity to supplement current knowledge on the nature of these relationships. In the next chapter, I describe the assessments that I used for my study. In addition, I provide a detailed description of how these assessments were administered and I explain the methods I used to obtain the scores for each assessment.

Chapter 3: Methodology

1. Introduction

As previously discussed, my study builds on the current body of research on demonstrated relationships between phoneme isolation, verbal fluency, and letter naming by adding comparisons with measures of phonological productive abilities. In this chapter, I describe the methodology used for each component of the current study. In section 2, I introduce the background study from which I gathered the data for my thesis. In the following sections, I describe how I built on the results of this background study, through the transcription and analysis of phonological data recorded as part of this study. In section 3, I introduce the *qualitative assessment of language development*. In section 4, I describe the testing procedures and my scoring criteria for the Phoneme Isolation, Verbal Fluency, and Letter Naming tasks. I then elaborate on the Picture Naming Task and Semi-Directed Narrative, as well as the transcription process I used to prepare the sound files for phonological analysis, in section 5. Finally, in section 6, I present the methods that I used to examine the relationships among the children's scores on the Phoneme Isolation, Verbal Fluency, and Letter Naming tasks, and their phonological performances on the Picture Naming Task and Semi-Directed Narrative.

2. Background Study

The data used in the current study come from a larger study of children's language and reading abilities which was conducted by Dr. Catherine Penney, Department of Psychology, Memorial University of Newfoundland. In this section, I provide a brief overview of this study. For my study, I selected 26 participants from the original Penney study, on the condition that they had completed assessments (2) through (6) described below. All participants were either attending kindergarten or were registered to enter kindergarten within two to eight weeks at the time of testing. The study includes the following assessments:

(1) Qualitative assessment of language development, a speech-language pathologist's clinical evaluation of the children's speech and language abilities using the recordings from tasks (5) and (6) of this list

(2) Phoneme Isolation, which consists of four separate phonological awareness tasks used to assess children's phoneme deletion abilities at the onset-rime and phonemic levels (see Goswami & Bryant 1990; Wagner et al. 1997)

(3) Verbal Fluency, a task used to assess children's recall and word association, as well as their ability to produce rhyming words

(4) Letter Naming, a task where children identify randomized letters of the English alphabet

(5) *Hodson Assessment of Phonological Patterns Third Edition* (HAPP-3; Hodson Assessment), a picture-naming task used for screening productive phonological issues

(6) *Frog Story*, a semi-directed narrative used to assess children's productive speech abilities.

The Penney study also includes (7) *Slosson Oral Reading Test* (SORT-R3), a standardized test of word recognition, (8) phoneme counting in monosyllabic words, (9) reading training for words with the same rime, and (10) visual memory of symbols.

I concentrate my research on the results from tasks (2) to (6) above, namely Phoneme Isolation, Verbal Fluency, Letter Naming, Hodson Assessment, and Frog Story, as these are the most relevant to my research questions. I describe each of these in more detail in sections 4 and 5 below. In addition, I use language assessments performed by a speech-language pathologist (henceforth, S-LP), as stated in (1) above, to interpret the data; I elaborate on these qualitative language assessments in the next section. Note that sociolinguistic data (e.g. socioeconomic status) and language background (L1, L2, etc.) were not part of the information provided by the parents/guardians of the children.[1] Therefore, I do not consider these factors as part of the current analysis.

3. Qualitative Assessment of Language Development

The S-LP from the Penney study completed a summary assessment of the language skills that each child exhibited. The S-LP did not interact directly with the participants; instead, she used the audio recordings for the Hodson Assessment and Frog Story to conduct qualitative assessments of the children's speech and language abilities. The S-LP was not informed of any possible non-English L1 language influences.[2] Considering the limitations of the information to which the S-LP had access, the assessment of language development should be regarded as preliminary rather than a concrete diagnostic method for the children participating in this study. I present the S-LP's observations in Chapter 4, section 2.

For my study, I include a letter prefix in the children's identification numbers to differentiate the children whom the S-LP assessed as having typical speech with no concerns (**T##**) from those who exhibited characteristics of disordered speech (**D##**). The two digits (##) correspond to the participant number from the Penney study. I consider the language assessment in relation to the scores from the three quantitative assessments, Phoneme Isolation, Verbal Fluency, and Letter Naming, in Chapter 4, sections 3, 4.3, and 5.3, respectively. In addition, I use this assessment to validate the findings of the phonological analysis in Chapter 4, sections 8 through 11.

1 Comments on the children's non-English L1 influences are from informal interactions between the researchers and the staff members from the testing sites. Other than English, specific information about which L1 the children spoke and the amount of exposure to this language are not available.

2 Assessing multilingual children is an ongoing challenge for researchers (Scarpino et al. 2011; Core et al. 2013).

4. Quantitative Data

In this section, I describe the contexts under which the raw scores for the Phoneme Isolation, Verbal Fluency, and Letter Naming tasks were obtained. I use these results quantitatively for my study, as this facilitates comparisons with the phonological inventories from the Picture Naming Task and Semi-Directed Narrative. This approach also allows me to easily assess the individual performance of the participants across the different measures.

4.1 Phoneme Isolation

The researchers involved in the Penney study used a testing procedure compiled by Dr. Penney to assess phoneme isolation, a skill related to phonological awareness. Phoneme Isolation involves four separate tasks, all of which require the child to produce a segment contained within a monosyllabic stimulus word: Rimes, Onsets, Codas, and Vowels. Prior to the scored assessment, the researchers used a list of practice items for each task. They provided feedback to ensure that the children understood the instructions. The researchers orthographically or phonetically transcribed the responses, and audio-recorded each task to allow for post-hoc verifications of the child's pronunciations. If a child did not seem to understand the exercises or performed poorly on the Rimes, Onsets, and Codas tasks, the researchers used their own discretion to decide whether or not to proceed with the Vowels section.

For the Rimes task, the researcher instructed the child to produce the last part of each word, with the target response being the rime (e.g. *-ile* for *sm<u>ile</u>*). The rimes of the first half of the stimulus words consist of recognizable English words (e.g. *-old*, *-ate*, *-and*), while the other half consist of phonotactically possible but non-existent words (e.g. *-ope*, *-oot, -eme*). For the Onsets task, the researcher asked the child to say the first part of the word, producing a word without its rime (e.g. *gr-* for *<u>gr</u>een*). The Onsets stimuli consist of six words with simple onsets and six with complex onsets. For the CODAS task, the researcher prompted the child to say the last sound in each word, resulting in a singleton coda (e.g. [d] for *wi<u>de</u>*). Finally, for the VOWELS task, the researcher asked the child to isolate the middle sound of the word, producing the nucleus of the syllable (e.g. [iː] for *p<u>ee</u>k*).

As implied above, VOWELS was the only Phoneme Isolation task that was not completed by all of the participants in my study; for this reason, I chose to exclude this task from the current study. For each of the remaining Phoneme Isolation tasks, the score corresponds to the number of target responses that the child produced. The maximum score is 12 for RIMES and ONSETS and 18 for CODAS. For the three tasks combined, the highest possible score is thus 42.

In all of the Phoneme Isolation tasks, I considered partially correct responses and *don't know* responses as errors. For RIMES, I accepted all isolated rimes except: [eɪk] for *l<u>ate</u>* (**D11**); [ʊɫ] for *sm<u>ile</u>* (**T12**); [ɔft] for *fr<u>ost</u>* and [ʌnd] for *d<u>oes</u>* (**T17**); and [ʌɡz] for *d<u>oes</u>* (**D52**). For ONSETS, I counted all cluster errors as incorrect, including substitutions (e.g. [ɡwɪ] for *<u>gr</u>een*) and deletions (e.g. [s(ʌ)] for *<u>sk</u>ate*). I scored the results using a lenient interpretation of the vocalic elements that the children used to form their productions of isolated onset and coda consonants. I therefore accepted all correctly produced onsets followed by a vowel in the ONSETS scoring, including: [sɪ] for *<u>s</u>it*, [snæ] for *<u>sn</u>ack*, [ʧaɪ] for *<u>ch</u>ild* and [skeɪ] for *<u>sk</u>ate*. Recall that the children in my study have little to no schooling, and that many of them were not yet fluently literate at the time of testing. Given the children's limited literacy, it is important to consider how they can express their linguistic competence in a way that demonstrates their metalinguistic knowledge; this includes actively reflecting on and manipulating the sounds of their language.

Similarly, for ONSETS and CODAS, if the response was a letter instead of a sound, I marked it as correct, provided that the letter name was similar enough to the corresponding letter sound, or the letter response matched the correct part of the syllable for the task. For example, I accepted

C for *c*ough (**D37**, ONSETS), but I did not include *G* for *gr*and (**D37**, **T55**, ONSETS), *K* for *fog* (**D10**, CODAS) or *S* for *dish* (**D37**, **T44**, CODAS). I chose not to penalize children for voicing errors in Phoneme Isolation, since I am also not considering voicing contrasts as part of my phonological analysis (explanation provided in section 5 below).[3] The results of the Phoneme Isolation tasks, and how they relate to time in kindergarten, are presented in Chapter 4, section 3.

4.2 Verbal Fluency

This test, prepared by Dr. Penney, comprises two separate tasks which assess both vocabulary level and lexical retrieval abilities: Semantic Associations and Rhyming Words. Semantic Associations tests the ability to retrieve words within a particular semantic category; no prior training was necessary, as the requirements of the task are clear and it is an age-appropriate measure (see Ardila, Ostrosky−Solís & Bernal 2006). The three categories for Semantic Associations are FOOD, TOYS & GAMES, and ANIMALS. In contrast, Rhyming Words assesses the ability to recognize the rime part of a monosyllabic word and to retrieve other words which share the same rime, similar to Muter et al. (1997). The three stimuli for Rhyming Words are *hill*, *not*, and *day*. The researcher asked the child to name words that rhyme with the stimuli. For both Semantic Associations and Rhyming Words, the researcher presented each stimulus word and allowed 30 seconds for the child to produce as many relevant words as possible. One point was awarded for each appropriate response to the stimulus, yielding a raw score with no predetermined ceiling.

For my study, I scored the children on the number of appropriate responses to each Verbal Fluency category. I omitted duplicate and inappropriate responses from the calculation. Compound words and expressions such as *chicken noodle soup* (**T02**) and *plates for toy food*

3 Voicing contrasts were only present in CODAS, and accounted for less than 5% of all CODAS responses.

(**D09**) were counted as one response each. I use the raw scores to compare verbal fluency among participants in this study. Although the accuracy of the responses (the number of acceptable responses out of the total number of responses) may tell us something about the cognitive abilities of the children, this topic is beyond the scope of my study. I am therefore focusing only on the number of correct responses.

For Semantic Associations, the FOOD responses were judged as inherently edible or not. The only beverage mentioned was *milk* (**T18** and **T58**), which I accepted. For TOYS & GAMES, if the first response was *toys*, the researcher asked the child to elaborate; I therefore excluded *toys* for eight children (**D11**, **T18**, **T34**, **T44**, **D52**, **T65**, **T67**, and **T68**). I also did not count non-specific items such as *birthday party* or *go do fun things* (**T21**), as they are too vague. Finally, I excluded all animate entities such as *cats* (**D10**), *family* (**T12**), and *your friends* (**T21**). For ANIMALS, the responses were either clearly appropriate or invalid. I accepted all types of species from the animal kingdom (such as aquatic creatures, birds, reptiles, insects, and mammals), but not the words *person* (**D08**) and *elephant zoo keeper* (**D23**).

For the Rhyming Words stimuli *hill*, *not*, and *day*, I only included real words that rhymed with the stimulus words. Bisyllabic responses were acceptable, provided that they met these criteria. For example, *Advil* for *hill* (**T68**) was included, whereas the non-word *buh-lot* form for *not* (**D09**) was excluded. Finally, I did not include any repetitions of the stimulus words in the scores. I discuss the results of the Semantic Associations and Rhyming Words tasks, and how the scores relate to time in kindergarten, in Chapter 4, sections 4.1 and 4.2, respectively.

4.3 Letter Naming Accuracy

Letter Naming evaluates the ability to accurately identify all of the letters in the English alphabet. The letters are randomized and printed on a single letter-sized sheet of paper, with separate sheets for upper-case and lower-case letters. The researchers recorded the amount of time to complete each sheet. If the response was two possible answers or *don't know*, it was marked as incorrect. In Chapter 4, section 5.1, I discuss the relationship between the number of errors and time in kindergarten for upper-case and lower-case Letter Naming. *Letter Naming Total Accuracy* scores (the number of correct responses on both tasks out of a maximum of 52, multiplied by 100), are presented in Chapter 4, section 5.3.

4.4 Letter Naming Fluency

For *Letter Naming Fluency*, I reconfigured the Letter Naming scores into the number of letters correctly identified. I then calculated Letter Naming Fluency by dividing the number of correct responses by the number of seconds needed for the child to complete the task. Letter Naming Fluency is therefore the number of correct letters per second, with a higher number indicating higher fluency. For example, a child with a larger number of correct responses in a shorter amount of time (25 correct letters/45 seconds = 0.56) has a higher fluency score than a child who made more errors but in the same time (22 correct letters/45 seconds = 0.49). One implication of this method is that children with more errors can have higher fluency scores if they completed the task faster (22 correct letters/30 seconds = 0.73). I address Letter Naming Fluency and how it relates to time in kindergarten in Chapter 4, section 5.2. Finally, I report on the *Letter Naming Combined Fluency* scores in section 5.3 of the same chapter.

5. Phonological Production Data

To assess the phonological abilities of the children in my study, I used both a Picture Naming Task and a Semi-Directed Narrative; these data originate from the Hodson Assessment and the Frog Story in the Penney study, which I describe in sections 5.2 and 5.3 of the current chapter, respectively. I elaborate on the general transcription process for both of these assessments in section 5.1. The transcriptions from these assessments facilitated a detailed analysis of the children's phonological productive abilities, allowing me to identify systematic pronunciation patterns for each child.

In my analysis, I do not consider voicing errors. The perception of voicing contrasts produced by children can be rather challenging (Macken & Barton 1980). Without sophisticated recording equipment and systematic acoustic analysis of the data, it is difficult to impressionistically ascertain how much voicing is applied to a particular phonetic segment. For example, I incorporated voicing diacritics in my transcriptions, but it was difficult to establish whether a sound should be represented as a devoiced consonant (i.e. [b̥], [z̥]) or a voiceless consonant to which voicing had been added (i.e. [p̬], [s̬]). Shriberg & Kwiatkowski (1980) identify this issue and advise caution when transcribing voicing as, even for experienced transcribers, it can yield inconsistent results. Therefore, in the phonological inventories, I combined pronunciations that only deviate from the target in terms of voicing with the target pronunciations for each phoneme. For example, /k/ → [k]/[g] were both entered as correct responses for the phoneme /k/, while /g/ → [g]/[k] were both considered correct for the phoneme /g/.

5.1 Phonological Transcription

An undergraduate student in linguistics with extensive experience in phonetic transcription and I phonetically transcribed the recordings of the Hodson Assessment and the Frog Story. We completed the transcriptions using *Phon*, a software program that enables researchers to create detailed phonological transcription records and to perform in-depth analyses of phonological and acoustic patterns in speech production (Rose et al. 2006; Rose & MacWhinney 2014). When we could not reach a consensus on a pronunciation, I consulted the S-LP from the original Penney study. As illustrated in Figure 1 below, once we had completed the transcriptions, the final steps in preparing the files for analysis were to verify that the phones in the IPA Target (which represents the adult/model form) and IPA Actual (which represents the child's actual rendition of the form) were properly aligned and that the phones were associated with the correct syllable position.

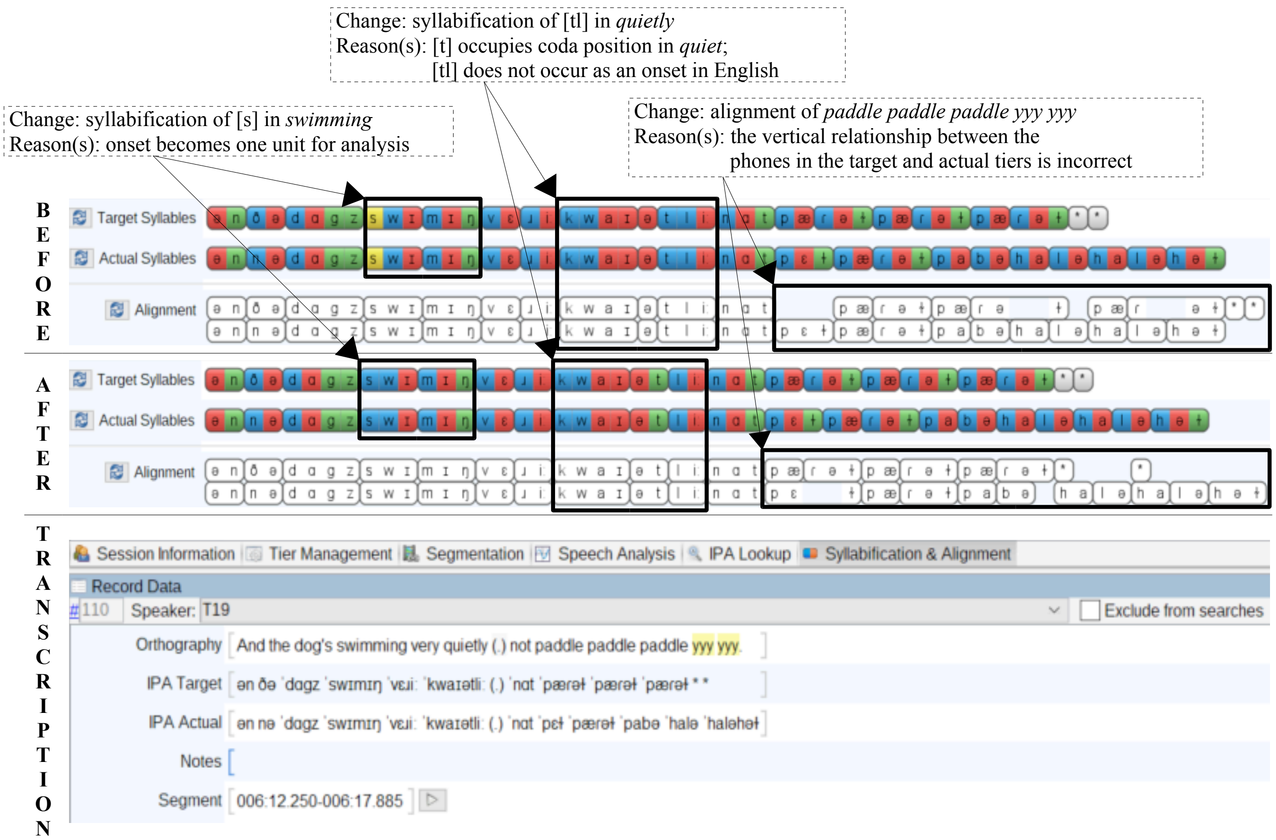

Figure 1. Adjustment of Syllabification and Alignment of Phonological Transcriptions

Proper syllabification and phone alignment are imperative since, to determine patterns of phonological production, Phon matches the sequences of sounds from the IPA Target tier with those in the IPA Actual tier. Provided that the speaker produces the sounds in the correct order, Phon will identify these sequences as target-appropriate pronunciations. It does not mean that the speaker did not make any errors within the word (specifically epenthesis); instead, this signifies that the sounds appear in the correct position. Phon will automatically report epenthesis only if it occurs within the sequence. For instance, in a query for branching onsets, Phon will identify [təɹæk] and [stɹæk] for *track* as tɹ↔təɹ and tɹ↔tɹ, respectively. To generate a specific report on epenthesis, a separate query is required.

I used the query functions in Phon to obtain a phonological inventory for each child. As displayed in Table 1 below, I conducted six queries for onsets and four for codas; these queries are divided by phonological position, both within the syllable and within the word. *Singleton* refers to a sequence comprising a single consonant, whereas a *branching* sequence contains two or more consonants. *sC cluster* is a specific type of onset consonant cluster comprising a sibilant, typically [s] in English, followed by one or two other consonants. In English consonant clusters, /s/ has the potential to violate sonority constraints within the syllable (Selkirk 1982; Clements 1990; Barlow 1997). sC clusters also exhibit different cluster simplification patterns in production from other branching onsets (Smit 1993b; Pater & Barlow 2003; Goad & Rose 2004). Given these considerations, I analyzed sC clusters and branching onsets using separate phonological queries.

Table 1. List of Phon Queries for Phonological Inventory

	Part of Syllable	
Syllable Position in Word	*Onset*	*Coda*
Initial	singleton branching sC cluster	---
Medial	singleton branching sC cluster	singleton branching
Final	---	singleton branching

Note: Onsets in the final syllable of a word were included in the medial query; likewise, codas in the initial syllable of a word were part of medial codas.

This concludes my description of the general procedures that I used for phonetic transcription and the phonological queries that I used for my analysis. I now turn to how I proceeded with my evaluation and scoring for the Picture Naming Task and the Semi-Directed Narrative, in sections 5.2 and 5.3, respectively. In section 5.4, I present the *weighted scoring* method that I used to interpret the Semi-Directed Narrative results.

5.2 Picture Naming Task

The Hodson Assessment of Phonological Patterns, Third Edition (HAPP-3) is a standardized test of speech sound production. It is used to identify errors in speech articulation that may indicate phonological and articulation delays or disorders. The stimuli used in the current study are pictures of words from the HAPP-3 Preschool Phonological Screening Record Form (see Table 2 below; the forms in brackets are the variations that I accepted as part of my study). In the Penney study, the researcher showed 12 separate photos to the child and asked them to identify each one. If the child was unfamiliar with the image or did not produce the target word, the researcher provided the correct word, prompting the child to repeat it. The audio recordings obtained for each child were then given to a licensed S-LP to identify any speech production issues.

Table 2. Hodson Assessment Stimuli (Arranged by Syllable Structure)

Singleton Onsets		Branching Onsets	Singleton Codas		Branching Codas	
boats	*rock*(*s*)	*glasses*	*glasses*	*spoon*	*boats*	(*rocks*)
fork	*soap*	*spoon*	*gum*	*star*	*fork*	(*stars*)
glasses	*watch*	*star*(*s*)	*leaf*	*watch*	(*gums*)	(*zippers*)
gum(*s*)	*zip*		*nose*	*zip*	(*leaves*)	
leaf(*s*)	(*zipper*(*s*))		*rock*	(*zipper*)		
nose			*soap*			

Note: Entries in brackets are variations of the Hodson Assessment stimulus words that I accepted for my study.

All of the children in my study attempted either the target form or a morphologically-related variant of the Hodson Assessment words. I accepted and transcribed all such variants for analysis. My analysis supplements the standardized methods of the Hodson Assessment by identifying the position of the segment within the syllable as well as the syllable position in the word. For my study, I refer to this assessment as the Picture Naming Task.

Of the five queries for consonants in medial position listed in Table 1, singleton onsets (medial) was the only phonological context that produced results for the Picture Naming Task. This was expected, as *glasses* and *zipper*(*s*) were the only bisyllabic words attempted in this task. Due to the overall limited number of pronunciations obtained from this task, I included sC clusters with branching onsets and I collapsed the data into the following phonological contexts:

Singleton Onsets: syllable-initial singleton consonants (word-initial and -medial)
Branching Onsets: syllable-initial consonant clusters (word-initial)
Singleton Codas: syllable-final singleton consonants (word-final)
Branching Codas: syllable-final consonant clusters (word-final)

I compiled the number of errors that the children made in each of these contexts and calculated the *Total Accuracy* using the formula in (1) below. *Attempts* represents the number of *sequences* that the child attempted in a given syllable position and does not necessarily correspond to the number of consonants that the child attempted (e.g. in *boats*, there is one attempt each for singleton onsets and branching codas). *Total Attempts* is the combined number of attempts from the four phonological contexts listed above. Similarly, *Targets* indicates the number of correctly-produced singleton or branching sequences, whereas *Total Targets* is the sum of the correctly-produced sequences from all four contexts.

(1) $$\textit{Total Accuracy}\,(\%) = \frac{\textit{Total Targets}\text{ (number of correctly produced consonants/clusters in all phonological contexts)}}{\textit{Total Attempts}\text{ (number of attempted consonants/clusters in all phonological contexts)}} \times 100$$

This approach provides a consistent basis of comparison, as it accommodates the possible variations of the target words that the children attempted in their actual productions.

With respect to scoring, I assigned a single error point regardless of whether the child made one or multiple errors in a particular sequence. For example, [gwɑk] for *r̠ock* (**D37**) contains both a substitution and consonant epenthesis, but only counts as one error in singleton onsets. Similarly, I counted consonant epenthesis as a single error if it was produced on its own (i.e. the sequence also did not contain any deletions or substitutions). In contrast, I did not consider cases of vowel epenthesis as errors, e.g. [ˈliːfɛ] (**D10**) and [ɡəˈlæsəz] (**D37**), as my analysis focuses on the children's pronunciations of the consonants in the stimulus words. I present the Picture Naming Task errors, as well as the Total Accuracy score for each child, in Chapter 4, sections 6 and 7, respectively.

5.3 Semi-Directed Narrative

The Frog Story is a semi-directed narrative of the wordless picture book *Frog, where are you*? (Mayer 1969). It allows children to narrate a sequence of events in a way that can be better structured than with a spontaneous narrative, which also requires access to personal memories (Goldman-Eisler 1964). *Frog, where are you*? (Mayer 1969) depicts the story of a boy, his dog, and his pet frog. The frog escapes from its jar, and the boy and his dog embark on a journey through a forest to retrieve the frog. In the Penney study, the researchers introduced the picture book and asked the child to describe what happens in each picture. The researchers audio-recorded the Frog Story and the same S-LP assessed the sound files to determine if the children had expressive delays or if they produced systematic phonological errors. In addition, the S-LP used Brown's stages of morphological development (Brown 1973) to establish if the participants' productions were age-appropriate.

The Frog Story (henceforth, the Semi-Directed Narrative) elicits a sample of the participants' connected speech. In this type of assessment, word boundaries are phonetically less defined than with isolated words, so the transcription process of the Semi-Directed Narrative therefore has special considerations that do not apply to the Picture Naming Task. For instance, among other phenomena, consonants may be resyllabified due to phonotactic constraints, i.e. the preference of syllables to have an onset rather than a coda (see Kahn 1976; Clements 1990). For this reason, I did not consider resyllabification of word-final codas to word-initial onsets as an error, provided that the phonological segments were articulated in the appropriate order. In comparison, if a coda was not articulated in a word followed by an onset with the same place and manner of articulation, such as *frog gets* and *he's sleeping,* I removed the coda from the IPA Target, so as not to penalize the child for the phonetic merger involved in these contexts.

With respect to deletions within the syllable structure, if the IPA Actual was the result of two phonological words connected in speech, we manually entered the orthography and the IPA Target to reflect the phonological shape of these connected speech forms (e.g. *got+on* was transcribed as /ˈɡɑɾɑn/ → [ˈɡɑn] (**D11**). I also removed phones from the IPA Target tier if a word was clearly incomplete due to *truncation* or *retracing*. This occurred when the child stopped abruptly in the middle of the utterance and either repeated part of the utterance, reformulated it, or continued with a distinctly new topic. Note that I did not include truncated syllables as part of my analysis, as the available data did not contain enough information to establish the cause of truncation (e.g. whether it relates to the child's lexical representation or if it is a production error that is caused by deficient motor skills; see Kehoe & Stoel-Gammon 1997).

On the phoneme level, /ŋ/ and its allophone [n] presented challenges in transcription. We transcribed the IPA Target as /ŋ/ for the coda in -*ing* words such as *looking*, *swimming*, and *chasing*. This includes *something*, for which the target form is /ˈsʌmθɪŋ/ for all children. The only exceptions were specific cases of *tryi<u>ng</u> to* and *tryi<u>ng</u>+to* (e.g. [ˈtɹaɪn tə] and [ˈtɹaɪnə])[4] and a single production of *looki<u>ng</u>* [ˈlʊkən] by **T21**,[5] for which I entered the -*<u>ng</u>* target as /n/. The reason for this choice is that I did not have sufficient information to establish whether the variations in /ŋ/ productions were sociolinguistic in nature or related to issues in phonological production, a question which also falls outside the current scope of this study. Given these limitations, I considered /ŋ#/ → [n] (where # indicates a word boundary) as a target response for all of the children in my study; however, I retained forms like *swimmi<u>ng</u>* [ˈswɪn] (**D43**) as errors, since the syllable structure is also affected. In addition, I excluded the following forms from my analysis, due to their variable status in Newfoundland and Labrador English: /ð/ and /h/ in both initial and medial singleton onsets and /ɾ/ in medial singleton onsets.[6] In summary, every time a prescriptive transcription of the target forms could unnecessarily underestimate a speaker's phonological abilities, I chose not to base my analysis on this prescriptive marking.

In the Semi-Directed Narrative, 11 children did not produce any words with word-medial branching onsets. The remaining children made between one and four attempts at these clusters in this position. I therefore merged all branching onsets into a single category. Similarly, 20 children made 11 or less attempts at word-medial singleton codas, so I merged all singleton codas. Due to the low frequency of occurrence of sC cluster productions in my data, I removed this context from my analysis.

Branching codas (medial and final combined) were more frequent, with 14 to 75 cluster attempts per child; however, this context contained a large variety of target forms that were attempted by relatively few children.[7] This is understandable, given that the number of possible

---

4 These forms occur in adult speech; since /ŋ/ precedes an alveolar, it is more likely to be produced with this place of articulation.
5 The child was impersonating the little boy using a character voice.
6 For more information on this dialect, Newfoundland and Labrador English, see Clarke (2010a,b).
7 25 of the 41 CC targets and 12 of the 13 CCC targets were attempted by five or less participants.

consonant combinations in English creates an expansive inventory of branching codas (see Hultzén 1965). This creates challenges for drawing comparisons among the children's productions. The analysis of branching codas in production is further confounded by the acquisition of derivational and inflectional morphology. Morphological development was not overtly tested as part of the Penney study, and the nature of its relationship with phonological production lies beyond the scope of my thesis. I therefore excluded all attempts at branching codas from my analysis. In summary, my analysis of the Semi-Directed Narrative is limited to the following phonological contexts:

Singleton Onsets (Initial):	syllable-initial singleton consonants (word-initial)
Singleton Onsets (Medial):	syllable-initial singleton consonants (word-medial)
Branching Onsets:	syllable-initial consonant clusters (word-initial and -medial)
Singleton Codas:	syllable-final singleton consonants (word-medial and -final)

For each child, I calculated the *Total Accuracy* separately for these phonological contexts, using the formula in (2) below. Total Accuracy provides a measure of overall consonant proficiency and does not include epenthesis. If all consonants present in the words attempted by the child are produced in the correct sequence, the score will be 100%.

(2) $$\mathit{Total\ Accuracy}\,(\%) = \frac{\mathit{Total\ Targets}\,(\text{number of correctly-produced consonants in a given phonological context})}{\mathit{Total\ Attempts}\,(\text{number of attempted consonants in a given phonological context})} \times 100$$

I also used the same formula to calculate the children's accuracy scores for consonant sound classes (oral stops, fricatives/affricates, nasals, liquids, and glides) for singleton sequences and consonant position within the segment (C1, C2) for branching onsets; for these component values, I use *Attempts* and *Accuracy* to differentiate them from the overall scores (Total Attempts and Total Accuracy) in each phonological context.

The results from the Semi-Directed Narrative are available in Chapter 4, sections 9 and 10. In the next section, I describe the method that I used to convert the Semi-Directed Narrative Total Accuracy scores into *weighted scores*.

5.4 Semi-Directed Narrative: Weighted Scores

The children's accuracy scores for each phonological context are useful in determining the proportion of correctly produced consonants; however, accuracy alone creates challenges for a comparative analysis of the different phonological contexts. Most importantly, accuracy is heavily influenced by productivity; for instance, a child who makes one error out of two attempts at a given phone has the same accuracy score as another child who makes 50 errors out of 100 attempts. In addition, if a child does not make any attempts in a context, this creates a gap in the data.

In order to address these issues, I converted the Total Accuracy scores for each child individually using the proportion of consonants attempted by the child in each phonological context. I present this weighted scoring method schematically in Table 3 below, followed by a fabricated example. In the example, the superscript numbers represent the number of correctly produced consonants for that specific phonological context. For simplicity, I have rounded the Total Accuracy and weighted score values to whole numbers. Note that the example illustrates the procedure for a single participant.

Table 3. Semi-Directed Narrative Weighted Scores Method

	Phonological Context				
Method	Singleton Onsets (Initial)	Singleton Onsets (Medial)	Branching Onsets	Singleton Codas	Total
Total Attempts	A	B	C	D	T = A + B + C + D
Weight	$E = \frac{A}{T}$	$F = \frac{B}{T}$	$G = \frac{C}{T}$	$H = \frac{D}{T}$	W = E + F + G + H 1.00
Total Accuracy (%)	I	J	K	L	
Weighted Score	M = E x I	N = F x J	O = G x K	P = H x L	
Example	Singleton Onsets (Initial)	Singleton Onsets (Medial)	Branching Onsets	Singleton Codas	Total
Total Attempts	$70^{(64)}$	$30^{(28)}$	$20^{(20)}$	$80^{(72)}$	$200^{(184)}$
Weight	0.35	0.15	0.10	0.40	1.00
Total Accuracy (%)	91	93	100	90	
Weighted Score	32	14	10	36	

To obtain the weighted scores, I first tallied the number of consonants attempted in each phonological context, yielding the *Grand Total* (T) of all consonants attempted. I then divided the Total Attempts for each phonological context by the Grand Total to obtain the corresponding *weight*; as a *proportion*, the weight controls for differences caused by higher and lower productivity. Finally, I multiplied the weight by the Total Accuracy to obtain the weighted score for each phonological context. I present the weighted scores in Chapter 4, section 11.

This completes the data entry and analysis components of my methodology. In the next section, I describe the methods that I used to compare the scores of the Phoneme Isolation, Verbal Fluency, and Letter Naming tasks with the participants' phonological production data from the Picture Naming Task and Semi-Directed Narrative.

6. Comparative Analysis

As shown in Table 4 below, the comparative analysis part of my study primarily involves a matrix of correlations among the 10 scores obtained for each child. Considering the relatively small sample size of the current study, I used the *Spearman correlation* for my statistical analysis. This method compares the *rankings* of scores instead of the scores themselves, allowing me to effectively compare the consistency of each child's performance across all of the measures, while eliminating the influence of potential outliers.

Table 4. Summary of Correlations for Comparative Analysis

		Phoneme Isolation	Verbal Fluency		Letter Naming		Picture Naming Task	Semi-Directed Narrative Weighted Score[a]			
		Combined Score	Semantic Associations	Rhyming Words	Total Accuracy	Combined Fluency	Total Accuracy	SingON (Initial)	SingON (Medial)	BranchON	SingCO
Phoneme Isolation	Combined Score	---	---	---	---	---	---	---	---	---	---
Verbal Fluency	Semantic Associations	✔	---	---	---	---	---	---	---	---	---
	Rhyming Words	✔	✔	---	---	---	---	---	---	---	---
Letter Naming	Total Accuracy	✔	✔	✔	---	---	---	---	---	---	---
	Combined Fluency	✔	✔	✔	✔	---	---	---	---	---	---
Picture Naming Task	Total Accuracy	✔	✔	✔	✔	✔	---	---	---	---	---
Semi-Directed Narrative Weighted Score	SingON (Initial)	✔	✔	✔	✔	✔	✔	---	---	---	---
	SingON (Medial)	✔	✔	✔	✔	✔	✔	✔	---	---	---
	BranchON	✔	✔	✔	✔	✔	✔	✔	✔	---	---
	SingCO	✔	✔	✔	✔	✔	✔	✔	✔	✔	---
Legend:		✔	Assessments for Current Study			--- (shaded)	Same Measure		---	Duplicate Correlation	

[a]SingON = singleton onsets, BranchON = branching onsets, and SingCO = singleton codas.

The Spearman correlation starts by ranking the scores on a scale of 1 to *n*, where *n* is the total number of scores or subjects and also represents the highest possible rank. Conversely, the rank of 1 is reserved for the lowest score in the sample. For repeated scores, the rank positions are averaged and this value becomes the new ranking for each of these duplicate scores. All non-repeated scores retain their original rankings. For example, consider the rankings [1], [2], [3], [4], [5], where ranks 3 and 4 represent identical scores. The rankings of the tied scores will be adjusted to 3.5 and the rank order will now be [1], [2], [3.5], [3.5], [5]. The rankings are then compared using a *Pearson correlation*, which produces the final Spearman correlation coefficient, r_s. Spearman correlation values range from $r_s = 0$ to $r_s = 1.00$, signifying no relationship and a perfect linear relationship, respectively (Gravetter & Wallnau 2009). Finally, while the value indicates the strength of the correlation, the *direction* identifies the nature of the relationship between variables. A positive relationship indicates that an increase in the value of one variable corresponds to an increase in the other variable; as the value of one variable decreases, so does that of the other variable. If two variables are negatively correlated, one value increases as the other decreases, and vice versa (Dörnyei 2007).

For my comparative analysis, I used *R*, a statistical computing program (R Core Team 2017), to generate the Spearman correlation matrix. I entered all accuracy and weighted scores with one decimal place, and Letter Naming Fluency with two decimal places. Note that these are single correlations only and that I did not correct for multiple testing. For a sample size of $n = 26$, the critical values of the Spearman correlation coefficient are: $r_s = 0.390$ ($p = .05$); $r_s = 0.501$ ($p = .01$); and $r_s = 0.619$ ($p = .001$) (Zar 1972). To reach a given level of significance, r_s must be equal to or greater than the critical value for that confidence interval (Gravetter & Wallnau 2009). In my analysis, I report the highest confidence interval for each statistically significant correlation. I use $p < .05$ as the confidence interval for statistical significance, which is the standard in social science research (Dörnyei 2007). This level of confidence indicates that 5% or less of the correlation can be due to chance; the remaining part of the correlation, which is 95% or greater, is attributed to the relationships among the variables (Gass 2010). I discuss the results of the comparative analysis in Chapter 4, section 12.

This completes the methodology chapter of my thesis. In the next chapter, I present the results and analysis of my research.

Chapter 4: Results and Analysis

1. Introduction

In this chapter, I present the results and analysis of the data used in my study. I begin with the S-LP's qualitative assessment of language development in section 2. I then introduce the data obtained from the original Penney study (recall Chapter 3, section 4). These results appear in the following order: Phoneme Isolation, Verbal Fluency Semantic Associations, Verbal Fluency Rhyming Words, Letter Naming Errors, Letter Naming Fluency, and Letter Naming Total Accuracy and Combined Fluency, presented in sections 3 through 5.3. With respect to the phonological production data (recall Chapter 3, section 5), I discuss the findings of the Picture Naming Task in sections 6 through 8, and I explore the Semi-Directed Narrative results in sections 9 through 11. Finally, in section 12, I assess the results of the comparative analysis (recall Chapter 3, section 6); in this final section, I use statistics to examine the relationships among the children's scores on each of the measures.

I also present the Phoneme Isolation, Verbal Fluency, and Letter Naming scores with respect to the children's relative school ages, measured as *time in kindergarten (months)*, which corresponds to the month in which the child was assessed. July prior to starting kindergarten is -2 and August before kindergarten is -1. The numbering resumes at 0 for September, and increases by one with each subsequent month, ending with 9 for June. There is no further distinction for days within the month (i.e. May 1st and May 30th were both counted as *May*). Note that all bar graph and scatterplot figures presented below were generated using the chart functions in LibreOffice Calc, and that overlapping points, which occur when children share the same scores in a given month, appear as a single entry in the scatterplots. In the event that a child required multiple sessions to complete all sections of a task, I selected the month that represents the mid-point of the dates. This was only necessary for Phoneme Isolation and Verbal Fluency, but was more common with the former due to the increased complexity of the task; the time between the components of these assessments generally did not exceed eight days.[8] The averaged ages of the children at the time of the five assessments are depicted in Figure 2.

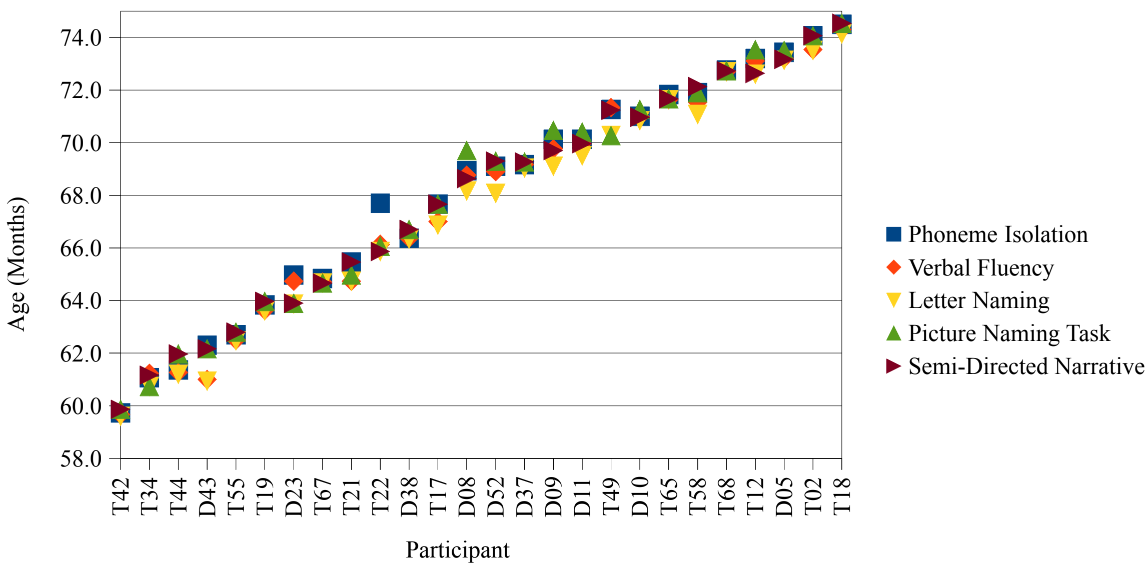

Figure 2. Age of Participants at Time of the Assessments

As we can see from this figure, the children typically completed all of the assessments for the current study within one to two months or less.

2. Qualitative Assessment of Language Development

In this section, I provide a summary of the individualized qualitative language assessments from the Penney study. I highlight the S-LP's assessment notes in Table 5 below, which I have organized in order of the participants with the most to the least serious concerns. In this assessment, N/C signifies 'no concerns' as well as 'age-appropriate language skills'.[9]

8 The only exceptions were **D09** and **T22** with Phoneme Isolation. For **D09**, April 10 and May 1 averaged as *April*; **T22**, who was assessed on three separate days between August and November, was entered as *October*.

9 This includes speech errors that are suitable for a child's particular stage of development (Brown 1973).

Table 5. Speech-Language Pathologist's Assessment of Language Development

	Picture Naming Task	Semi-Directed Narrative	
Participant	*Phonology Summary*	*Phonology Summary*	*Language Summary*
D10	Rhotic and lateral gliding	Overall imprecise articulations, /d/ → [g] in *dog* (item-specific)	Difficult to assess
D43	Rhotic gliding	Rhotic gliding	N/C
D37	Rhotic and lateral gliding (inconsistent from one production to the next); /ɹ/ and /l/ are emerging, and not yet mastered	Some rhotic gliding	N/C
D23	Occasional gliding of /l/ and /ɹ/, not consistent	Mild gliding, /l/ and /ɹ/ quite stable	N/C
D52	Occasional rhotic gliding	Occasional inconsistent rhotic gliding; /ɹ/ not quite mastered	N/C
D08	N/C	Mild gliding of lateral /l/ Mild interdental stopping: /θ/ and /ð/ → [d]	Resonance Very mild stuttering Some mild problems with past tense and auxiliary verbs
D09	N/C	/θ/ → [f] Occasionally, minor sound prolongations and minor blocking Imprecise articulations in rapid speech, some lateral gliding	N/C
D05	Slight rhotic gliding	Slight rhotic gliding	N/C
D38	Some cluster reduction	Some imprecise articulations Speech runs together	N/C
D11[a]	N/C	Occasional rhotic gliding	N/C
No concerns/Age-appropriate skills: T02, T12, T17, T18[a], T19, T21, T22, T34, T42, T44, T49, T55, T58, T65, T67, T68			

[a]The researchers were told that these children have L1 influences other than English; more specific information, including which language and the amount of exposure that the children had to these languages, is not available.

Of the 10 children with specific phonological and/or speech production concerns, **D08** is the only child for whom the S-LP listed stuttering as a concern. Stuttering, which is related to neurological functions and motor control rather than phonological processes per se (see Wolk, Edwards & Conture 1993), is outside the scope of the current study; for this reason, I did not consider stuttering as part of the ranking. Similarly, **T22** produced some incomplete sentences in the Semi-Directed Narrative, but the S-LP did not identify any phonological production issues. Since my focus does not extend to syntax, I included **T22** among the children without concerns.

D05 has slightly glided productions of /ɹ/, but the S-LP indicated that it is closer to [ɹ] than the [w] glide. The S-LP also noted that the cluster reduction by **D38** during the Picture Naming Task may be due to obstruction caused by hands in the mouth (the researcher indicated this in the recording), as cluster reduction was not apparent in this child's Semi-Directed Narrative. I have therefore ranked **D05** and **D38** among the children with the least concerns.

Table 6 below groups the children according to age at the time of the Semi-Directed Narrative assessment. The three major divisions are meant to represent six-month intervals in between 5;0 and 6;5; however, the oldest child was 6 years 2 months at the age of testing. As with time in kindergarten (recall section 1), these indicate the year and months, with no further breakdown for days in the month. As we can see from this table, seven children who exhibited disordered speech patterns were between the ages of 5;6 and 5;11, while **D23** and **D43** were in the youngest age group. **D05** was the only child in the older group who was included among those with suspected speech disorders.

Table 6. Participant Age at the Time of the Semi-Directed Narrative

	Age			
	4;11	5;0-5;5	5;6-5;11	6;0-6;2
Participant(s)	T42[a]	D23, D43, T19, T21, T22[b], T34, T44, T55, T67	D08, D09, D10, D11, D37, D38, D52, T17, T49, T65	D05, T02, T12, T18, T58, T68

[a]T42 was 4;11.26 at the time of this assessment. [b]T22 was 5;05.26 at the time of this assessment.

Finally, note that **T22**'s age borders between the two age groups; given that the majority of this child's assessments occurred prior to entering kindergarten, I consider **T22** to be on the higher end of the younger age group.[10] This concludes my summary of the S-LP's qualitative language assessment. In the next section, I present the scores that the children obtained on the phoneme isolation test.

10 With the exception of Phoneme Isolation (mentioned above), the testing ages for **T22** appear as 5;5 and 5;6.

3. Phoneme Isolation

In this section, I report on the results from the Phoneme Isolation tasks (Rimes, Onsets, and Codas). I also examine the relationship between the combined Phoneme Isolation scores and time spent in kindergarten (refer to Appendix A for the scores sorted by participant). As Figure 3 below illustrates, the combined Phoneme Isolation scores vary widely, ranging from 2 to 37. The number of correct responses for each task ranges from 0 to 11 for both Rimes and Onsets, and 0 to 18 for Codas.

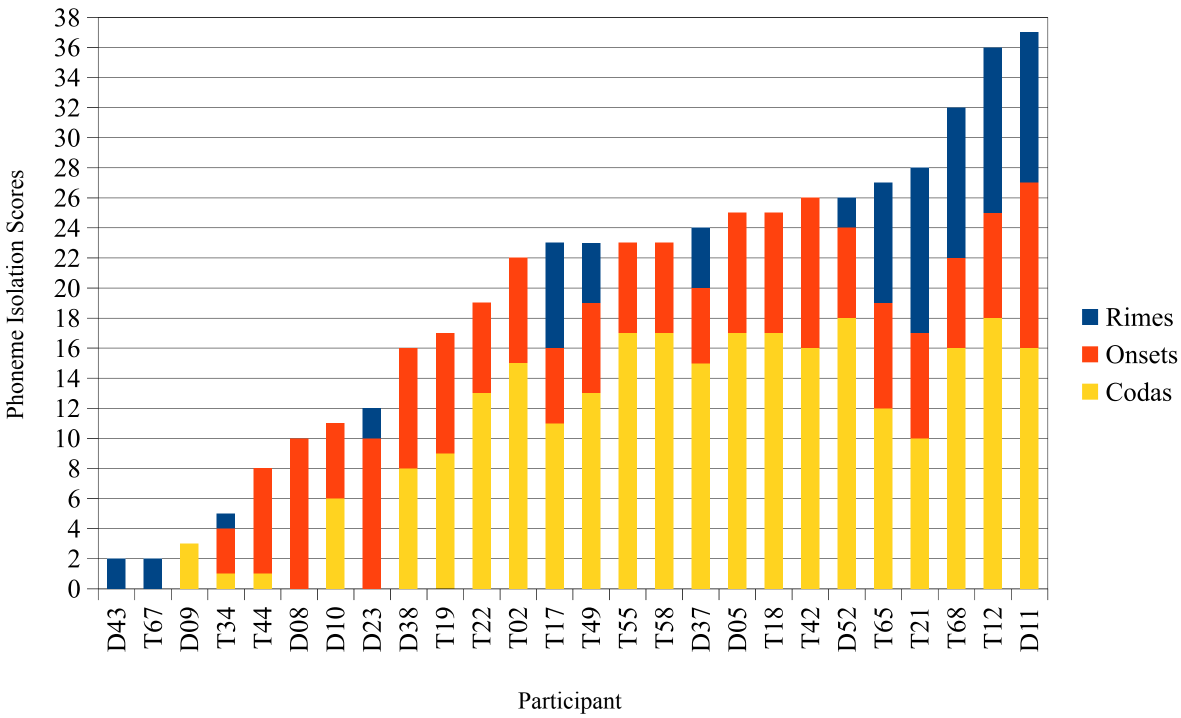

Figure 3. Phoneme Isolation Combined Scores

As a group, the children have the lowest scores for Rimes, with half of the children receiving a score of 0. In contrast, the children have considerably higher scores for Codas, with 18 children scoring 8 or higher. Four of the children only provided correct responses for one task each: **D43** and **T67** (Rimes), **D08** (Onsets), and **D09** (Codas). Consequently, their scores are among the lowest overall.

As shown in Figure 4 below, a small positive relationship exists between the Phoneme Isolation scores and the duration of time spent in kindergarten. As a group, the overall score increases by approximately one point for every month.

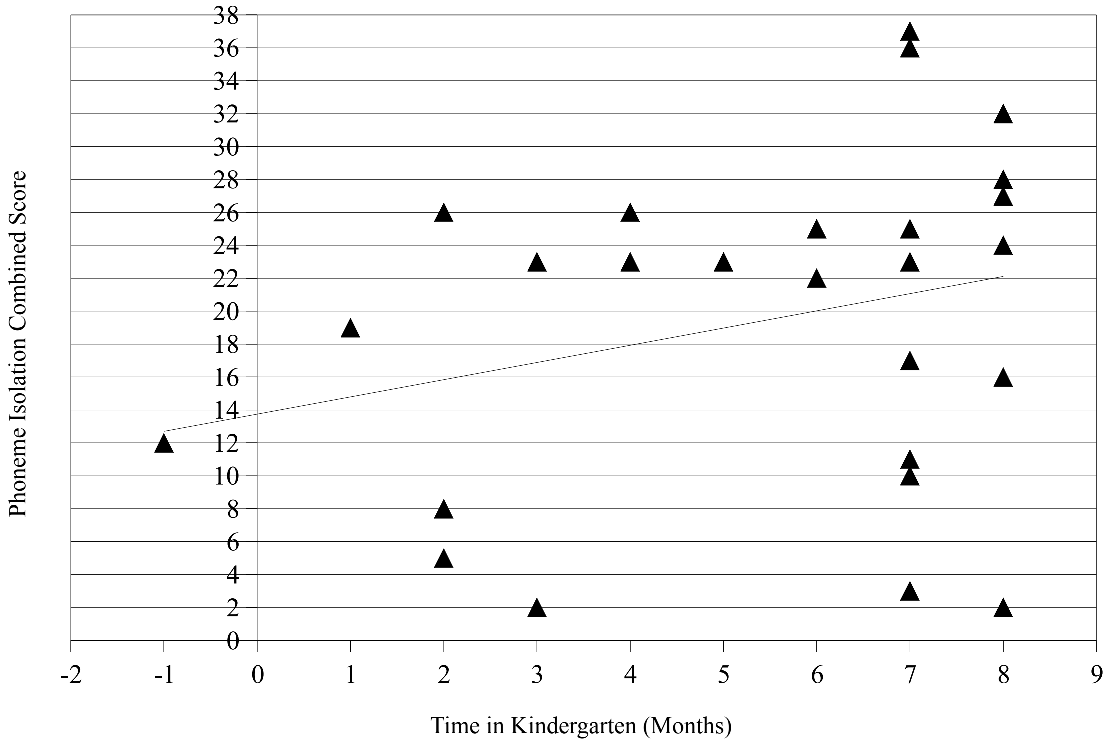

Figure 4. Phoneme Isolation vs. Time in Kindergarten

With respect to the three speaker groups, the relationship among the Phoneme Isolation Combined scores, suspected speech disorder, and age is depicted in Figure 5 below. As we can see in this graph, the 11 children with scores below 20 tend to be those who were considered speech-disordered and/or were younger in age at the time of testing. **T22**, who scores 19 overall, is the only child in the older age group whose score is below this value; however, if this child had completed the Rimes tasks at the same time as the other tasks (i.e. when the child was older), the overall score would have potentially been higher.[11]

11 Recall that the assessment date for Rimes was three months earlier than both Onsets and Codas, and that this child did not produce any correct responses for Rimes.

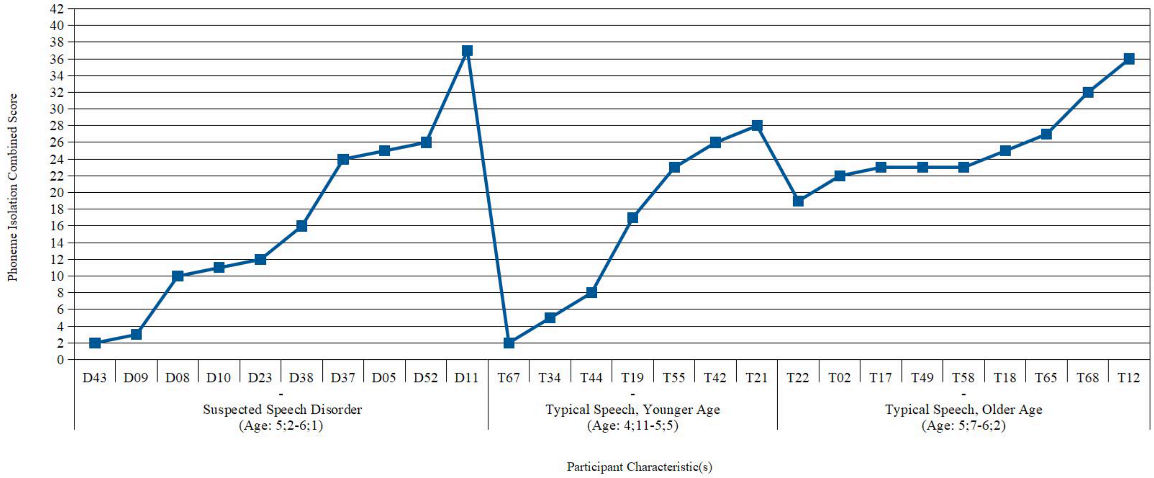

Figure 5. Phoneme Isolation vs. Suspected Speech Disorder and Age

In comparison, four of the children who exhibited disordered speech patterns (**D05**, **D11**, **D37**, and **D52**) and three of the younger children with typical speech (**T21**, **T42**, and **T55**) score above 20. In summary, although lower scores are associated with suspected speech disorders and younger age, other factors (e.g. individual differences and understanding of the task instructions) also appear to influence performance on this assessment.

This completes my presentation of the Phoneme Isolation results. In the next section, I discuss the children's scores from the Verbal Fluency assessments.

4. Verbal Fluency

In this section, I provide the results from the two Verbal Fluency tasks. I discuss Semantic Associations and Rhyming Words separately, in sections 4.1 and 4.2, respectively. I also explain how these scores relate to time in kindergarten. Finally, in section 4.3, I discuss the relationships between the Verbal Fluency results, suspected speech disorder, and age.

4.1 Semantic Associations

The combined scores for Food, Toys & Games, and Animals range from 11 to 27 (see Figure 6 below). The number of responses within each category ranges from 3 to 11 for Food, 1 to 7 for Toys & Games, and 2 to 11 for Animals. Toys & Games generally appears to have been the most difficult semantic category for the children.

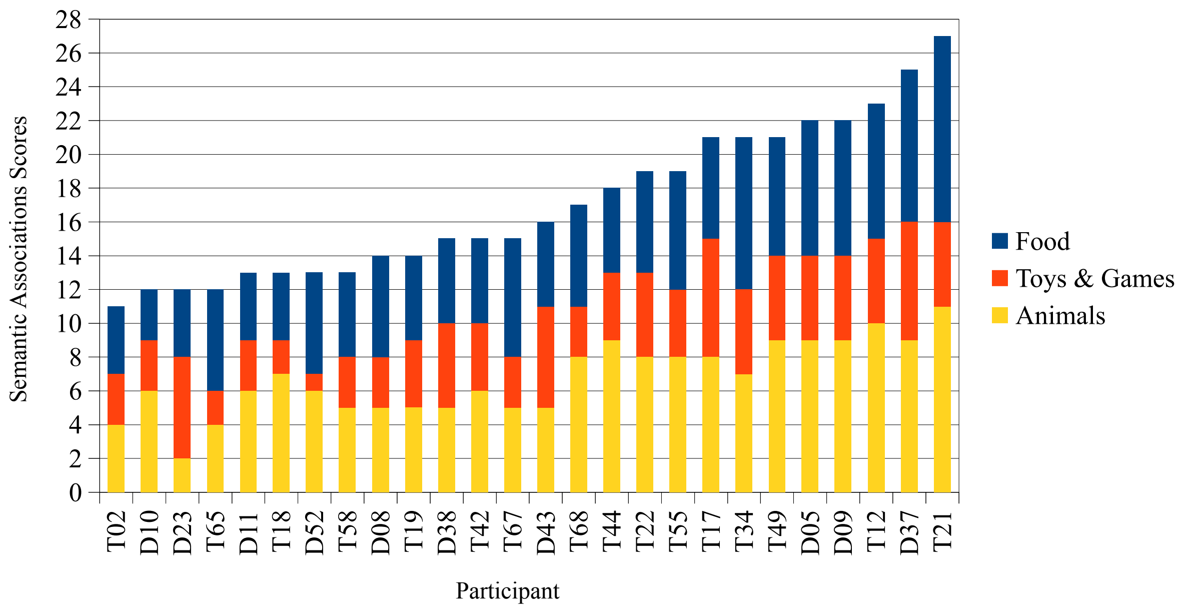

Figure 6. Verbal Fluency Semantic Associations Combined Scores

Figure 7 below illustrates the relationship between the children's Semantic Associations total scores and how long the children had been attending kindergarten. Overlapping data points occur at four, seven, and eight months (see Appendix B for scores sorted by participant).

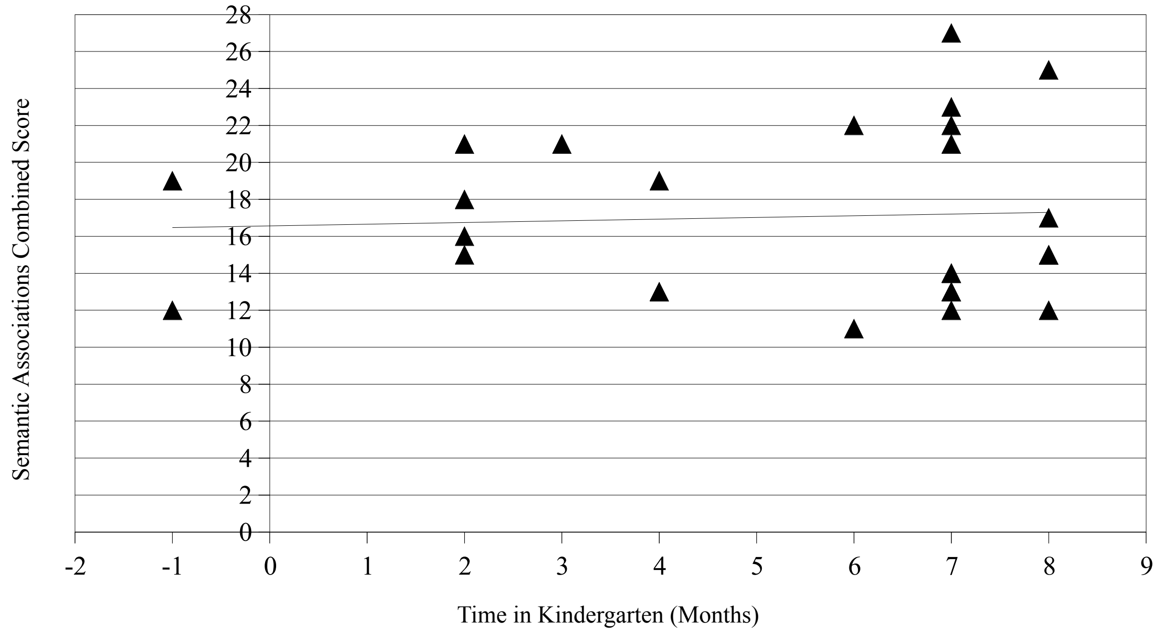

Figure 7. Verbal Fluency Semantic Associations vs. Time in Kindergarten

The slope of Figure 7 suggests that time in kindergarten has little effect on the number of Semantic Associations responses that the children provided.

4.2 Rhyming Words

The results for Rhyming Words appear in Figure 8 below. The scores range from 0 to 14, and are distinctly lower than those of the Semantic Associations task. The total number of accepted words per child ranges from 0 to 6 for *hill*, 0 to 5 for *not*, and 0 to 7 for *day*. **D10** responded with *don't know* for all three categories, and therefore has an overall score of 0. **D11** and **T21** are the only children to score 0 in a single category, for *hill* and *not*, respectively. Figure 8 shows that **D11** is in the middle range of the scores for both *not* and *day*, but consequently has a lower overall score. Similarly, although **T21** has one of the highest number of responses for *hill*, the low scores for *not* and *day* result in a lower overall score.

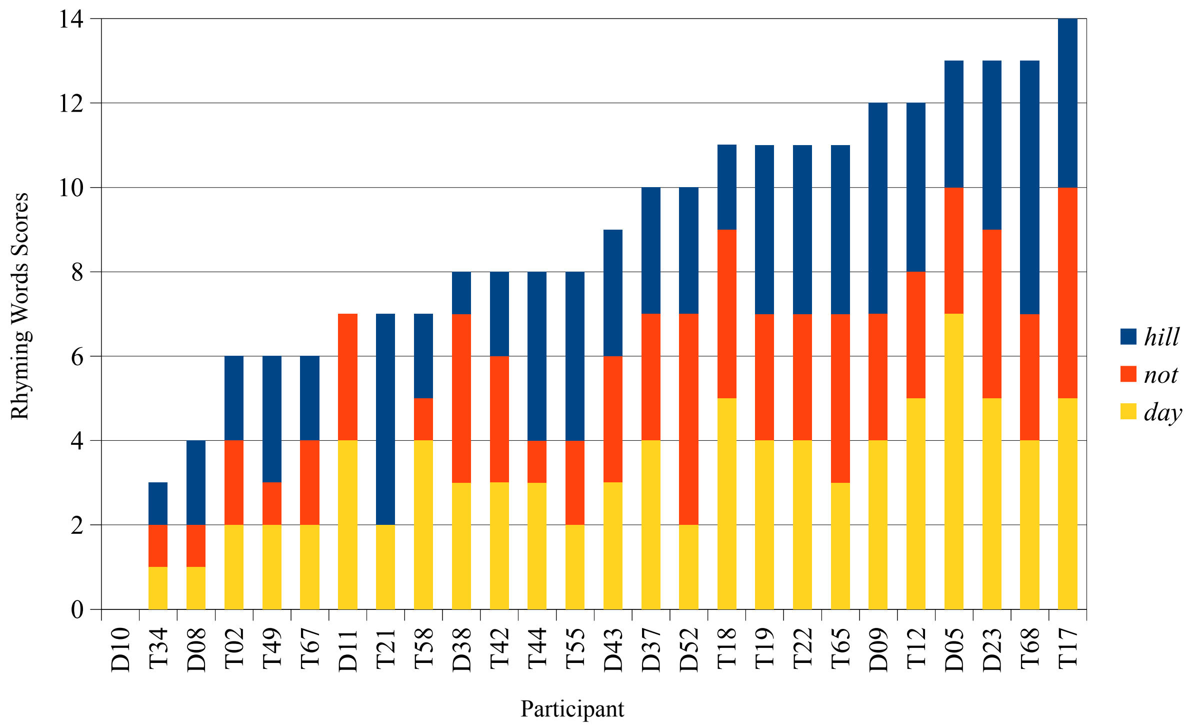

Figure 8. Verbal Fluency Rhyming Words Combined Scores

Figure 9 below suggests that no clear relationship exists between Rhyming Words and time in kindergarten. This result mirrors that of the Semantic Associations task. Furthermore, the correlation between Rhyming Words and time in kindergarten is weaker than with Semantic Associations. Note that Figure 9 has overlapping points at both two and seven months (see Appendix B for individual scores).

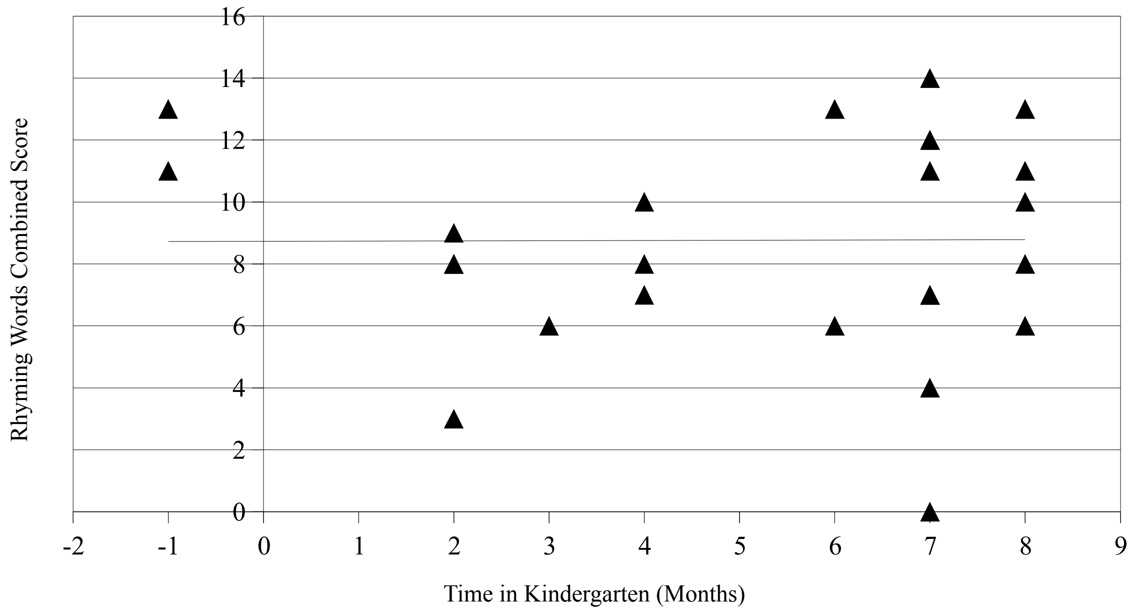

Figure 9. Verbal Fluency Rhyming Words vs. Time in Kindergarten

As we can see in Figure 10 below, while neither of the two Verbal Fluency tasks relates to the amount of time in kindergarten, Semantic Associations and Rhyming Words are, in fact, related to each other.

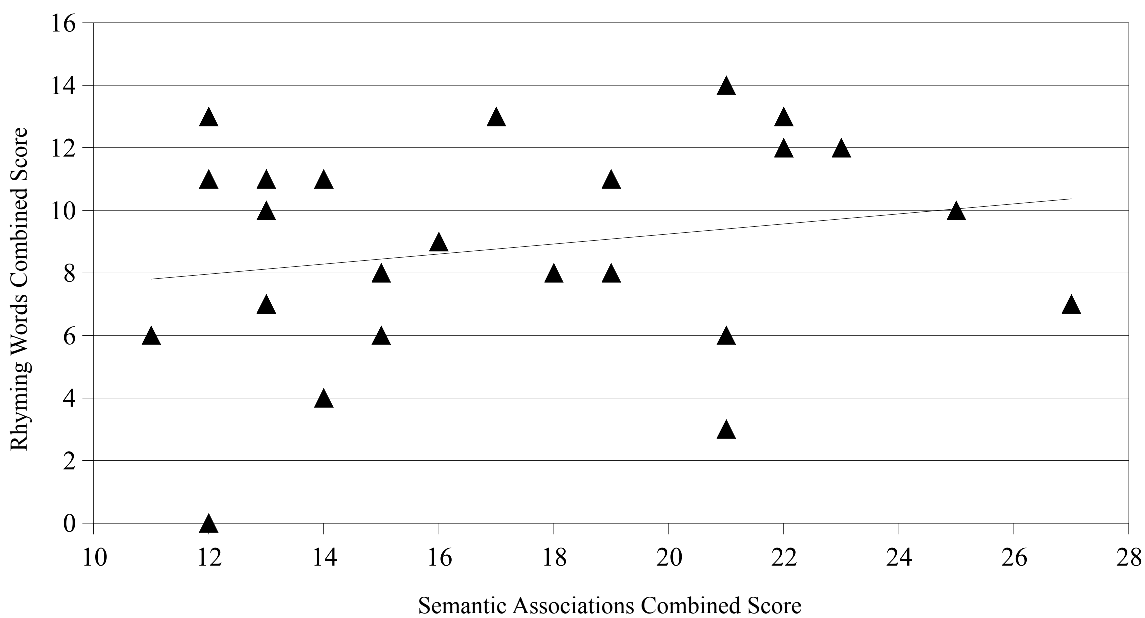

Figure 10. Verbal Fluency Semantic Associations vs. Rhyming Words

Although the correlation between the Semantic Associations and Rhyming Words scores is small (r_s = 0.22, *ns*), it still points to the existence of a relationship between these two types of lexical retrieval. In this graph, two overlapping points appear where the children scored 13 and 15 in Semantic Associations.

This completes my discussion of the results from the two Verbal Fluency tasks. Next, I report on the ambiguous relationships among the overall Verbal Fluency scores, suspected speech disorder, and participant age.

4.3 Combined Scores and Qualitative Language Assessment

The Verbal Fluency Semantic Associations scores for all of the children who were considered speech-disordered, as well as the younger and older children with typical speech, appear in Figure 11 below. As with Phoneme Isolation (recall section 3), the children in each of these three speaker groups are arranged by increasing score.

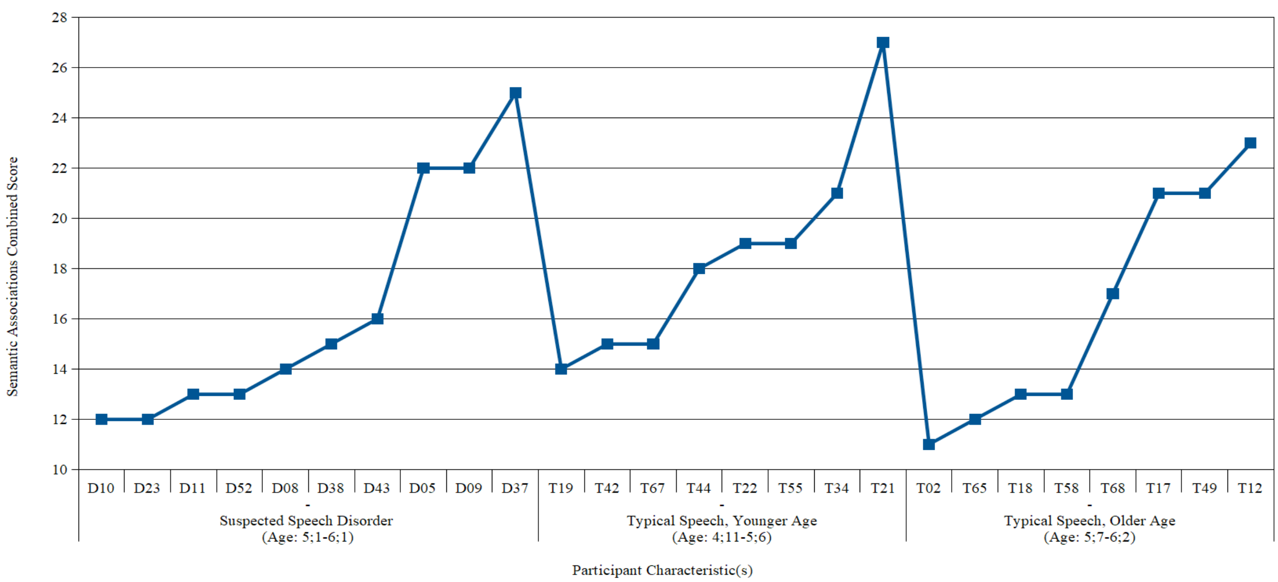

Figure 11. Verbal Fluency Semantic Associations vs. Suspected Speech Disorder and Age[12]

12 **D43**'s age at the time of testing was 5;00.30 for Verbal Fluency and 5;00.28 for Letter Naming; in both cases, this value is rounded to 5;1 to more precisely represent the age range of the suspected speech-disordered group.

As this graph illustrates, seven of the children who were considered speech-disordered achieve comparably lower scores on this assessment; however, this is also true of three younger and four older children with typical speech. These results therefore do not offer any clear indication that speaker group is directly related to the Semantic Associations scores.

Similarly, as shown in Figure 12 below, the magnitude of the scores for Rhyming Words does not clearly pattern with either suspected speech disorder or child age.

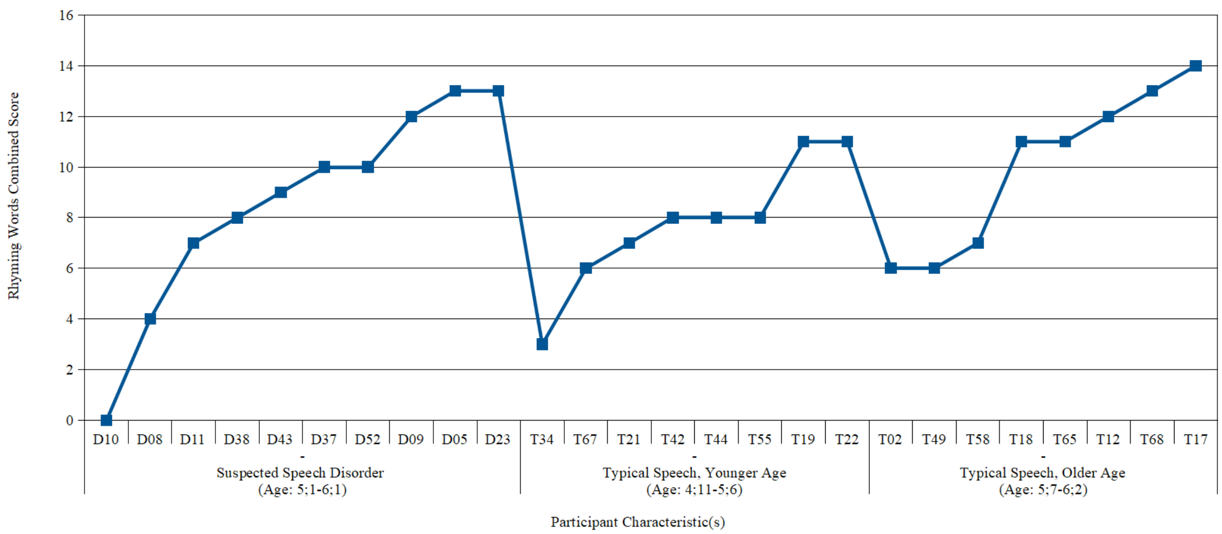

Figure 12. Verbal Fluency Rhyming Words vs. Suspected Speech Disorder and Age

As we will see in section 12, the absence of relationships between the Verbal Fluency scores and speaker groups is also reflected by a general absence of significant correlations between Verbal Fluency and the other measures considered.

This concludes my discussion of the Verbal Fluency results. In the next section, I discuss the findings from the upper-case and lower-case Letter Naming tasks.

5. Letter Naming

In this section, I discuss the results for both Letter Naming tasks. I first present the children's raw upper-case and lower-case Letter Naming scores, and how they relate to time in kindergarten, in section 5.1. The raw scores for each participant are provided in Appendix C. In section 5.2, I address the Letter Naming Fluency scores and their relationship with time in kindergarten. Finally, in section 5.3, I provide a summary of the Letter Naming Total Accuracy and Combined Fluency scores and the nature of their relationship.

5.1 Letter Naming Errors

The number of upper-case Letter Naming errors is illustrated in Figure 13 below. As a group, the children performed well on upper-case Letter Naming, with 18 of the 26 participants making no letter identification errors. The other eight children made between one and four errors each.

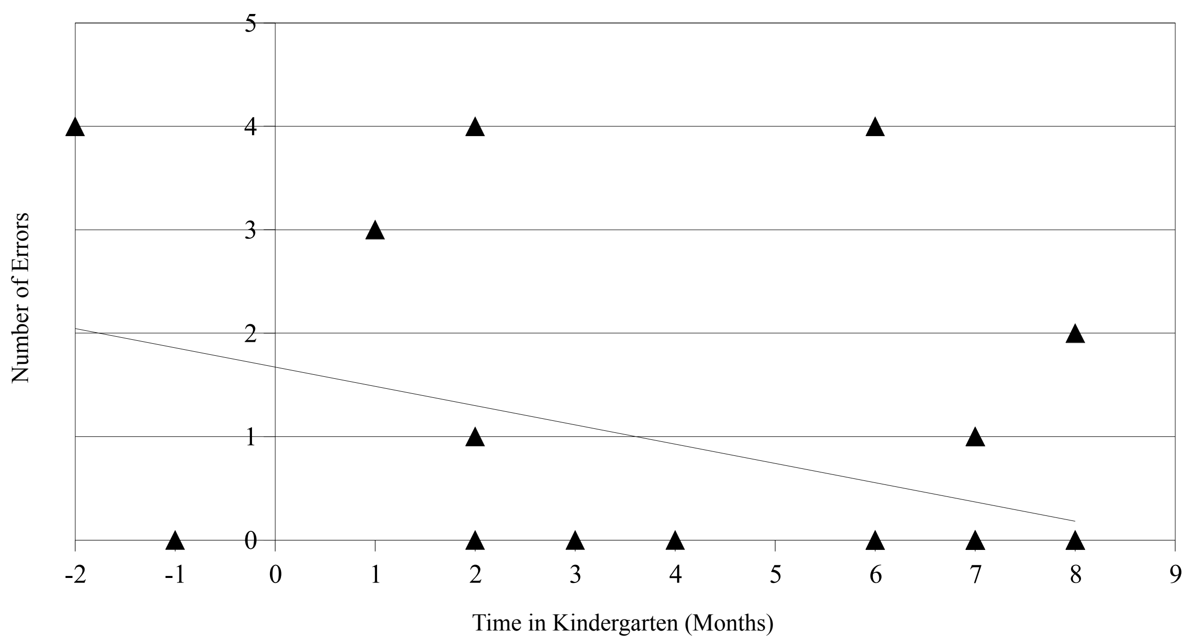

Figure 13. Upper-case Letter Naming Errors vs. Time in Kindergarten[13]

A closer look at these children reveals that, in general, those who spent more time in kindergarten made fewer errors; specifically, as a group, the number of errors decreases by one for approximately every 5.3 months spent in kindergarten. Participants **D09** and **T67** made the most

13 Note that 16 of the 18 children who score 0 overlap within five data points. In addition, two children made one error at seven months.

errors toward the end of kindergarten and are therefore the least proficient of the group at upper-case Letter Naming.

In general, the children made more errors in lower-case than in upper-case Letter Naming, with half of the 26 children making between zero and three errors. As shown in Figure 14 below, this creates a decreasing trend in error patterns over time which is more visible than in upper-case Letter Naming.

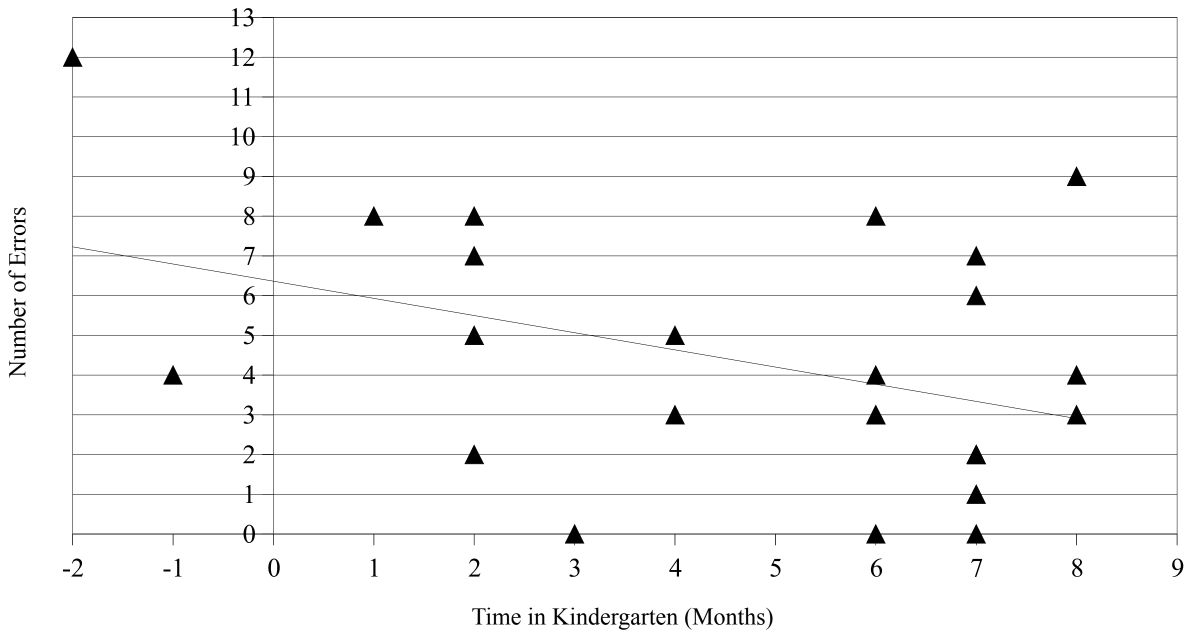

Figure 14. Lower-case Letter Naming Errors vs. Time in Kindergarten

As a group, the children make one fewer error for approximately every 2.3 months in kindergarten. Figure 14 only contains two overlapping points, which each correspond to three children.

This completes my overview of the children's Letter Naming errors. In the next section, I consider these scores with respect to the duration of time in which these tasks were completed.

5.2 Letter Naming Fluency

I now consider the measure of Letter Naming Fluency. Recall from Chapter 3, section 4.4 that this score signifies the number of correct letters that the child produced per second. As displayed in Figure 15 below, a positive correlation exists between upper-case and lower-case Letter Naming Fluency.

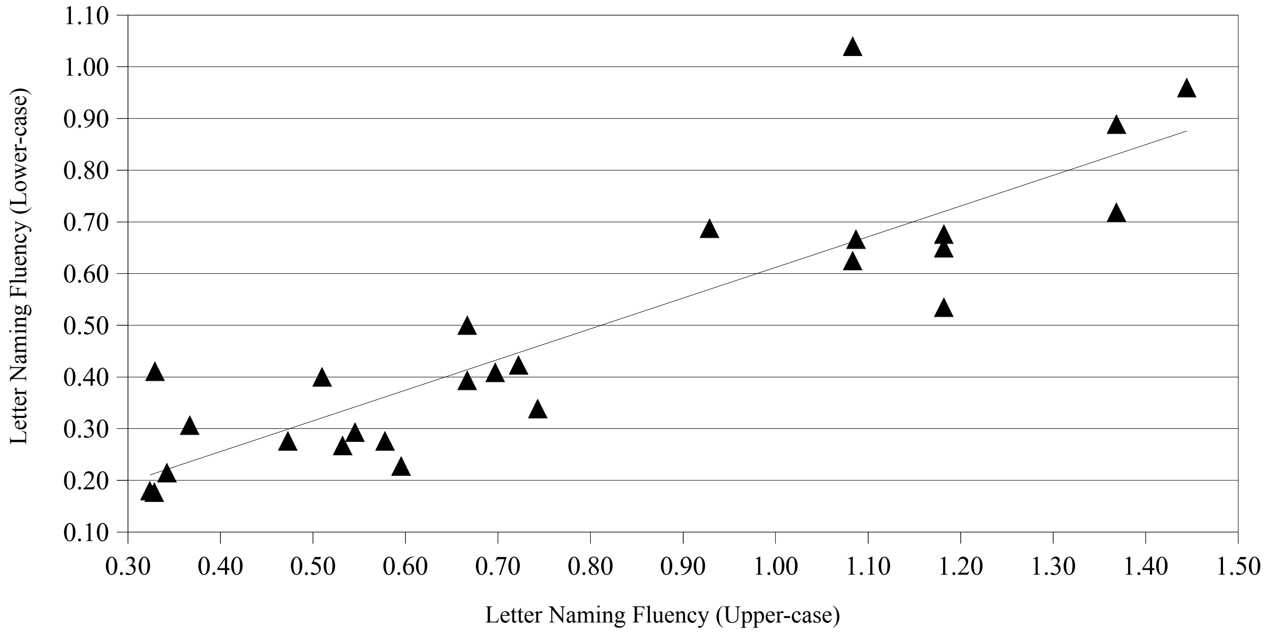

Figure 15. Upper-case vs. Lower-case Letter Naming Fluency

The strength of this correlation ($r_s = 0.86$, $p < .001$) suggests that the upper-case Letter Naming Fluency score is a good predictor of lower-case Letter Naming Fluency. Since the children in this study produced consistent rates with both upper-case and lower-case Letter Naming Fluency, I combined these values for the comparative analysis (see Table 7, page 50 below).

Figure 16 below shows that Letter Naming Fluency scores positively correlate with the amount of time spent in kindergarten. As a group, Letter Naming Fluency increases by approximately 0.10 correct letters/second for every month in kindergarten.

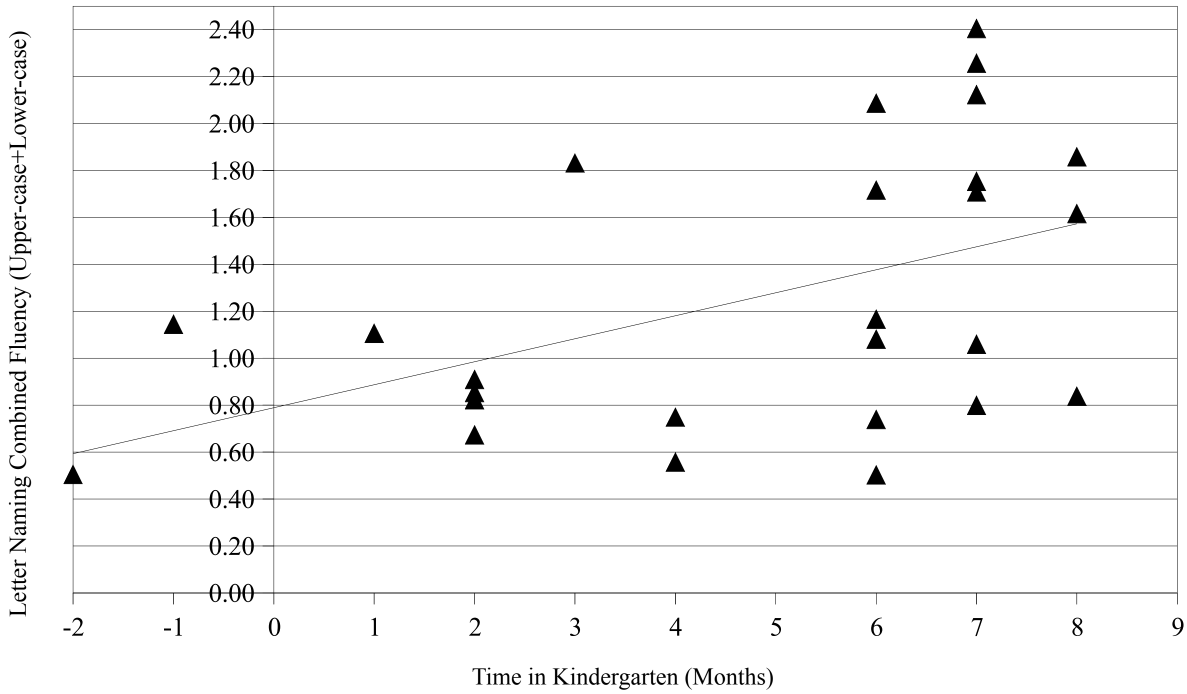

Figure 16. Letter Naming Combined Fluency vs. Time in Kindergarten

In summary, although the children in this study made more errors in lower-case than upper-case Letter Naming, the scores for both tasks suggest that more time in kindergarten is related to fewer letter identification errors. Similarly, Letter Naming Combined Fluency also improves with more time in kindergarten.

This completes my discussion of the separate errors and fluency scores for upper-case and lower-case Letter Naming. In the next section, I present an aggregated version of these results.

5.3 Letter Naming Total Accuracy and Combined Fluency

The Letter Naming Total Accuracy and Combined Fluency scores appear in Table 7 below. As shown in this table, the scores range from 69% to 100% for Total Accuracy and 0.50 to 2.40 correct letters/second for Combined Fluency. The seven children whose Letter Naming Total Accuracy is 85% or lower also tend to have comparatively lower Letter Naming Combined

Fluency scores; for example, six of these children are also among those with the ten lowest Combined Fluency scores. In comparison, of the children whose Letter Naming Total Accuracy is above 95%, only **D10** and **T44** are in the bottom half of the group for Letter Naming Combined Fluency scores.

Table 7. Letter Naming Total Accuracy and Combined Fluency

Participant	Months in Kindergarten	Total Accuracy (%)	Combined Fluency (correct letters/sec.)	Participant	Months in Kindergarten	Total Accuracy (%)	Combined Fluency (correct letters/sec.)
D09	6	77	0.50	T34*	1	79	1.11
D23	-2	69	0.51	T22*	-1	92	1.15
T55*	4	94	0.56	D11	6	100	1.17
T42*	2	79	0.67	T68+	8	92	1.62
T02+	6	94	0.74	D38	7	98	1.71
T58+	4	90	0.75	D05	6	94	1.72
T19*	7	85	0.80	T17+	7	87	1.75
T49+	2	83	0.82	D52	3	100	1.83
T67*	8	79	0.84	T65+	8	94	1.86
D43	2	90	0.85	T12+	6	94	2.09
T44*	2	96	0.91	T18+	7	100	2.12
D10	7	96	1.06	D37	7	96	2.26
D08	6	92	1.08	T21*	7	96	2.40

Note: Children with suspected speech disorders were approximately between the ages of 5;1 and 6;1.
*Children with typical speech, younger ages (4;11-5;5).
+Children with typical speech, older ages (5;6-6;2).

The numerical values in this table, as well as the linear relationship depicted in Figure 17 below, indicate that Letter Naming Total Accuracy and Combined Fluency are related; however, even though both measures contain the number of letters correctly identified and the correlation is significant ($r_s = 0.64$, $p < .001$), a large amount of variance still can not be explained by the relationship. This suggests that individual differences likely contribute to the contrasts among the children's scores on these measures (i.e. a hesitant child may have a higher accuracy score but lower fluency score). In addition, children with suspected speech disorders (ages 5;1 to 6;1), younger children with typical speech (ages 4;11 to 5;5), and older children with typical speech (ages 5;6 to 6;2) appear to be distributed rather randomly in Table 7. In effect, these results fail to offer any clear indication that suspected speech disorder or age are related to the Letter Naming Total Accuracy and Combined Fluency scores.

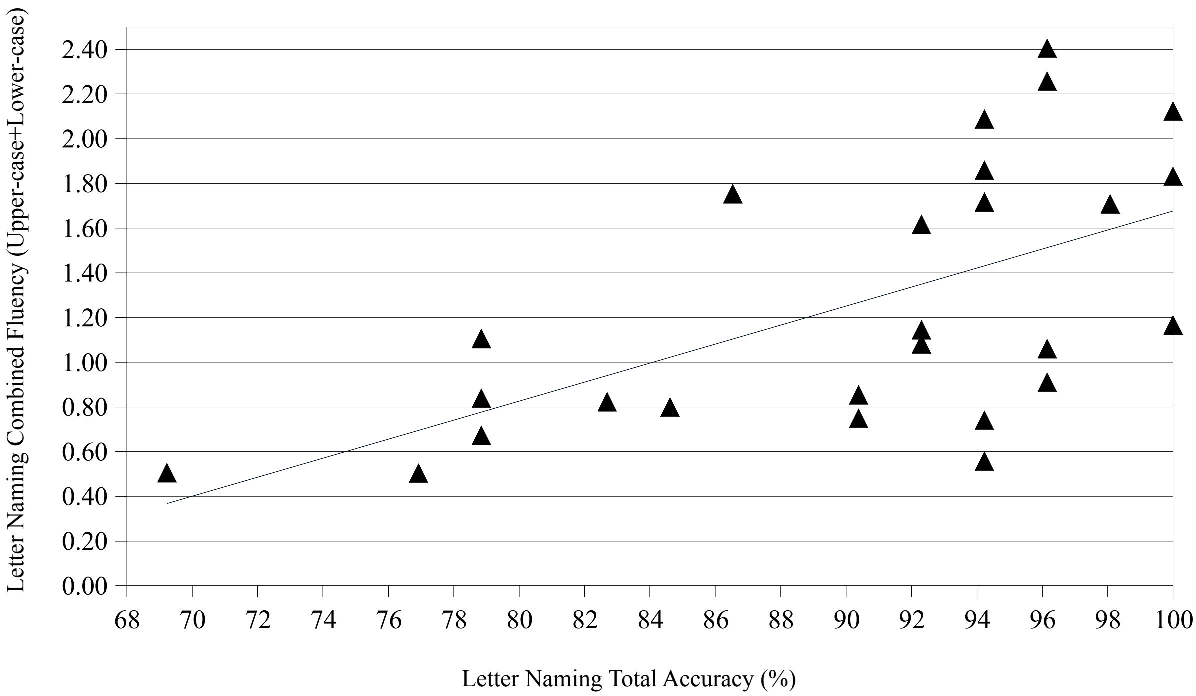

Figure 17. Letter Naming Total Accuracy vs. Combined Fluency

This concludes the quantitative scores portion of the results. In the following sections, 6 through 11 inclusive, I report on the findings of the phonological production tasks, and how these scores relate to the S-LP's assessments introduced in section 2.

6. Picture Naming Task

In this section, I discuss the results of the Picture Naming Task. I present the qualitative errors of each participant for singleton onsets, branching onsets, singleton codas, and branching codas, in sections 6.1, 6.2, 6.3, and 6.4, respectively.

6.1 Picture Naming Task: Singleton Onsets

The target words for singleton onsets in syllable-initial position are *boats*, *fork*, *gum(s)*, *leaf(s)*, *nose*, *rock(s)*, *soap*, *watch*, and *zip/zipper(s)*. In syllable-medial position, the targets are *glasses* and *zipper(s)*. **D10**, **D37**, and **D43** are the only participants who made multiple singleton onset errors. **D10** is the only child who made an error for [b] in *boats;* this child spirantized the onset, producing [f]. Three children substituted [f] in *fork* with an oral stop: [p] (**T22** and **D38**) and [t^w] (**D43**). The only child with an error for [l] in *leaf* is **T18**, who produced [b]. For [z] in *zip(per)*, **D43** and **T55** produced [ʦ] and [l], respectively. The children made the most errors for [ɹ] in *rock(s)*, which are all labialized responses: [ʍ] by **D10**, [gw] by **D37**, and [w] by **D43** and **D52**. In comparison, none of the children made substitution errors for [n] in *nose*, [s] in *soap*, [w] in *watch*, and [p] in *zipper(s)*. Finally, the only error in syllable-medial singleton onsets was by **T02**, who produced [θ] in *glasses*.

Five children produced consonant epenthesis in syllable-initial singleton onsets and **D37** is the only child with two cases of epenthesis. Recall from Chapter 3, section 5.2 that epenthesis and substitution in the same position only count as a single error, so [t^w] for *fork* (**D43**) and [gw] for *rock* (**D37**) are already accounted for in the substitutions. The other instances of epenthesis involve the insertion of a single consonant, and count as one error each. For [f] in *fork*, **T34** and **D37** both produced [fw]. For [w] in *watch*, both children epenthesized before the singleton onset: [gw] (**D23**) and [bw] (**T67**).

6.2 Picture Naming Task: Branching Onsets

Of the children in my study, only seven made errors when producing the following branching onsets: [gl] in *glasses*, [sp] in *spoon*, and [st] in *star*; in total, this amounts to eight errors. **D43** is the only child who made two branching onset errors. The most errors occurred with [gl] in *glasses*, with four different productions: [l] (**D08**), [gɹ] (**D23**), [d] (**D38**), and [gw] (**T49**). **D43** is the only child who made an error in the onset of *spoon*, by substituting [sp] with [tv]. Three children made errors in *star*: [s] (**T19**), [ʃ] (**D43**), and [d] (**T55**). Overall, the children did not specifically make any of the same errors in production, although there are common error types. I classify these errors as: 1) *C1 deletion*, the deletion of the first consonant in the cluster ([l] in *glasses* and [d] in *star*); 2) *C2 substitution*, the substitution of the second consonant in the cluster ([gɹ] and [gw] in *glasses*); and 3) *CC error*, the production of both consonants in the cluster in error, ([d], [tv], and [ʃ] in *glasses*, *spoon*, and *star*, respectively). Note that CC errors also include cases of *fusion*, whereby the cluster is reduced to a single phone containing a mixture of features from both elements of the target cluster (i.e. place from one consonant and manner from the other one; for example, /gl/ → [d] in *glasses*). **T19** is the only child who produced *C2 deletion*, the deletion of the second consonant in the target cluster ([s] for [st] in *star*).

6.3 Picture Naming Task: Singleton Codas

The stimulus words for word-final singleton codas are *glasses*, *gum*, *leaf*, *nose*, *rock*, *soap*, *spoon*, *star*, *watch*, and *zip*/*zipper*. The errors with singleton codas are presented in Table 8 below. There were no errors with the [z] coda in *glasses* and all of the 16 children who produced *rock* articulated the target [k] coda. For the singleton codas in *gum*, *leaf*, and *soap*, only one segmental error was made by **D43**, **T44**, and **T34**, respectively. The most errors are for [n] in *spoon,* five of which are deletions (**D08**, **D09**, **T34**, **T44**, and **T67**) and two result in oral stops (**D11** and **D23**). Similarly, most of the errors for coda [ɹ] involved deletion. **D23**, **D43**, and **D52** only deleted the [ɹ] coda. In contrast, **D05** and **D37** both manipulated the vowel in addition to deleting the coda in *star*; **D05** repeated the vowel [ɑ^ɑ], whereas **D37** lengthened the vowel [ɑː].[14] Finally, **D10** produced a substitution in the form of the diphthongized vowel [aʊ].

Table 8. Picture Naming Task Singleton Coda Segmental Errors

Stimulus Word	*gum*	*leaf*	*nose*	*soap*	*spoon*	*star*	*watch*	*zip*	*zipper*
Target IPA / Participant	[m]	[f]	[z]	[p]	[n]	[ɹ]	[ʧ]	[p]	[ɹ]
T02							[t^{h}]	ʔ	
D05						Ø			
D08					Ø				
D09					Ø				
D10						[ʊ]			
D11					[d]				
D23					[p]				Ø
T34			[θ]	[f]	Ø				
D37						Ø			
D38			[d]						
D43	Ø								Ø
T44		[z]			Ø			[f]	
D52						Ø	[t^{h}]		
T67			[f]		Ø				

Epenthesis in singleton codas primarily involved denasalization, with an oral release following the nasal singleton coda. Four children produced this type of epenthesis in *gum* (**D10**) and in *spoon* (**T42**, **T49**, and **T68**), which I did not count as errors. The other case of epenthesis was by **T34**, who added [ɫ] before spirantizing the /p/ in *soap*, resulting in the complex coda [ɫf]; this error is already included with the substitutions.

14 The symbol ^ indicates an intra-word pause.

6.4 Picture Naming Task: Branching Codas

The branching coda targets are [ts] in *boats*, [ɹk] in *fork*, [mz] in *gums*, [vz] in *leaves*, [ks] in *rocks*, and [ɹz] in *stars* and *zippers*. **D11**, **T22**, **T58**, and **T12** are the only children who attempted *gums*, *leaves*, *stars*, and *zippers*, respectively; all of these children produced the target codas. Similarly, the 10 children who produced the plural *rocks* all achieved the target [ks] complex coda.[15] The most frequent error occurred with the [ts] in *boats*; nine children deleted the second consonant in the cluster. Of these children, **T12**, **T21**, **T65** had this C2 deletion as their only error in the entire Picture Naming Task. Finally, **D10**, **D37**, and **D38** deleted the rhotic portion of the cluster in *fork* (C1 deletion), whereas **D23** labialized the continuant [wk] (*C1 substitution*, the substitution of the first consonant in the cluster).

7. Picture Naming Task Total Accuracy and Summary

In general, the children made more errors affecting singleton consonants than errors affecting clusters, in both onset and coda position; however, as shown in Table 9 below, the number of attempts at singleton consonants for each child was substantially higher than the number of attempted clusters. The children also made fewer errors in onsets than codas, for both singleton consonants and clusters. **T17**, **T42**, **T58**, and **T68** are the only children who did not make any segmental errors in the Picture Naming Task. In contrast, **D37**, **D38**, and **D43**, three of the children who have the lowest overall accuracy scores, are the only ones who made errors in both the onset and the coda of the same word ([ˈfwɑk] for *fork*, [ˈpɔəg] for *fork*, and [ˈʦɛpɔ] for *zipper*, respectively).

15 The children who produced *gums*, *leaves*, *rocks*, *stars*, and *zippers* all have three or more attempts at branching codas in Table 9 below.

Table 9. Picture Naming Task Errors by Position in the Syllable

	Phonological Context								Total		
	Singleton Onsets		Branching Onsets		Singleton Codas		Branching Codas				
Participant	Attempts	Errors	Attempts	Errors	Attempts	Errors	Attempts	Errors	Attempts	Errors	Accuracy (%)
D43	11	3	3	2	10	2	2	1	26	8	69
D23	11	1	3	1	10	2	2	2	26	6	77
D10	10	2	3	0	9	1	3	1	25	4	84
D37	10	2	3	0	10	1	2	1	25	4	84
D38	10	1	3	1	10	1	2	1	25	4	84
T34	11	1	3	0	10	3	2	0	26	4	85
T67	11	1	3	0	9	2	3	1	26	4	85
T02	10	1	3	0	9	2	3	0	25	3	88
T44	10	0	3	0	10	3	2	0	25	3	88
D52	10	1	3	0	10	2	2	0	25	3	88
T55[a]	9	1	2	1	9	0	2	0	22	2	91
D11	10	0	3	0	9	1	3	1	25	2	92
D08	11	0	3	1	9	1	3	0	26	2	92
D09	11	0	3	0	10	1	2	1	26	2	92
T49	11	0	3	1	9	0	3	1	26	2	92
D05	10	0	3	0	9	1	3	0	25	1	96
T18	10	1	3	0	10	0	2	0	25	1	96
T19	10	0	3	1	10	0	2	0	25	1	96
T21	10	0	3	0	9	0	3	1	25	1	96
T12	11	0	3	0	8	0	4	1	26	1	96
T22	11	1	3	0	9	0	3	0	26	1	96
T65	11	0	3	0	9	0	3	1	26	1	96
T17	10	0	3	0	9	0	3	0	25	0	100
T42	10	0	3	0	10	0	2	0	25	0	100
T58	10	0	3	0	9	0	3	0	25	0	100
T68	11	0	3	0	10	0	2	0	26	0	100

Note: The variation in number of attempts reflects the morphological forms that each child attempted to produce.
[a]T55's pronunciation of glasses was ambiguous, so I excluded it from the analysis. This child consequently has one less attempt each for singleton onsets, branching onsets, and singleton codas.

For singleton onsets, **D10**, **D37**, and **D43** are the only children who made multiple errors, and **D23**, **T34**, **D37**, **D43**, and **T67** are the only children who produced epenthesis; these children all have a Total Accuracy score of 85% or lower. With respect to branching onsets, **D43** produced the only *CC substitution* error, and has the lowest Total Accuracy score. All of the other children's errors for branching onsets involved cluster simplification (C1 deletion or C2 deletion) or C2 substitution. Finally, concerning singleton codas, the most common error produced was deletion (i.e. [n] in *spoo<u>n</u>* and [ɹ] in *sta<u>r</u>*/*zippe<u>r</u>*). **T34** and **T44**, who both made three errors, were the least accurate in their productions of singleton codas. In the next section, I discuss how the Total Accuracy scores from this assessment relate to suspected speech disorder and age at the time of testing.

8. Picture Naming Task and Qualitative Language Assessment

The S-LP identified 10 children with speech issues and/or language concerns (recall section 2). As shown in Table 10 below, six of these children have Total Accuracy scores below 90% for the Picture Naming Task; **D23** and **D43**, who have the lowest scores, were also in the youngest age group. The other four children that the S-LP identified have Total Accuracy scores above 90%; they were included among the children with less serious concerns. An additional four children, **T02**, **T34**, **T44**, and **T67**, also score below 90%; they all exhibited typical speech but, with the exception of **T02**, were in the youngest age group. The children whose Total Accuracy is below 90% are therefore more likely to exhibit characteristics of speech disorders and/or to be younger in age.

Table 10. Picture Naming Task Total Accuracy and Qualitative Language Assessment

	Participant Characteristic(s)		
Total Accuracy	Suspected Speech Disorder (Age: 5;2-6;1)	Typical Speech, Younger Age (Age: 4;11-5;6)	Typical Speech, Older Age (Age: 5;7-6;2)
65-70%	D43	---	---
71-75%	---	---	---
76-80%	D23	---	---
81-85%	D10, D37, D38	T34, T67	---
86-90%	D52	T44	T02
91-95%	D08, D09, D11	T55	T49
96-100%	D05	T19, T21, T22, T42[a]	T12, T17, T18, T58, T65, T68

[a]T42 was 4;11.26 at the time of the assessment.

With respect to syllable position, the 10 children that the S-LP identified all made at least one error in singleton codas. Similarly, **T02**, **T34**, **T44**, and **T67** all had two or more errors in singleton codas. In branching codas, **D10**, **D23**, **D37**, and **D38** all produced an error for the rhotic in *fork*; the first three all exhibited rhotic gliding in the clinical assessment, whereas **D38** had cluster reduction.

This completes my description of the children's speech patterns in the Picture Naming Task. In the next section, I expand on the children's phonological abilities in production using the results from the Semi-Directed Narrative.

9. Semi-Directed Narrative

In this section, I report on the results from the Semi-Directed Narrative task. I discuss singleton onsets (initial), singleton onsets (medial), branching onsets, and singleton codas in 9.1, 9.2, 9.3, and 9.4, respectively. In each of these subsections, I briefly discuss some of the phonological patterns that are present in the data. I also indicate potential factors that influence the production of sequences in these syllable positions. For this assessment, drawing comparisons among the children is more challenging, since each child provided his or her own unique rendition of the sequence of events depicted in *Frog, where are you?* (Mayer 1969). This yielded differences in the word forms used by the children and, consequently, the inventories and frequencies of the consonants they used across all syllabic contexts. Errors that are associated with a particular word or similar syllable type may thus be over- or under-represented. Additionally, children who made fewer errors may appear less proficient if they were also less voluble. Although my analysis is primarily quantitative, I also expand on some cases where accuracy scores are attributable to errors in specific phonological environments and/or low productivity.

For each phonological context, I describe common error patterns. I identify the most and least proficient children in terms of their accuracy scores on consonants and I report on the number of errors that they produced. In addition, I provide a quantitative summary table in each subsection; the participants are sorted first by accuracy score and then by number of attempts, both in ascending order. For the three phonological contexts involving singleton consonants, I divide the attempts and errors into sound classes by manner of articulation and in order of increasing sonority (see Pater & Barlow 2003). Because affricates were infrequent in initial singleton onsets and sparse in both medial singleton onsets and singleton codas,[16] I merged fricatives/affricates as a single category across these contexts. For branching onsets, I separate the attempts and errors into two categories, C1 and C2, which represent segmental positions within consonant clusters. Note that these classifications are for descriptive purposes only, as they do not affect my comparative analysis, which is solely based on the total number of attempts and the Total Accuracy score. Building on these results, I present the weighted scores, which are derived from these two sets of values, in section 11. Finally, in my discussion of these results, I consider the S-LP's general evaluations, as well as the age of each individual at the time of the assessments (recall section 2). I use this additional information to verify whether phonological performance with particular sound classes or in certain phonological contexts can be related to suspected speech disorder or to the age of the participants.

9.1 Semi-Directed Narrative: Singleton Onsets (Initial)

In this subsection, I provide an overview of the children's productions of word-initial singleton onsets in the Semi-Directed Narrative. Singleton onsets constitute the least-marked consonantal syllable component (Battistella 1990). This is primarily due to the fact that CV is the only

16 The children each attempted between zero and nine affricates in initial singleton onsets. In medial singleton onsets and singleton codas, 19 and 14 children did not attempt any affricates.

syllable form that is considered universal (Clements & Keyser 1983; Clements 1990; Blevins 1995). Singleton onsets are also typically the first consonantal position that children acquire (Smith 1973; Fikkert 1994; Demuth & Fee 1995; Rose 2000). Concerning position within the word, perceptual and related prosodic factors generally make word-initial onsets easier to acquire than those in word-medial position (Inkelas & Rose 2007; Rose 2009; Lin & Demuth 2015). The data from the current study support these observations, as the children tended to make proportionally more errors in phonological contexts that are considered more marked and/or are prosodically less favourable.

As a group, the children produced word forms containing 19 different types of initial singleton onsets, eight of which were attempted by all children at least once. The children did not attempt any words with [z], [ʒ], or [ŋ] initial onsets; in English, the first two phonemes are relatively infrequent in this position, while the latter is phonotactically not permitted (Kahn 1976; Kessler & Treiman 1997). All of the children produced more oral stops than any other sound class, whereas nasals tended to be less frequent. The least frequent initial singleton onsets, [v] and [ʃ], were attempted by two and thirteen children, respectively. For further details on the frequency of the individual sounds that the children produced, see Appendix D.

Table 11 below ranks the children with respect to their accuracy scores. This table is divided into six parts. The first represents the Total Accuracy score for all initial singleton onsets. Directly below this, I separate the general score into five manner of articulation components: oral stops, fricatives/affricates, nasals, liquids, and glides. This table serves as a quantitative summary of the children's deletions and substitutions. I provide a more qualitative summary of the children's errors in Appendix E.

Table 11. Singleton Onsets (Initial) Consonant Accuracy by Sound Class

	Participant																									
Total	D10	T44	D37	D43	D09	T34	T68	D23	T19	D11	T49	T67	T21	D38	T55	D52	T58	T12	T02	T65	D08	T18	T22	T42	T17	D05
Attempts	86	79	110	109	171	177	67	54	190	89	109	56	260	58	117	149	127	87	227	147	162	95	102	85	106	108
Errors	25	8	11	9	11	11	4	3	10	4	4	2	9	2	4	4	3	2	5	3	3	1	1	0	0	0
Deletions	0	1	1	1	1	1	0	1	1	0	1	0	0	0	3	2	2	2	3	1	0	0	0	--	--	--
Substitutions	25	7	10	8	10	10	4	2	9	4	3	2	9	2	1	2	1	0	2	2	3	1	1	--	--	--
Accuracy (%)	71	90	90	92	94	94	94	94	95	96	96	96	97	97	97	97	98	98	98	98	98	99	99	✓	✓	✓
Oral Stops	D10	T44	D09	T19	T12	T68	T67	T55	D43	T49	T21	T34	D37	D11	T02	T58	T65	D52	D38	D23	T22	T18	T42	T17	D05	D08
Attempts	47	46	77	106	39	22	25	51	56	56	96	66	43	47	108	61	72	78	21	31	38	40	42	46	49	72
Errors	18	5	6	7	2	1	1	2	2	2	3	2	1	1	2	1	1	1	0	0	0	0	0	0	0	0
Deletions	0	0	0	1	2	0	0	1	0	1	0	1	0	0	2	0	0	1	--	--	--	--	--	--	--	--
Substitutions	18	5	6	6	0	1	1	1	2	1	3	1	1	1	0	1	1	0	--	--	--	--	--	--	--	--
Accuracy (%)	62	89	92	93	95	95	96	96	96	96	97	97	98	98	98	98	99	99	✓	✓	✓	✓	✓	✓	✓	✓
Fricatives/ Affricates	D43	D10	T68	D37	D38	T34	D08	D11	D09	T49	T44	T19	D52	T21	T02	D23	T42	T67	T55	T18	D05	T17	T22	T58	T65	T12
Attempts	15	13	14	18	13	36	24	17	34	19	14	29	18	60	33	6	10	10	11	12	14	15	18	19	19	20
Errors	4	3	3	3	2	5	3	2	4	2	1	2	1	2	1	0	0	0	0	0	0	0	0	0	0	0
Deletions	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	--	--	--	--	--	--	--	--	--	--	--
Substitutions	4	3	3	3	2	5	3	2	3	2	1	2	1	2	1	--	--	--	--	--	--	--	--	--	--	--
Accuracy (%)	73	77	79	83	85	86	88	88	88	89	93	93	94	97	97	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Nasals	D23	T21	T22	D38	T44	T68	T02	D05	T58	T67	D11	T17	D43	T65	T12	T55	T18	D08	D52	T34	D37	T19	T49	D09	T42	D10
Attempts	11	24	15	1	1	4	5	5	5	5	7	7	7	7	8	8	9	10	11	12	12	17	18	19	19	0
Errors	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	--
Deletions	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Substitutions	1	2	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Accuracy (%)	91	92	93	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	--
Liquids	D23	D37	D43	D10	T55	T34	T18	D09	T21	D52	T58	T19	T02	T67	T49	D11	T12	T42	T44	D05	D38	T17	T22	T68	T65	D08
Attempts	2	13	9	12	16	27	10	11	29	19	19	23	28	3	6	9	9	10	10	11	12	14	14	15	17	30
Errors	1	5	3	4	2	3	1	1	2	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Deletions	0	0	1	0	2	0	0	0	0	0	1	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--
Substitutions	1	5	2	4	0	3	1	1	2	1	0	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--
Accuracy (%)	50	62	67	67	88	89	90	91	93	95	95	96	96	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Glides	D23	T44	D11	D37	T67	T65	D52	T58	T34	T02	T42	T49	T12	D38	T68	D10	T19	T22	D43	T17	T18	D08	D05	D09	T55	T21
Attempts	4	8	9	24	13	32	23	23	36	53	4	10	11	11	12	14	15	17	22	24	24	26	29	30	31	51
Errors	1	2	1	2	1	2	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deletions	1	1	0	1	0	1	1	1	0	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Substitutions	0	1	1	1	1	1	0	0	1	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Accuracy (%)	75	75	89	92	92	94	96	96	97	98	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Legend:	✓ 100%	-- N/A	-- Not Attempted

As shown in this table, the distribution of errors suggests that more children favoured substitution over deletion in initial singleton onsets. **D05**, **T17**, and **T42** did not produce any errors, while **T18** and **T22** made a single error each. In terms of accuracy, 13 children have rounded scores between 95% and 98%. In contrast, eight children have scores of 94% or lower; other than **T68**, who has low productivity, these children were considered speech-disordered and/or were younger compared to the other children.

The substitution errors that the children produced involve a variety of phonological processes, including spirantization, labialization, stopping, and gliding. In general, errors were more frequent with oral stops and fricatives/affricates, whereas productions of nasals and glides yielded fewer errors. For instance, none of the children made more than two errors with nasal and glide consonants combined. This is expected, given that word-initial [m], [n], [w], and [j] are among the earliest sounds acquired by L1 English children (Shriberg 1993). The individual errors affecting nasals and glides did not appear to be related to specific production patterns. However, one pattern was apparent for [w] at the word level: the children's errors occurred almost exclusively in function words such as <u>*w*</u>*as* and <u>*w*</u>*ith*, and primarily involved deletion or spirantization to [v].[17] Due to the infrequency of errors with nasal and glide consonants, I do not elaborate further on the production of these sound classes. Instead, my analysis focuses on the performance of oral stops, fricatives/affricates, and liquids.

With respect to oral stop consonants, eight children did not produce any errors, and 14 children have rounded accuracy scores between 95% and 99%. In comparison, **D09**, **D10**, **T19**, and **T44** score below 94%, and were either considered speech-disordered or were in the youngest age group. **D10** made noticeably more errors than any other child, but these were mostly in productions of a single word (<u>*d*</u>*og*). Of the 18 substitutions for oral stops that this child produced, one involved gliding in <u>*d*</u>*og* [ˈjæg] and consonant harmony in <u>*d*</u>*og* [ˈgɑg] affected 15 pronunciations; however, even if all of these word-specific errors were discounted, **D10** would still obtain one of the lowest Total Accuracy scores for initial singleton onsets. Finally, **D09**

17 **T44** produced the only error affecting [w] in a content word, with <u>*w*</u>*aving* produced as [ˈɹeɪvɪŋ].

showed overall high variability in the production of velar stops; these errors occurred twice in both *c̲ome*(*s*) and *g̲oing*.

Regarding fricatives and affricates, the accuracy scores are generally lower than other sound classes and are associated with lower productivity. Eleven children did not make any errors, while **T02**, **T44**, and **D52** produced one error each. Of the 12 children with multiple errors, **T21** is the only one whose accuracy score exceeds 95%. Except for **T49** and **T68**, the children with accuracy scores below 95% were otherwise considered speech-disordered and/or were among the youngest children at the time of testing.

Concerning liquids, 13 children did not make any errors and seven children produced a single error each. In contrast, six children made multiple errors and obtain accuracy scores below 95%. These latter children were all considered speech-disordered and/or were in the youngest age group. **T21**, **T34**, and **T55** produced multiple errors with [l], whereas **D10**, **D37**, and **D43** made multiple errors with [ɹ]; various errors with [l] and [ɹ] therefore appear to be associated with younger age and suspected speech disorder, respectively.

This concludes my description of the children's performance of initial singleton onsets. In the next subsection, I discuss the children's productions of singleton onsets in word-medial position.

9.2 Semi-Directed Narrative: Singleton Onsets (Medial)

As a group, the children produced word forms containing 20 different phonemes in word-medial singleton onsets. They did not attempt any [ʒ] or [ŋ] medial onsets; the former phoneme is acquired later by L1 English children (Templin 1957; Shriberg 1993), whereas [ŋ] is phonotactically not allowed in this syllable position (Kahn 1976; Kessler & Treiman 1997). Similar to word-initial singletons, the children produced more oral stops than any other sound class, but [d] was the only sound for which all children made at least one attempt. Other frequent sounds include [l] and [w], which were attempted by 23 and 25 children, respectively. In contrast, the least prevalent medial singleton onsets were [ʧ], [ʤ], and [j]. For the inventory of sounds that each child produced, see Appendix F.

Table 12 below provides an overview of the distribution of errors and is organized in the same way as the previous table. A more detailed, qualitative summary of the children's errors in this position is available in Appendix G.

Table 12. Singleton Onsets (Medial) Consonant Accuracy by Sound Class

Participant

Total	D10	D38	T18	T19	D09	T12	D43	D37	T58	D08	T34	T49	T21	T67	D11	D23	T55	T02	T68	T44	T22	T42	D05	T17	T65	D52
Attempts	21	14	22	60	53	26	26	44	39	31	63	33	83	27	30	21	44	95	24	18	19	23	24	28	37	44
Errors	5	3	3	8	7	3	3	5	4	3	6	3	7	2	2	1	2	4	1	0	0	0	0	0	0	0
Deletions	2	0	1	3	3	1	3	2	3	0	4	1	4	0	2	0	0	1	0	--	--	--	--	--	--	--
Substitutions	3	3	2	5	4	2	0	3	1	3	2	2	3	2	0	1	2	3	1	--	--	--	--	--	--	--
Accuracy (%)	76	79	86	87	87	88	88	89	90	90	90	91	92	93	93	95	95	96	96	✓	✓	✓	✓	✓	✓	✓

Oral Stops	D10	T21	T34	T19	D37	D08	D09	T67	D23	T49	D43	D11	T02	T12	D38	T44	T18	T22	T42	T68	D05	T65	T17	T58	T55	D52
Attempts	13	26	26	40	28	15	25	11	12	12	14	21	45	6	7	7	9	10	11	11	12	13	17	19	20	24
Errors	3	4	4	6	4	2	3	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Deletions	1	2	4	2	2	0	1	0	0	0	1	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--
Substitutions	2	2	0	4	2	2	2	1	1	1	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--
Accuracy (%)	77	85	85	85	86	87	88	91	92	92	93	95	98	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Fricatives/ Affricates	D38	D09	T18	D10	T58	T12	D43	T49	T34	D37	T68	T21	T55	T02	D08	D23	T44	D11	T17	T19	D05	T42	T67	T22	D52	T65
Attempts	4	9	6	4	8	9	5	10	11	6	7	18	10	30	2	2	2	3	3	3	4	5	5	6	6	13
Errors	3	4	2	1	2	2	1	2	2	1	1	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Deletions	0	2	1	0	2	0	1	1	0	0	0	1	0	0	--	--	--	--	--	--	--	--	--	--	--	--
Substitutions	3	2	1	1	0	2	0	1	2	1	1	1	1	1	--	--	--	--	--	--	--	--	--	--	--	--
Accuracy (%)	25	56	67	75	75	78	80	80	82	83	86	89	90	97	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Nasals	T58	D11	T18	D43	T19	T21	D10	D23	D38	T12	T42	T67	T68	D05	T65	T02	T44	T49	T17	D37	D52	D08	T55	D09	T34	T22
Attempts	5	3	4	4	5	11	1	1	1	2	2	2	2	3	3	4	4	4	5	5	5	6	6	9	9	0
Errors	2	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	--
Deletions	1	1	0	1	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Substitutions	1	0	1	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Accuracy (%)	60	67	75	75	80	91	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	--

Liquids	D10	T12	T02	T55	T19	T17	T18	T22	D37	D08	T42	D43	T44	T68	D05	D23	T49	D52	T58	T65	D09	T67	T34	T21	D11	D38
Attempts	1	4	11	6	8	1	1	1	2	3	3	3	3	3	4	4	4	4	4	5	6	8	11	17	0	0
Errors	1	1	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	--	--
Deletions	1	1	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Substitutions	0	0	2	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Accuracy (%)	0	75	82	83	88	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	--	--

Glides	T67	D08	D05	T68	D10	T17	T18	T22	D23	D38	T42	T44	T55	D11	D37	T49	T58	T65	D09	T19	T02	T12	D52	T34	T21	D43
Attempts	1	5	1	1	2	2	2	2	2	2	2	2	2	3	3	3	3	3	4	4	5	5	5	6	11	0
Errors	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	--
Deletions	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Substitutions	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Accuracy (%)	0	80	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	--

Legend:	✓ 100%	-- N/A	-- Not Attempted

As we can see in this table, seven children did not make any errors in their medial singleton onset productions, and four children have a Total Accuracy score of either 95% or 96%. The remaining 15 children all score below 95%; seven were considered speech-disordered, while the eight children with typical speech varied in age. Although these data do not suggest a clear relationship between overall performance and suspected speech disorder or participant age, productivity appears to be a general factor affecting the Total Accuracy scores in this context.

Overall, more children made errors with oral stops and fricatives/affricates. **D09**, **T19**, **T21**, and **D37** showed the most variability in their error patterns in medial singleton onsets; these children were either considered speech-disordered or were younger, and they all produced multiple deletions and substitutions in a variety of phonological environments. In comparison, 14 children did not produce any errors with nasals, liquids, or glides, and no child had more than two errors for the three classes combined. For this reason, I focus on the production of oral stops and fricatives/affricates in this phonological context.

With respect to oral stops, 13 children did not make any errors, while six children produced one error each. In contrast, the seven children who made multiple errors all have accuracy scores below 90%; they were all considered speech-disordered and/or were younger. For the four children with the lowest accuracy scores, phonological environment appears to be a factor. **T21**'s errors were predominantly after syllables with [n] codas, e.g. *wandered* [ˈwɑnəɹd], whereas **D10** and **T34** produced three errors in *window*[18] and *didn't*,[19] respectively. Finally, **T19** produced two errors each in *holding* and *doggy/('s)*. In medial singleton onset position, [d] therefore appeared to be challenging for some individuals with suspected speech disorders or who were younger, especially if the preceding coda consonant shared the same place of articulation.

In their productions of fricatives and affricates, 12 children did not produce any errors, and six children made a single error each. In comparison, the eight children with multiple errors have accuracy scores ranging from 25% to 89%, but can not be distinguished on the basis of

18 **D10** produced the following incorrect forms for *window*: [ˈwʌngoʊ], [wəmˈboʊ], and [wəˈnoʊ].
19 **T34** repeatedly deleted the medial onset in *didn't*: [ˈdɪɛ̃], [ˈdɪə̃] and [ˈdɪən].

suspected speech disorder or age; in this case, low productivity appears to be the common factor influencing performance. Note that **D38**, who has an accuracy score that is considerably lower compared to the other children (25%), consistently produced incorrect syllable segmentation in *sear<u>ch</u>ing*: [ˈs̪ʌɹt̚^ʃɛŋ], [ˈʃɔɹt̚^ʃæŋ], and [θʌɹt̚^ʃɛŋ].

This completes my report on the children's performance of singleton onsets. In the next subsection, I look at the children's productions of branching onsets.

9.3 Semi-Directed Narrative: Branching Onsets

Branching onsets are considered to be marked cross-linguistically (Battistella 1990); they are neither universal nor obligatory components, and languages that allow these complex sequences must also permit the universally-attested singleton onsets (Blevins 1995). Apart from strident+C clusters,[20] which I omitted from my study, branching onsets typically adhere to sonority constraints. Branching onsets that violate sonority constraints are less frequent and often occur in languages that also permit sequences with increasing sonority (Clements 1990; cf. Goad & Rose 2004; Goad 2012). Due to these sonority constraints, obstruents and sonorants tend to occupy the first (C1) and second (C2) consonant position in a cluster, respectively (Pater & Barlow 2003), and a greater difference in sonority between the two consonants in an onset cluster signifies a less marked sequence (Barlow 1997). In English, branching onsets are even more restricted. For instance, only the six oral stops ([p], [b], [t], [d], [k], and [g]) and the four voiceless coronal fricatives ([f], [θ], [s], and [ʃ]) occur in word-initial C1 position (Algeo 1978; Clements & Keyser 1983).[21]

20 For more information on the special status of these clusters cross-linguistically and in acquisition, see Fikkert (1994); Goad & Rose (2004).
21 Hultzén (1965) also identifies [hw] as a variation of the onset [w] (e.g. *<u>wh</u>ere*). In my experience, this is dialectal.

Sonority and markedness influence the acquisition of clusters, as well as the types of errors that children produce (Barlow 1997; Goad & Rose 2004). Some branching onsets, including those which are more marked, are still developing in children between the ages of five and eight, whereas singleton onsets are acquired much earlier (Templin 1957). With respect to errors in production, Smit (1993b) suggests that children are more accurate in their productions of obstruent+/l/ clusters than obstruent+/ɹ/ clusters, which relates to /l/ being slightly less marked than /ɹ/ (Battistella 1990). Furthermore, the more sonorous part of the cluster is considered marked and is consequently more vulnerable to errors in production. For younger children, this means deletion of the liquid or glide, whereas older children tend to substitute the sonorant portion of the onset sequence (Ingram 1976). The results of the current study are consistent with these findings.

As a group, the children in the current study produced word forms containing 15 different consonant combinations syllabified within onsets. With the exception of [kw], these branching onsets consist exclusively of C[l] and C[ɹ] clusters.[22] I excluded C[j] onsets from my analysis because the [j] portion is an onglide that behaves differently from the glide [w] (Davis & Hammond 1995); this did not affect my results, given that only one child attempted words with C[j] sequences. The most frequent branching onsets were [fɹ], which all children attempted, and [tɹ], which 24 children attempted at least once (recall that the narrative centres around a *fr̲og* and takes place in a forest with *t̲r̲ees*). In contrast, five types of branching onsets ([bl], [gl], [pɹ], [dɹ], and [kw]) were attempted by five or fewer children. The specific clusters attempted by each child are reported in Appendix H.

22 The clusters [tw] and [dw], which none of the children attempted, are relatively less frequent in English; [gw] as in *g̲u̲ava* and [θw] as in *t̲h̲w̲art* are also possible, but these forms are even rarer (Algeo 1978).

Table 13 below shows the consonant accuracy for each participant. The table is separated into three main components. The first shows the Total Accuracy scores for all branching onsets, while the other two parts break down these general scores by the segmental position of the consonant. The first (C1) and second (C2) consonants in a cluster are presented in the middle and bottom parts of the table, respectively. For a more qualitative summary of the errors affecting branching onsets, see Appendix I.

Table 13. Branching Onsets Consonant Accuracy by Position in Cluster

	Participant																									
Total[a]	D43	D52	D10	T44	D37	D38	T67	D09	T68	D08	T22	T42	T17	T58	T19	T34	D11	T18	T12	T49	D05	T55	T65	T02	D23	T21
Attempts	22	54	16	22	30	22	18	38	20	32	28	32	38	38	40	24	48	26	32	36	42	50	50	74	20	52
Errors	11	24	6	5	6	4	3	4	2	3	2	2	2	2	2	1	2	1	1	1	1	1	1	1	0	0
Deletions	2	7	0	1	5	2	2	1	1	1	0	1	0	0	1	1	2	0	0	0	0	0	0	0	--	--
Substitutions	9	17	6	4	1	2	1	3	1	2	2	1	2	2	1	0	0	1	1	1	1	1	1	1	--	--
Accuracy (%)	50	56	63	77	80	82	83	89	90	91	93	94	95	95	95	96	96	96	97	97	98	98	98	99	✓	✓
C1	T67	D38	D43	T44	D09	T58	T68	T34	D11	T18	T22	T17	T19	D05	T65	D10	D23	D37	D08	T12	T42	T49	T55	T21	D52	T02
Attempts	9	11	11	11	19	19	10	12	24	13	14	19	20	21	25	8	10	15	16	16	16	18	25	26	27	37
Errors	2	2	2	2	2	2	1	1	2	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Deletions	2	1	1	1	0	0	1	1	2	0	0	0	0	0	0	--	--	--	--	--	--	--	--	--	--	--
Substitutions	0	1	1	1	2	2	0	0	0	1	1	1	1	1	1	--	--	--	--	--	--	--	--	--	--	--
Accuracy (%)	78	82	82	82	89	89	90	92	92	92	93	95	95	95	96	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
C2	D52	D43	D10	D37	T44	D08	D38	T42	T67	D09	T68	T22	T12	T49	T17	T19	T55	T02	D23	T34	T18	T58	D05	D11	T65	T21
Attempts	27	11	8	15	11	16	11	16	9	19	10	14	16	18	19	20	25	37	10	12	13	19	21	24	25	26
Errors	24	9	6	6	3	3	2	2	1	2	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
Deletions	7	1	0	5	0	1	1	1	0	1	0	0	0	0	0	1	0	0	--	--	--	--	--	--	--	--
Substitutions	17	8	6	1	3	2	1	1	1	1	1	1	1	1	1	0	1	1	--	--	--	--	--	--	--	--
Accuracy (%)	11	18	25	60	73	81	82	88	89	89	90	93	94	94	95	95	96	97	✓	✓	✓	✓	✓	✓	✓	✓
Legend:	✓ 100%			-- N/A																						

[a]All CC errors which involve reduction to a single cluster element are represented here as C1 deletion, C2 substitution.

As we can see from this table, the children tended to be less accurate in their productions of branching onsets than singleton onsets. **T21** and **D23** are the only children who did not make any errors, while 12 children have rounded Total Accuracy scores between 95% and 99%. In contrast, 12 other children score between 50% and 94%; with the exception of **T68**, who has lower overall productivity, these children were all considered speech-disordered and/or were in the youngest age group. Four of these children (**D38**, **D43**, **T44**, and **T67**) are also the only participants who made errors affecting both C1 and C2 in the same branching onset.

Overall, and in line with the general observations highlighted at the beginning of this section, the majority of the C1 and C2 branching onset errors occurred in C[ɹ] clusters, affecting [fɹ] and [tɹ] in particular (see Appendix I). C1 errors were mostly substitutions in word-initial position and, with the exceptions of *from* (**T68**) and the errors affecting whole clusters, all other C1 deletions occurred word-medially. A total of 11 children did not produce any C1 errors, and eight children produced a single error each. The remaining seven children each made two errors and have C1 accuracy scores ranging from 78% to 92%. Except for **T58**, these latter children were considered speech-disordered and/or were younger; however, these results should be interpreted with caution, considering the low productivity which affects the assessment of branching onsets in general. Therefore, the relative performance of each child may be misrepresented in some cases, consequently leading to an inaccurate assessment of phonological abilities.

With respect to C2, eight children did not produce any errors, and nine children produced a single error each. Nine other children made multiple C2 errors, yielding accuracy scores below 90%. Except for **T42** and **T44**,[23] who were in the youngest age group, these children were all considered speech-disordered. Of the children who score below 90%, **D37** and **D52** are the only ones who frequently deleted C2, and **D10**, **D43**, and **D52** are the only ones who produced various gliding errors. These four children consequently have the lowest C2 accuracy scores, as well as lower Total Accuracy scores.

23 **T44**'s errors were exclusively in [tɹ] clusters and they predominantly involved affrication.

This completes my analysis of the children's productions of consonants in branching onsets. In the next subsection I report on the children's performance of singleton codas, which is another relatively marked syllable position.

9.4 Semi-Directed Narrative: Singleton Codas

Consonants in syllable coda position are cross-linguistically less favoured, if compared to those in onset position. For instance, languages universally prefer CV syllables over more complex syllable structures (Clements 1990), and the coda is an optional component of the syllable that is not present in all languages (Clements & Keyser 1983; Blevins 1995). Even if a language allows closed syllables, codas are not mandatory and they tend to exhibit more distributional restrictions than syllable onsets, in terms of the types of consonants they allow (Itô 1988; Zec 1995; Mateus & d'Andrade 2000). Codas are also prone to resyllabification, which is partially motivated by sonority constraints or syllabification patterns in connected speech (Kahn 1976; Clements 1990). English allows for a wide variety of singleton and branching codas; however, coronal consonants are more prevalent in codas than either labials or dorsals (see Hultzén 1965; Battistella 1990).

The coda position is further disfavoured due to its status as the prosodically weakest part of the syllable (Selkirk 1982). This can also be compounded by a number of factors, including: decreasing sonority from the preceding nucleus, syllable stress assignment, syllable position in the word, frequency of the coda phoneme in the language, and whether the coda is part of a function or content word (Zamuner, Gerken & Hammond 2004; Demuth, Culbertson & Alter 2006; Núñez-Cedeño 2007; Demuth & McCullough 2009; Solé 2010). The acquisition and phonological production of codas in English is further confounded by an overlap with morphological derivation and inflection in this syllable position (Ettlinger & Zapf 2011; Zamuner, Kerkhoff & Fikkert 2012; Polo Cano 2013). For example, the codas in *babies* and *catches* occur in the unstressed syllable of a bisyllabic word and both represent inflectional morphemes. Finally, the production of codas is variable even in adult productions (see Song, Shattuck-Hufnagel & Demuth 2015), which further contributes to perceptual challenges affecting their acquisition. In addition to the prosodic influences already discussed, this creates difficulties when assessing the potential sources of issues observed from the perspective of productive abilities. For instance, coda errors in production could be related to deficient perceptual, morphological, phonological, or articulatory processes; consequently, more specific information is required to determine the nature of these errors than what is available through the current methodology.

As a group, the children in my study produced word forms comprising 18 distinct phonemes in singleton codas. They did not attempt any words with [b], [ð], or [ʒ] codas; of these, the latter two are relatively infrequent in English (Kessler & Treiman 1997) and they are also acquired much later by L1 English learners (Templin 1957; Shriberg 1993). I present the inventory of these sounds for each child in Appendix J. Note that [h], [w], and [j] are also not present, as they are not permitted in the coda position of English syllables (Battistella 1990). With the exceptions of **D05** and **D10**, the children produced more nasals than any other sound class. In contrast, liquids were generally less prevalent. The most frequent sounds were [z] and [n], which all children attempted, while 11 children did not make any attempts for either [ʃ], [ʧ], or [ʤ].

Table 14 below details the consonant accuracy for each participant. The table is divided into five parts, starting with the Total Accuracy for all singleton codas. The four components directly below this represent the children's accuracy scores for the sound classes of oral stops, fricatives/affricates, nasals, and liquids. For a more qualitative summary of the children's errors in production, refer to Appendix K, where the two tables document deletions and substitutions separately.

Table 14. Singleton Codas Consonant Accuracy by Sound Class

	Participant																									
Total	D52	D43	T44	D09	D37	T22	D10	T19	D11	T55	D08	D23	T18	T34	T49	T68	T21	D38	D05	T42	T67	T02	T58	T17	T65	T12
Attempts	263	162	91	264	201	129	111	286	155	211	179	90	159	209	143	115	331	87	161	150	80	413	219	177	229	177
Errors	33	20	9	26	19	11	9	23	12	16	12	6	10	13	8	6	17	4	7	6	3	13	6	4	5	3
Deletions	21	14	1	12	12	5	5	14	6	8	7	4	7	7	5	4	7	2	4	1	2	6	5	1	4	2
Substitutions	12	6	8	14	7	6	4	9	6	8	5	2	3	6	3	2	10	2	3	5	1	7	1	3	1	1
Accuracy (%)	87	88	90	90	91	91	92	92	92	92	93	93	94	94	94	95	95	95	96	96	96	97	97	98	98	98
Oral stops	D52	T22	D09	D11	T68	T55	D05	D37	D38	T34	T19	T18	D08	T44	T65	T21	T02	T42	D43	T58	T67	D23	T49	D10	T12	T17
Attempts	69	37	76	39	26	38	55	50	19	63	64	45	46	25	64	100	112	42	44	50	18	20	27	39	50	50
Errors	10	5	10	5	3	4	4	3	1	3	3	2	2	1	2	3	3	1	1	1	0	0	0	0	0	0
Deletions	7	3	6	2	3	3	3	3	1	2	3	2	2	0	2	3	2	1	1	1	--	--	--	--	--	--
Substitutions	3	2	4	3	0	1	1	0	0	1	0	0	0	1	0	0	1	0	0	0	--	--	--	--	--	--
Accuracy (%)	86	86	87	87	88	89	93	94	95	95	95	96	96	96	97	97	97	98	98	98	✓	✓	✓	✓	✓	✓
Fricatives/ Affricates	T44	D23	T02	D37	T22	T18	T55	D52	T34	T49	T21	T42	D09	T19	D11	D05	D43	D38	D08	T67	T12	T17	T65	D10	T68	T58
Attempts	26	26	57	40	29	27	41	55	30	40	62	40	50	68	23	35	36	13	36	21	34	50	53	14	15	51
Errors	6	5	10	7	5	4	6	8	4	5	7	4	5	6	2	3	3	1	2	1	1	1	1	0	0	0
Deletions	1	3	4	2	1	1	1	4	1	3	1	0	1	1	0	1	1	0	1	0	1	0	0	--	--	--
Substitutions	5	2	6	5	4	3	5	4	3	2	6	4	4	5	2	2	2	1	1	1	0	1	1	--	--	--
Accuracy (%)	77	81	82	83	83	85	85	85	87	88	89	90	90	91	91	91	92	92	94	95	97	98	98	✓	✓	✓
Nasals	D09	D43	T19	D08	D52	D10	T68	T17	T18	D37	T34	T21	T58	T44	T55	D11	D23	T12	T42	T22	T49	T65	T67	D38	D05	T02
Attempts	96	60	117	62	101	39	43	54	66	92	72	112	88	33	99	67	34	70	45	48	52	77	31	35	36	182
Errors	10	6	10	5	8	3	3	3	3	4	3	4	3	1	3	2	1	2	1	1	1	1	0	0	0	0
Deletions	4	3	7	1	4	1	1	1	3	2	3	0	2	0	2	1	1	1	0	1	1	1	--	--	--	--
Substitutions	6	3	3	4	4	2	2	2	0	2	0	4	1	1	1	1	0	1	1	0	0	0	--	--	--	--
Accuracy (%)	90	90	91	92	92	92	93	94	95	96	96	96	97	97	97	97	97	97	98	98	98	99	✓	✓	✓	✓
Liquids	D43	D10	D37	T67	D52	T44	D11	T19	D38	T55	D08	T49	T34	T58	T21	T18	T65	D09	D23	T22	T12	T17	T42	T68	D05	T02
Attempts	22	19	19	10	38	7	26	37	20	33	35	24	44	30	57	21	35	42	10	15	23	23	23	31	35	62
Errors	10	6	5	2	7	1	3	4	2	3	3	2	3	2	3	1	1	1	0	0	0	0	0	0	0	0
Deletions	9	4	5	2	6	0	3	3	1	2	3	1	1	2	3	1	1	1	--	--	--	--	--	--	--	--
Substitutions	1	2	0	0	1	1	0	1	1	1	0	1	2	0	0	0	0	0	--	--	--	--	--	--	--	--
Accuracy (%)	55	68	74	80	82	86	88	89	90	91	91	92	93	93	95	95	97	98	✓	✓	✓	✓	✓	✓	✓	✓
Legend:	✓ 100%			-- N/A																						

As we can see in this table, the majority of the children were overall less precise in their productions of singleton codas than in their productions of singleton onsets. Considering the numerous factors disfavouring codas that I discussed above, this is not surprising. Three children score 98%, while another eight children have rounded scores between 95% and 97%. In contrast, 15 children have scores below 95%. Of the latter children, eight were considered speech-disordered, and five had typical speech but were among the youngest participants. **T18** and **T49**, who both score 94%, were not among those with suspected speech disorders nor in the youngest age group, but they have lower productivity.

With respect to position within the word, between 90% and 98% of the singleton codas that each child attempted are in word-final position, and the children's errors affecting codas are also predominantly in this position.[24] Overall, [t], [z], [n], and [ɹ] were the most frequently deleted singleton codas. The most common substitutions were stopping of [θ] and [z], affrication of /z/ to [ʦ]/[ʣ], and labialization of [n] to [m]. **T02** and **D05** are the only children who did not make any errors with nasals or liquids. On the contrary, **D10** only made errors with nasals and liquids.

In their attempts at oral stops, six children did not make any errors, while five children made a single error each. In terms of consonant accuracy, 12 children have scores between 95% and 98%. In comparison, eight children score lower than 95%; except for **T68**, who has fewer overall attempts, these children were considered speech-disordered or were younger. As a group, the children generally produced more deletions than substitutions for oral stops. The most deletions were for [t], which were all in phonological environments that allow for its unreleased [t̚] and glottalized [ʔ] allophones (e.g. *it*, *out*, and *that*). Note that I did not count /t#/ → [ʔ] as an error, since [ʔ] is one of the possible allophones of /t/ in word-final position (Kahn 1976; Song, Shattuck-Hufnagel & Demuth 2015).[25] This is consistent with Smit (1993a), who reports that [t] is the most commonly deleted and least accurate stop consonant in coda position. Considering the lack of sonority associated with this consonant (Pater & Barlow 2003), as well as the allophonic and free variation for this phoneme in this position in adult English, this result is not surprising, even for a consonant otherwise considered among the least-marked cross-linguistically (Ladefoged & Maddieson 1996).

---

24 Ten children only made singleton coda errors word-finally and twelve children made all but one error (67% to 95%) in word-final position. **D09**, **T19**, **T34**, and **D52** are the only children who made multiple word-medial errors; 83% to 94% of their errors are word-final.

25 For more information on factors influencing glottalization in codas, see Huffman (2005).

Concerning the production of fricatives and affricates in singleton codas, **D10**, **T58**, and **T68** did not make any errors, with an additional four children scoring 95% or higher. In contrast, 19 children score below 95%, and they can not be distinguished by either suspected speech disorder or age. Errors with fricatives were more frequent and variable than with other sound classes, and substitutions were generally more common than deletions. Over half of the errors affected the consonant [z]. These errors were generally inconsistent, and occurred predominantly in function words (e.g. *is* and *was*), in unstressed syllables of content words, and/or are related to morphological suffixes (e.g. *babies*, *bees*, *catches*, *froggy's*, *he's*, *says*).

With respect to nasals, four children did not produce any errors, and six children made a single error each. In terms of accuracy, 14 children score between 95% and 99%. In comparison, eight children have accuracy scores below 95%; except for **T17** and **T68**, who have lower productivity, these children were considered speech-disordered and/or were younger.

In their productions of singleton coda liquid consonants, eight children did not make any errors and four children made a single error each; except for **T44**, whose productivity is considerably lower, these children are among the four participants who have accuracy scores of 95% or higher. Excluding **T44**, 13 children score below 95%; **T49** and **T58**, who have lower productivity, are the only ones in this group who were not considered speech-disordered and/or were younger at the time of testing. Deletions of liquids were far more common than substitutions. Of the children with 95% or lower accuracy, **D11**, **T19**, **T34**, and **T58** are the only ones who made multiple errors with [ɫ]; of these four children, **T58** is the only one who was neither younger in age nor considered speech-disordered. In comparison, seven children with accuracy scores below 95% made multiple errors with [ɹ]; except for **T55**, who was younger, they were all considered speech-disordered.[26]

This concludes my phonological analysis of the Semi-Directed Narrative. In the next section, I provide a complete summary of these results.

10. Semi-Directed Narrative: Summary

In this section, I provide a condensed version of the phonological production results obtained from the Semi-Directed Narrative. I begin with an overview of the phonological forms included and excluded from the current analysis, shown in Table 15 below. As a group, the children attempted almost all of the singleton onset, branching onset, and singleton coda types phonotactically allowed in English, across all relevant word positions. However, the inventory of sounds attempted by each individual child is different, due to the fact that every participant provided his or her own unique version of the narrative.

Table 15. Singleton Phonemes and Consonant Clusters (Group Summary)

	Singleton Phonemes or Consonant Clusters					
Phonological Context	Most Attempted	Least Attempted	Not Attempted	Omitted (Analysis)	Most Deleted	Most Substituted
Singleton Onsets (Initial)	[b] [d] [w]	[v] [ʃ]	[z] [ʒ] *[ŋ][a]	[ð] [h]	[d] [l] [w] [j]	[b] [s] [ʤ] [ɹ] [l]
Singleton Onsets (Medial)	[d] [l] [w]	[ʧ] [ʤ] [j]	[ʒ] *[ŋ][a]	[ð] [h] ([ɾ])[d]	[d] [θ] [n]	[d] [k] [g] [θ] [l]
Branching Onsets	[tɹ] [fɹ]	[bl] [gl] [pɹ] [kw]	[tw] [dw][b]	C[j]	[gɹ][e] [fɹ]	[tɹ] [fɹ]
Singleton Codas	[z] [n]	[ʃ] [ʧ] [ʤ]	[b] [ð] [ʒ] *[h] *[w] *[j][c]	---	[t] [z] [n] [ɹ]	[θ] [z] [n]

[a]The phoneme [ŋ] is not permitted in the onset position of English syllables, whereas [ʒ] is limited to certain borrowed words.
[b]This list does not include strident+C or C+glide onset clusters, which I did not consider as part of the current analysis. Obscure clusters, such as borrowings from other languages or archaic words, are also excluded here (e.g. [gw] in guava; [θw] in thwart).
[c]These three phonemes do not occupy the coda position in English.
[d]Word-medial flapping was entered as a target during transcription. It appears here in brackets, as it is an allophone of /t/.
[e]All of the deletions with [gɹ] were word-medial in angry.

26 **T21**, who has 95% accuracy for liquids and was younger, is the only other child who made multiple errors with [ɹ].

As shown in Figure 18 below, the children attempted more oral stops than any other sound class in both initial and medial singleton onsets, and the least common sound class was variable among the children. In contrast to this, nasals were the most prevalent sound class in singleton codas, while liquids were generally the least frequent. Finally, in their productions of branching onsets, the children attempted C[ɹ] clusters more frequently than C[l] clusters; [kw], the only C[w] cluster present in the data set, was only marginally attempted by five children.[27]

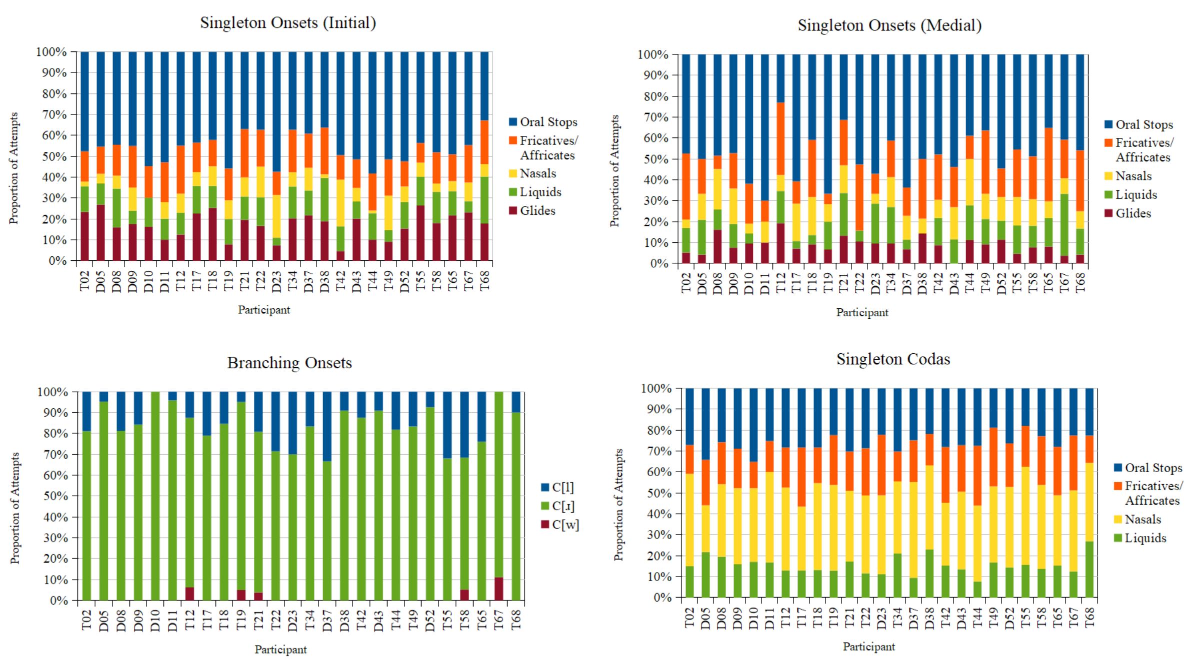

Figure 18. Proportion of Consonants and Clusters Attempted (Arranged by Sound Class)

As reported in section 9.1 above, singleton onsets are considered unmarked and universal (Battistella 1990; Clements 1990), and are generally the first consonantal position to be acquired by children (Smith 1973; Fikkert 1994; Demuth & Fee 1995; Rose 2000). In terms of position within the word, word-initial onsets are easier to acquire than those in word-medial position, due to a variety of perceptual and prosodic factors (Inkelas & Rose 2007; Rose 2009; Lin & Demuth

27 C[ɹ] clusters accounted for approximately 63% to 100% of the branching onsets that each child attempted.

2015). These generalizations are reflected in the current data: the children's Total Accuracy scores in initial singleton onsets are generally higher than those in medial singleton onsets.

In comparison to singleton onsets, branching onsets consist of marked sequences of phones (Battistella 1990; Blevins 1995) that are also governed by sonority constraints within syllable structure (Clements 1990; Pater & Barlow 2003). The sonorant component of the cluster is typically a more marked consonant and therefore more likely to be produced in error (Ingram 1976). The results of the current study also support these findings, as the children generally made fewer C1 than C2 errors in their productions of branching onsets (recall that all stops and fricatives were in C1 position; liquids and glides were in C2 position). Furthermore, errors in C[ɹ] clusters were more frequent than those in C[l] clusters. For instance, 15 children only made errors in C[ɹ] clusters, while three others made 83% to 92% of their errors in C[ɹ] clusters.

Similar to branching onsets, singleton codas are disfavoured cross-linguistically (Clements & Keyser 1983; Blevins 1995), and are prosodically the weakest part of the syllable (Selkirk 1982). Word-final codas in English can also consist of grammatical markers (e.g. *bee<u>s</u>* [biː[<u>z</u>] and *he<u>'s</u>* [hiː[<u>z</u>]). These factors make perception and production of these consonants more challenging for language learners (Ettlinger & Zapf 2011; Zamuner, Kerkhoff & Fikkert 2012; Polo Cano 2013). Again, the results of the current study support these predictions. The children were less accurate and more variable in their productions of consonants in singleton codas than in other phonological contexts. For instance, no child has more than 98% Total Accuracy, while 18 children score 95% or lower.

Table 16 below provides an overview of the children's accuracy scores for each phonological context. In this table, the children are grouped into the following three categories: 1) children who were considered speech-disordered; 2) children with typical speech who were in the youngest age group (ages 4;11 to 5;5) at the time of testing; and 3) children with typical speech who were either in the middle (ages 5;7 to 5;11) or older (ages 6;0 to 6;2) age groups.[28] Finally, the solid black line highlights the performance of the suspected speech-disordered children across the phonological contexts, as well as the younger children, who have lower scores for both branching onsets and singleton codas.

28 Recall that the three age groups are meant to approximate the three 6-month intervals between 5 years 0 months and 6 years 5 months; however, at the time of this assessment, the youngest child was 4;11.26 and the oldest child was 6;02.16.

Table 16. Summary of Semi-Directed Narrative Phonological Performance

Phonological Context	Accuracy Score	Participant Characteristic(s): Suspected Speech Disorder (Age: 5;2-6;1)										Typical Speech, Younger Age (Age: 4;11-5;5)								Typical Speech, Older Age (Age: 5;7-6;2)							
		D05	D08	D09	D10	D11	D23	D37	D38	D43	D52	T19	T21	T22	T34	T42	T44	T55	T67	T02	T12	T17	T18	T49	T58	T65	T68
Singleton Onsets (Initial)[a]	Total (≤ 95%)	✓		X	X		X	X		X		X		*	X	✓	X					✓	*				X
	Oral Stops (≤ 95%)	✓	✓	X	X	*	✓	*	✓		*	X		✓		✓	X		*		X	✓	✓		*	*	*
	Fricatives/ Affricates (< 95%)	✓	X	X	X	X	✓	X	X	X	*	X		✓	X	✓	*	✓	✓	*	✓	✓	✓	X	✓	✓	X
	Nasals (< 95%)	✓	✓	✓	--	✓	*	✓	✓	✓	✓	✓	X	*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Liquids (< 95%)	✓	✓	*	X	✓	*	X	✓	X	*	*	X	✓	X	✓	✓	X	✓	*	✓	✓	*	✓	*	✓	✓
	Glides (< 95%)	✓	✓	✓	✓	*	*	X	✓	✓	*	✓	✓	✓	*	✓	X	✓	*	*	✓	✓	✓	✓	*	X	✓
Singleton Onsets (Medial)[b]	Total[c] (≤ 95%)	✓	X	X	X	X	*	X	X	X	✓	X	X	✓	X	✓	✓	X	X		X	✓	X	X	X	✓	*
	Oral Stops (< 90%)	✓	X	X	X	*	*	X	✓	*	✓	X	X	✓	X	✓	✓	✓	*	*	✓	✓	✓	*	✓	✓	✓
	Fricatives/ Affricates (< 90%)	✓	✓	X	*	✓	✓	*	X	*	✓	✓	X	✓	X	✓	✓	*	✓	*	X	✓	X	X	X	✓	*
	Nasals (< 95%)	✓	✓	✓	✓	*	✓	✓	✓	*	✓	*	*	--	✓	✓	✓	✓	✓	✓	✓	✓	*	✓	X	✓	✓
	Liquids (< 90%)	✓	✓	✓	*	--	✓	✓	--	✓	✓	*	✓	✓	✓	✓	✓	*	✓	X	*	✓	✓	✓	✓	✓	✓
	Glides (< 85%)	✓	*	✓	✓	✓	✓	✓	✓	--	✓	✓	✓	✓	✓	✓	✓	✓	*	✓	✓	✓	✓	✓	✓	✓	✓
Branching Onsets	Total (≤ 95%)	*	X	X	X		✓	X	X	X	X	X	✓	X	*	X	X	*	X	*	*	X	*	*	X	*	X
	C1[d] (< 95%)	*	✓	X	✓	X	✓	✓	X	X	✓	*	✓	*	*	✓	X	✓	X	✓	✓	*	*	✓	X	*	*
	C2 (< 90%)	✓	X	X	X	✓	✓	X	X	X	X	*	✓	*	✓	X	X	*	*	*	*	*	✓	*	✓	✓	*
Singleton Codas	Total (≤ 95%)		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X					X	X			X
	Oral Stops (≤ 95%)	X		X	✓	X	✓	X	*	*	X	X		X	X	*	*	X	✓		✓	✓		✓	*		X
	Fricatives/ Affricates (< 95%)	X	X	X	✓	X	X	X	*	X	X	X	X	X	X	X	X	X	*	X	*	*	X	X	✓	*	✓
	Nasals (≤ 95%)	✓	X	X	X		*		✓	X	X	X		*		*	*		✓	✓		X	X	*		*	X
	Liquids (≤ 95%)	✓	X	*	X	X	✓	X	X	X	X	X	X	✓	X	✓	*	X	X	✓	✓	✓	*	X	X	*	✓

Legend: ✓ No errors; * One error; -- Not Attempted; X Accuracy score is *equal to* the indicated value; X (shaded) Accuracy score is *less than* the indicated value

Note: Children who made a single error and have an accuracy score equal to or less than the indicated value are represented here as "one error".
[a]No child made more than two errors for nasals and glides combined in initial singleton onsets.
[b]No child made more than two errors for nasals, liquids, and glides combined in medial singleton onsets.
[c]D23 produced one error with singleton medial onsets and has 95% Total Accuracy.
[d]No child produced more than two C1 errors in branching onsets.

From this table, we can see that children in the middle and older age groups with typical speech tend to be the most accurate across contexts (e.g. **T02**, **T12**, **T17**, and **T65**). **D05**, one of the older children (age 6;1), was also consistently accurate. Given that **D05** was ranked among the children with less serious speech concerns (recall section 2), this child may have been misidentified during the S-LP's assessment, or was mistakenly prioritized as speech-disordered for my study. In comparison, the consistently least accurate children were identified as having suspected speech disorders (e.g. **D09**, **D10**, **D37**, **D38**, and **D43**) or exhibited typical speech but were younger (e.g. **T19** and **T44**).

As previously discussed, all children were generally less accurate in their productions of more marked (phonologically complex and restricted) syllable constituents, branching onsets and codas (recall sections 9.3 and 9.4). More importantly, the children whose phonological systems were potentially less developed (those with suspected speech disorders or who had typical speech but were younger in age), were noticeably less accurate with their productions in both syllable positions than the older children with typical speech. For instance, 11 children have 95% or lower Total Accuracy for both branching onsets and singleton codas; with the exception of **T68**,[29] these children were either in the suspected speech-disordered group or were among the younger children with typical speech. Concerning the least marked syllable constituents (recall section 9.1), the children with lower accuracy scores in initial singleton onsets were also predominantly in these two speaker groups; in this case, however, the lower scores tend to pattern more with the children with suspected speech disorders than those with typical speech who were younger. Finally, due to lower productivity, the children's accuracy scores in word-medial singleton onsets appear to be the least related to suspected speech disorder or age.

This completes my summary of the children's phonological patterns in the Semi-Directed Narrative. In the next section, I present the weighted scores that I used to further interpret these results.

---

29 Recall that **T68**'s lower productivity contributed to lower accuracy scores in three phonological contexts.

11. Semi-Directed Narrative: Weighted Scores

In this section, I continue with a discussion of the weighted scores that I calculated for the Semi-Directed Narrative. Recall that I obtained these values individually for each child, using the proportion of consonants that the child attempted in a specific phonological context as the relative weight, in conjunction with the child's Total Accuracy score for that context. With respect to the weight of the phonological contexts, note that all children attempted the most consonants in singleton codas (*weight* = 0.43 to 0.55), followed by initial singleton onsets (*weight* = 0.27 to 0.40). The number of consonants attempted for medial singleton onsets (*weight* = 0.07 to 0.15) and branching onsets (*weight* = 0.05 to 0.15) followed within narrower ranges at the bottom end of the scale.

With these values in mind, I report on the weighted scores for each child, which appear in Table 17. The columns of this table follow the same organization as the preceding table, but I use the median to identify the children who consistently have lower scores across the phonological contexts; scores that are below the median value appear in boldface and are underlined. As in the previous table, the outlined section captures the overall performance of the children with suspected speech disorders, in addition to members of the younger speaker group, who scored lower on branching onsets and singleton codas.

Table 17. Semi-Directed Narrative Weighted Scores

	Participant Characteristic(s)																											
	Suspected Speech Disorder (Age: 5;2-6;1)										Typical Speech, Younger Age (Age: 4;11-5;5)								Typical Speech, Older Age (Age: 5;7-6;2)									
Phonological Context	D05	D08	D09	D10	D11	D23	D37	D38	D43	D52	T19	T21	T22	T34	T42	T44	T55	T67	T02	T12	T17	T18	T49	T58	T65	T68
Singleton Onsets (Initial) *Median*: 30.4	✓ 32.2	39.4	30.4	**26.1**	**26.4**	**27.6**	**25.7**	30.9	31.3	**28.4**	31.3	34.6	* 36.3	35.1	✓ **29.3**	33.8	**26.8**	**29.8**	**27.4**	**26.4**	✓ 30.4	* 31.1	32.7	**29.3**	31.1	**27.9**
Singleton Onsets (Medial) *Median*: 8.6	✓ **7.2**	**6.9**	8.7	**6.8**	8.7	* 10.8	10.1	**6.1**	**7.2**	✓ 8.6	9.0	10.5	✓ **6.8**	12.1	✓ **7.9**	✓ 8.6	10.0	13.8	11.2	**7.1**	✓ **8.0**	**6.3**	9.3	**8.3**	✓ **8.0**	* 10.2
Branching Onsets *Median*: 8.4	* 12.2	**7.2**	**6.5**	**4.3**	14.3	✓ 10.8	**6.2**	9.9	**3.4**	**5.9**	**6.6**	✓ **7.2**	9.4	* **4.9**	10.3	**8.1**	* 11.6	**8.3**	* 9.0	* 9.6	10.3	* **8.3**	* 10.9	8.5	* 10.6	**8.0**
Singleton Codas *Median*: 45.5	46.0	**41.3**	**45.2**	**43.6**	**44.4**	**45.4**	47.3	45.9	**44.5**	**45.1**	45.7	**43.3**	**42.4**	**41.4**	49.7	**39.0**	46.2	**42.5**	49.4	54.0	49.6	49.3	**42.1**	50.4	48.4	48.2
Legend:	✓ No errors			* One error			___ Weighted score is *less than* the median																			

From this table, we can also see that the children whose scores are in the bottom half for initial singleton onsets are not distinguished by either suspected speech disorder or age. Similarly, in medial singleton onsets, five of the children whose scores are below the median were considered speech-disordered, while the seven children with typical speech vary in age. Note, however, that five of these children did not actually make any errors; their lower scores are caused by the weight of the phonological context itself (i.e. proportionately fewer consonants attempted) instead of lower accuracy scores.[30] While the children in these three speaker groups do not noticeably differ in their performance of medial singleton onsets (recall section 9.2), lower productivity prevents us from formulating conclusions about this phonological context.

In comparison, lower weighted scores for branching onsets and singleton codas converge in two speaker groups in this table: the children who exhibited disordered speech patterns and the younger children with typical speech. These data are congruent with the previous discussion regarding the marked status of branching onsets and singleton codas (recall sections 9.3 and 9.4). More specifically, the complex and restricted nature of these syllable constituents appears to elicit

30 To a lesser extent, the weight also contributed to lower scores in initial singleton onsets (e.g. **T17** and **T42**), branching onsets (e.g. **T18**, **T21**, and **T34**), and singleton codas (e.g. **T21**, **T49**, and **T67**).

an increase in deletion and substitution errors, especially for individuals whose phonological systems are potentially disordered or immature.

In contrast, singleton onsets constitute unmarked syllable positions (recall section 9.1) and should be relatively less vulnerable to error. Regardless of how developed a child's phonological system might be, the deficiencies in these phonological contexts should be less apparent than those in the marked contexts. The weighted scores reflect these results as, for both initial and medial singleton onset positions, there is no clear distinction between the scores of younger or suspected speech-disordered children and those of older children with typical speech. Finally, the five children whose scores are below the median in at least three contexts (including branching onsets and singleton codas) were predominantly part of the suspected speech-disordered group (**D08**, **D10**, **D43**, and **D52**), while **T67** was the only younger child with typical speech. **D09** and **T44** also met most of these criteria, but they each have one singleton onset score that is equal to the median.

This concludes my analysis of the Semi-Directed Narrative. In the next section, I introduce the results of the comparative analysis, which evaluates the relative performance of the children across the five assessments described above.

12. Comparative Analysis

The primary objective of the comparative analysis presented in this section is to establish what relationships exist between the children's scores from each of the assessments in my study. As described in Chapter 3, section 6, I used Spearman correlations to evaluate these relationships. Table 18 below displays the results of the comparative analysis. Each value in this table represents a single correlation between two assessments.

Table 18. Correlations between Developmental Tasks and Phonological Productive Abilities

		Phoneme Isolation	Verbal Fluency		Letter Naming		Picture Naming Task	Semi-Directed Narrative Weighted Score[a]			
		Combined Score	Semantic Associations	Rhyming Words	Total Accuracy	Combined Fluency	Total Accuracy	SingON (Initial)	SingON (Medial)	BranchON	SingCO
Phoneme Isolation	Combined Score	---	---	---	---	---	---	---	---	---	---
Verbal Fluency	Semantic Associations	0.07	---	---	---	---	---	---	---	---	---
	Rhyming Words	0.30	0.22	---	---	---	---	---	---	---	---
Letter Naming	Total Accuracy	0.46*	-0.13	-0.09	---	---	---	---	---	---	---
	Combined Fluency	0.54**	0.28	0.21	0.64***	---	---	---	---	---	---
Picture Naming Task	Total Accuracy	0.57**	0.16	0.38	-0.12	0.17	---	---	---	---	---
Semi-Directed Narrative Weighted Score	SingON (Initial)	-0.32	0.25	-0.09	-0.21	0.07	0.16	---	---	---	---
	SingON (Medial)	-0.07	0.10	-0.16	-0.35	-0.28	-0.21	-0.16	---	---	---
	BranchON	0.43*	-0.05	0.23	-0.01	-0.09	0.33	-0.12	-0.05	---	---
	SingCO[b]	0.52**	-0.11	0.48*	0.04	0.10	0.47*	-0.54**	-0.15	0.30	---
	Legend:	*$p \leq .05$	**$p \leq .01$	*** $p \leq .001$							

Note: All values in this table are Spearman correlations (r_s). Recall that the levels of significance for r_s are: 0.390 ($p < .05$), 0.501 ($p < .01$), and 0.619 ($p < .001$).
[a]SingON = singleton onsets, BranchON = branching onsets, and SingCO = singleton codas.
[b]The negative value for the correlation between singleton onsets (initial) and singleton codas is caused by the weights of the two phonological contexts.

As we can see from this table, 36 of the 45 correlations are relatively weak and are not statistically significant ($r_s < 0.390$, *ns*); the correlation between the Verbal Fluency Rhyming Words and Picture Naming Task scores is the only one in this group that approaches significance ($r_s = 0.38$, $p = .06$). Verbal Fluency Semantic Associations and performance on medial singleton onsets produced during the Semi-Directed Narrative are not significantly correlated with any measures. These results are not surprising, given that 1) Verbal Fluency Semantic Associations is one of the least phonologically-related assessments in the current study; and 2) I previously identified Semi-Directed Narrative medial singleton onsets as an unreliable measure, given the small number of results for this phonological context.

In comparison, nine correlations reach statistical significance. With the exception of Letter Naming Total Accuracy and Combined Fluency ($r_s = 0.64$, $p < .001$; recall section 5.3 above), the correlations that are statistically significant all involve Phoneme Isolation and/or the scores for singleton codas in the Semi-Directed Narrative. With respect to Phoneme Isolation, the scores are significantly correlated with those of both Letter Naming Total Accuracy ($r_s = 0.46$, $p < .05$) and Combined Fluency ($r_s = 0.54$, $p < .01$). Phoneme Isolation is also significantly correlated with three of the five measures of phonological production: Picture Naming Task ($r_s = 0.57$, $p < .01$), Semi-Directed Narrative branching onsets ($r_s = 0.43$, $p < .05$), and Semi-Directed Narrative singleton codas ($r_s = 0.52$, $p < .01$).

With respect to Semi-Directed Narrative singleton codas, in addition to Phoneme Isolation, the scores involve correlations with those of three other measures: Verbal Fluency Rhyming Words ($r_s = 0.48$, $p < .05$), Picture Naming Task ($r_s = 0.47$, $p < .05$), and Semi-Directed Narrative singleton onsets ($r_s = -0.54$, $p < .01$). Although the Semi-Directed Narrative weighted scores for branching onsets appear to be somewhat related (recall section 11), this correlation fails to reach significance ($r_s = 0.30$, *ns*). Finally, the scores of the Semi-Directed Narrative singleton onsets (initial) and singleton codas produce the only statistically significant negative correlation. This negative value originates from the relationship between the weights of the phonological contexts; the lower accuracy scores in singleton codas caused a wider spread in the scores, thereby increasing the strength of this relationship.

This concludes the results and analysis chapter of my thesis. In the next chapter, I discuss some implications emerging from these findings.

Chapter 5: Discussion

1. Introduction

I begin this chapter with an overview of the current study and the measures I used to address my research questions. After I briefly reiterate the most prevalent findings of my study, I identify some limitations affecting the study and make suggestions toward future research.

2. Overview of Thesis

Throughout this thesis, I explored the relationships between performance on three developmental tasks (Phoneme Isolation, Verbal Fluency, and Letter Naming) and two phonological production assessments (Picture Naming Task and Semi-Directed Narrative). The sample studied comprised 26 children who were between the ages of 4 years 11 months and 6 years 2 months at the time of the assessments. In Chapter 4, I described the children's scores separately for each task. In order to determine if the scores on each of the assessments pattern with suspected speech disorder and/or speaker age, I divided the participants into three speaker groups. Finally, to establish whether performance on each of the paired measures is related, I used Spearman correlations. I summarize these results in the next section.

3. Summary of Results

In this section, I divide the primary findings of my study into two parts. I first identify the measures that pattern with speakers who were considered speech-disordered, speakers at a younger age with typical speech, and speakers at an older age with typical speech. I also highlight the measures in which lower scores are associated with the former two speaker groups. I then review the correlations between the measures in my study.

3.1 Performance with Respect to Disordered Speech and Age

Children with disordered speech and younger children with typical speech are more likely to have immature or less developed phonological systems than age-matched children with typical language development or older children, respectively (Ingram 1976; Magnusson 1983; Burt, Holm & Dodd 1999; Carroll et al. 2003). In addition, deficiencies with phonological systems should be more apparent on assessments that involve marked syllable constituents such as branching onsets and syllable codas (see Anthony et al. 2010; Preston, Hull & Edwards 2013). The findings of the current study support these predictions. Overall, the children whose performance is lower on the phonological tasks and measures involving complex syllable components tend to be either those with suspected speech disorders or younger children with typical speech.

In comparison, the performance among the three speaker groups is less distinct on measures that do not involve marked phonological contexts. For instance, for initial singleton onsets in the Semi-Directed Narrative, Total Accuracy scores below 95% are most prevalent with the group of children with suspected speech disorders; however, this trend is not confirmed by the weighted scores for this syllable position.

3.2 Implications of the Correlations

The purpose of the comparative analysis was to determine whether the scores from each of the five tasks compared within the current study are related. With the exception of Letter Naming Total Accuracy and Combined Fluency ($r_s = 0.64$, $p < .001$; recall Chapter 4, section 5.3), all of the statistically significant correlations involve Phoneme Isolation and the Semi-Directed Narrative weighted scores for singleton codas (recall Chapter 4, section 12). In the following paragraphs, I further explore the nature of the relationships among the relevant measures by formulating my interpretations of the correlations obtained through statistical analysis.

Phoneme Isolation is significantly correlated with both Letter Naming Total Accuracy ($r_s = 0.46$, $p < .05$) and Combined Fluency ($r_s = 0.54$, $p < .01$). These results are congruent with the findings of previous studies, and support the argument that the ability to access and manipulate phonological representations of words is related to the retrieval of letter names (Kaminski & Good, III 1996; Muter et al. 1997; Hogan, Catts & Little 2005; Manolitsis & Tafa 2011), which are precursors to reading abilities (Adams 1990; Fowler 1991; Torgesen & Mathes 2000).

Similarly, the trending but non-significant relationships that exist between Verbal Fluency Semantic Associations and Rhyming Words ($r_s = 0.22$, *ns*), and Verbal Fluency and Letter Naming Combined Fluency (Semantic Associations $r_s = 0.28$, *ns*; Rhyming Words $r_s = 0.21$, *ns*) suggest that these tasks rely on retrieval mechanisms involved in accessing phonological representations; however, the tasks differ in terms of the complexity of the retrieval process, as they require access to different levels of phonological representation (Wagner & Torgesen 1987). Other non-phonological factors such as shyness, vocabulary level, and general cognitive processing can also contribute to differences in performance on these tasks (Goldman-Eisler 1964; Spere & Evans 2009; Melby-Lervåg & Hulme 2010).

The general absence of significant relationships that the Verbal Fluency and Letter Naming tasks exhibit with the phonological production measures (Picture Naming Task and Semi-Directed Narrative) suggests that these measures may not be the most direct or effective to address children's phonological representations; performance on Verbal Fluency Rhyming Words, which is the most phonologically-related of these four measures, appears to be the most closely related to phonological abilities in production. These results also do not provide any further clarification of the ambiguous relationship between articulation and Letter Naming discussed in Chapter 2, section 2.2 (Webster, Plante & Couvillion 1997; Mann & Foy 2003; Sutherland & Gillon 2007) and, contrary to Vandewalle et al. (2012), lower scores for Verbal Fluency Semantic Associations are not concentrated in the group of children with suspected speech disorders.

Concerning phonological abilities and performance, immature or deficient phonological systems may yield performance problems, especially in the context of marked phonological strings; as discussed in preceding sections, these include branching onsets and syllable codas (see Mann & Foy 2007; Preston, Hull & Edwards 2013). The data from the current study are a testament to the complex nature of the relationships between phonological markedness and patterns in production. For instance, the scores from Phoneme Isolation correlate significantly with Picture Naming Task ($r_s = 0.57$, $p < .01$), Semi-Directed Narrative branching onsets ($r_s = 0.43$, $p < .05$), and Semi-Directed Narrative singleton codas ($r_s = 0.52$, $p < .01$); all of these measures involve syllable constituents that are considered marked and which are more difficult to perceive and/or produce. The role of markedness is also evidenced by the correlations with Semi-Directed Narrative singleton codas as, in addition to Phoneme Isolation, this measure correlates with Verbal Fluency Rhyming Words ($r_s = 0.48$, $p < .05$) and Picture Naming Task ($r_s = 0.47$, $p < .05$). In contrast, the significant correlation between Semi-Directed Narrative singleton onsets and singleton codas ($r_s = -0.54$, $p < .01$) appears to be an artifact of the methodology in the current study.[31] Semi-Directed Narrative weighted scores for branching onsets and singleton codas are somewhat correlated but this relationship is not significant ($r_s = 0.30$, *ns*); considering that the sample size for branching onsets is relatively limited, a larger sample of branching onsets in production would likely have produced a stronger relationship. In addition, the children's performance on singleton codas in the Semi-Directed Narrative is related

31 Recall that this value is negative due to the weights of the two phonological contexts.

to the accuracy of the sequences in the Picture Naming Task; as discussed in the previous section, lower scores on both measures are generally associated with the children with suspected speech disorders and younger children with typical speech.

In addition to the general challenges inherent to assessments with children in the school system, the current study encountered a number of limitations. I address the most prevalent of these in the next section.

4. Limitations of Current Study and Recommendations for Future Research

4.1 Quality of Sound Files

The data from the current study come from a previous study, with all recordings and assessments conducted prior to the start of my thesis project. The digital recorders that the researchers used were unfortunately not ideal for phonological or acoustic analysis. For instance, many recordings contained muffled segments, and the dynamic frequency range of the recording devices made detecting and/or differentiating certain phones challenging, particularly for the fricatives [f], [θ], [s], [z], and [ʃ]. The quality of the recordings was also not the most conducive to the S-LP's language assessments.

Due to the nature of the testing sites, the recordings also contained background noise and other distractions that interfered with the children's speech samples. In addition, the issue of overlapping speech arose when both the child and researcher spoke at the same time. In some cases, these factors inhibited data transcription and analysis, which at times meant that data had to be excluded. For future studies, controlling for these confounds and using a higher-quality recording system with a larger dynamic frequency range would better facilitate data transcription and analysis of the sound files.

4.2 Research Design

As described in Chapter 4, section 1, the data used in my study are cross-sectional. This means that each assessment was administered once over a relatively short period of time and, in some cases, the children required multiple sessions to complete the components of an assessment. In the context of my study, the advantages of this method include 1) assessing more participants in a relatively limited time frame; 2) enabling comparisons of each child's performance at a particular stage in development; and 3) facilitating the analysis of group trends. In contrast, the most prevalent constraint of this research design is that it does not provide any indication of how the children's linguistic skills develop on an individual level over time. Furthermore, if the child was tired, hungry, or generally distracted on a given day, the performance on the tasks may not be the most accurate representation of the child's potential abilities.

In order to assess the developmental progress of each child on every measure, researchers would need to repeat the assessments using a predetermined time interval. For instance, children could be assessed at the beginning of kindergarten, then reassessed in the final months of kindergarten. In addition, different words with similar phonological constructions could be used at each interval. This procedure would allow researchers to verify whether the correlations between measures are comparable at different stages of development, while also controlling for potential familiarity effects caused by repeated testing. Finally, better controlling for the child's overall level of comfort and repeating a similar task over a given period of time could help to ensure the consistency and accuracy of our assessments of the children's linguistic abilities.

4.3 Information about the Participants

The participant data from the Penney study are limited to the age (birthdate and testing date) and biological sex of the children. Other details pertaining to the speaker profiles would have been useful in some aspects of the data interpretation. For example, while not part of the speaker profiles, potential non-English L1 influences were identified by staff members or administrators at the testing locations (recall from Chapter 3, section 2 that no more specific information was available). Non-English L1 influences were only identified for two children, **D11** and **T18**. In the case of **D11**, the S-LP was not informed of the child's linguistic background prior to conducting her assessment; language influence is, however, essential in explaining the variations in this child's performance. For instance, **D11** obtained the highest score for Phoneme Isolation (37/42 correct responses) and did not make any Letter Naming errors. In contrast, this participant has one of the lowest scores for both Verbal Fluency measures and performance of singleton codas in the Semi-Directed Narrative. Considering that Verbal Fluency is vocabulary-dependent and performance on the Semi-Directed Narrative may reflect restrictions related to this child's first language (e.g. if this language does not allow codas or restricts the phones that can be produced in this syllable position), the child's performance on these tasks is more likely a product of being a second-language learner and should not be mistaken for deficient language skills (see Anthony, Aghara, Solari, et al. 2011; Scarpino et al. 2011; Core et al. 2013).

In contrast, except for Verbal Fluency Semantic Associations, **T18** is generally among the children with mid to high scores across most tasks; this could be due to a more prolonged exposure to English, another piece of information that was missing from this speaker's profile. In summary, given the methodologies of the current study, variation that is attributable to non-English L1 influences could underestimate or overestimate the correlations, depending on the task or phonological context. I did not explore the extent to which these influences affected the scores, as this lies beyond the scope of my study. For future research, all language influences should be identified prior to the assessments. Furthermore, the scores for second-language speakers may need to be considered separately from those of L1 English learners.

In addition to non-English L1 influences, I excluded social factors and biological sex from my analysis. Information pertaining to social factors, including socioeconomic status, was not collected from the parents/guardians of the children; apart from the dialectal influences that I identified in Chapter 3, section 5.3, I therefore could not consider any other sociolinguistic influences as part of my analysis. While social factors could help to explain why some children score lower on certain assessments or produce lower scores overall, this question falls outside the current scope of my study. Similarly, although biological sex may contribute to the individual scores of the children, it was not directly pertinent to my research question. The degree to which these social factors affect the results could be addressed through further research.

4.4 Sample Size

The current study includes 26 children, which is a relatively small sample size; despite this limitation, however, significant correlations are present between the different measures. To explore the external validity of the findings, researchers could expand the sample to include more participants from different regions of the province and/or country. Replicating these data on a larger scale would help to verify the validity of both the relationships found in the current study and the implications of these tasks as potential screening measures for children at risk of language and/or reading impairment.

In addition to the population sample size, some of the tasks are limited in terms of the amount of data they can generate. For instance, the Onsets part of Phoneme Isolation comprises six stimuli with singleton onsets and six with branching onsets. In comparison, the Codas task contains 18 singleton codas. The results show that the combined Phoneme Isolation scores correlate with both performance of branching onsets and singleton codas in the Semi-Directed Narrative. The nature of this relationship could be further clarified by comparing the scores for these syllable positions separately (e.g. through exploring the correlation between isolation of branching onsets in the Phoneme Isolation task and performance of branching onsets in the Semi-Directed Narrative). The amount of data with singleton codas for both tasks is sufficient to answer this question, but the six branching onsets in Phoneme Isolation do not provide enough contrast to differentiate the performance of each participant (recall also that the number of productions of branching onsets in the Semi-Directed Narrative is limited compared to singleton codas).[32] In order for this question to be fully considered, a separate task could be devoted to the isolation of branching onsets. Furthermore, to effectively distinguish the performance of the children, I would suggest a minimum of 15 to 20 words for both branching onsets and singleton codas Phoneme Isolation tasks. This would potentially help to verify whether the mastery of this skill is related to the emergence of accurate articulations of branching onsets in speech production.

Similarly, the Picture Naming Task scores are based on 12 words in isolation. A consequence of this is that even a small number of errors noticeably affects the children's scores, such that the contrast between children with suspected speech disorders and younger children with typical speech is not always apparent. In addition, singleton consonantal positions are more represented in the data than clusters (recall Table 2 on page 22 and Table 9 on page 56). A task that encompasses a wider range of stimuli, including more words with complex onsets and codas, would provide a more representative sample of the children's phonological abilities in production. For example, Preston & Edwards (2010) used a 125-word picture identification task in their assessment of preschool children's phonological abilities. In the context of the current study, a sample size of this magnitude could have been more effective in differentiating the

32 In my exploration of this question, I discovered that the scores for CODAS in Phoneme Isolation are significantly correlated with the weighted scores for singleton codas in the Semi-Directed Narrative; in contrast, the singleton onsets and branching onsets scores for these tasks do not appear to be related.

children who were considered speech-disordered from those with typical speech who were younger. Furthermore, this could potentially strengthen the non-significant correlations that the Picture Naming Task exhibits against the other phonological measures, specifically Verbal Fluency Rhyming Words and for branching onsets in the Semi-Directed Narrative.

4.5 Data Analysis

With respect to the data analysis, my interpretation and scoring methods represent only one of many possibilities. In this section, I discuss a few of the most prevalent methods that could influence the outcome of this study. With respect to the scoring of the Verbal Fluency Rhyming Words and Letter Naming tasks, I adhered to a strict approach; recall that I did not accept non-word responses for Verbal Fluency Rhyming Words or indecisive guesses such as *D*/*B* for *D* in Letter Naming. A more lenient approach in which these scores were accepted would have increased the raw scores and could have produced different results with the comparative analysis. Similarly, employing a different equation to calculate Letter Naming Fluency (e.g. total of correct upper- and lower-case letters divided by the combined time to complete both tasks), would produce different scores for this measure and could have an effect on the strengths of the correlations.

For the calculations of the weighted scores, I removed sC clusters and branching codas from the analysis altogether; the weight of potential consonant or cluster effects in these contexts was therefore redistributed among the four remaining syllable positions.[33] In addition to potentially affecting the strength of the correlations between measures, this restricts this analysis to (C)CVC syllables. Even if sC clusters and branching codas are not considered further as part of the analysis, it would minimally be worth exploring whether reserving their weights as

33 Before sC onsets and branching codas were removed, they represented approximately 10% of all consonants.

place-holders (i.e. calculating the weights of these phonological contexts but not considering the weighted scores) could produce a different outcome from the current analysis.

Finally, in my assignment of the three speaker groups, I consider the children who were identified as speech-disordered as one homogenous group. However, this categorization does not differentiate among potential sources or types of disorder (see Magnusson 1983; Forrest, Dinnsen & Elbert 1997; Dyck & Piek 2010). For instance, a child whose speech disorder is caused by poor motor control rather than deficient phonological representations could score relatively higher on Phoneme Isolation than children with representative deficits. In contrast, a child whose speech disorder lies in phonological representation would presumably produce lower scores on both Phoneme Isolation and phonological production measures. Differences in the sources of children's speech issues could also explain the variation in performance by members of the suspected speech-disordered group across measures. The same reasoning can also be extended to the participants with other language influences, as previously discussed.

5. Future Directions

The results of the current study suggest that the majority of the significant correlations between measures may be attributable to phonological processes involved across these measures, but the extent to which this contributes to the correlations between measures remains unclear. Similarly, lower scores on the assessments that rely more strongly on these processes (Phoneme Isolation, Picture Naming Task, and performance of branching onsets and singleton codas in the Semi-Directed Narrative) relate to children who exhibited disordered speech patterns and younger children with typical speech. Although I identified trends among these speaker groups for these measures, I did not investigate whether these differences are statistically significant. This question, as well as the significance of the effect that age and time in kindergarten have on the scores, fall outside the scope of the current study. Additional analyses could ideally help us to determine the significance of these factors, as well as the nature of the relationships observed between performance levels across different linguistic tasks.

Finally, a larger sample size with more geographical variation would reduce the potential confound of dialect. In addition to verifying the findings of the current study, including more participants would help to explore the effectiveness and efficiency of these assessments as screening methods for phonological disorders. Likewise, a more linguistically diverse sample could also reveal whether non-English L1 speakers and speech-disordered children have discernible characteristics in performance on these tasks that distinguish them from native English speakers with typically-developing speech and language abilities. Together, these improvements over current methods could ultimately provide insight into additional factors that influence the performance of different speaker groups on these tasks.

6. Conclusion

The strongest observation emerging from the current study is arguably that the phonological behaviours exhibited by members of specific speaker groups tend to be more divergent in the context of marked phonological structures. The results of this thesis support previous findings that performance of these syllable positions can be taken as useful indicators of less mature phonological systems. These results thus suggest that phonologically marked structures are central to the evaluation of phonological abilities and, by extension, offer an enticing promise toward further development of speech assessments for the early detection of phonological disorders.

References

Adams, Marilyn J. 1990. *Beginning to read: Thinking and learning about print*. Cambridge, MA: MIT Press.

Aguilar-Mediavilla, Eva, Lucía Buil-Legaz, Josep A. Pérez-Castelló, Eduard Rigo-Carratalà & Daniel Adrover-Roig. 2014. Early preschool processing abilities predict subsequent reading outcomes in bilingual Spanish–Catalan children with Specific Language Impairment (SLI). *Journal of Communication Disorders* 50. 19–35. doi:10.1016/j.jcomdis.2014.03.003.

Alegria, Jesus, Elisabeth Pignot & José Morais. 1982. Phonetic analysis of speech and memory codes in beginning readers. *Memory & Cognition* 10(5). 451–456.

Algeo, John. 1978. What consonant clusters are possible? *WORD* 29(3). 206–224. doi:10.1080/00437956.1978.11435661.

Anthony, Jason L., Rachel G. Aghara, Martha J. Dunkelberger, Teresa I. Anthony, Jeffrey M. Williams & Zhou Zhang. 2011. What factors place children with speech sound disorders at risk for reading problems? *American Journal of Speech-Language Pathology* 20(2). 146–160. doi:10.1044/1058-0360(2011/10-0053).

Anthony, Jason L., Rachel G. Aghara, Emily J. Solari, Martha J. Dunkelberger, Jeffrey M. Williams & Lan Liang. 2011. Quantifying phonological representation abilities in Spanish-speaking preschool children. *Applied Psycholinguistics* 32(1). 19–49. doi:10.1017/S0142716410000275.

Anthony, Jason L., Jeffrey M. Williams, Rachel G. Aghara, Martha Dunkelberger, Barbara Novak & Anuja Divatia Mukherjee. 2010. Assessment of individual differences in phonological representation. *Reading and Writing* 23(8). 969–994. doi:10.1007/s11145-009-9185-7.

Ardila, Alfredo, Feggy Ostrosky−Solís & Byron Bernal. 2006. Cognitive testing toward the future: The example of Semantic Verbal Fluency (ANIMALS). *International Journal of Psychology* 41(5). 324–332. doi:10.1080/00207590500345542.

Ball, Eileen W. 1993. Assessing phoneme awareness. *Language, Speech, and Hearing Services in Schools* 24(3). 130–139.

Barlow, Jessica A. 1997. A constraint-based account of syllable onsets: Evidence from developing systems. Indiana University Ph.D. dissertation.

Battistella, Edwin L. 1990. *Markedness: The evaluative superstructure of language*. Albany, NY: State University of New York Press.

Bird, Judith, Dorothy V. M. Bishop & Norman H. Freeman. 1995. Phonological awareness and literacy development in children with expressive phonological impairments. *Journal of Speech and Hearing Research* 38(2). 446–462.

Blaiklock, Ken E. 2004. The importance of letter knowledge in the relationship between phonological awareness and reading. *Journal of Research in Reading* 27(1). 36–57. doi:10.1111/j.1467-9817.2004.00213.x.

Blevins, Juliette. 1995. The syllable in phonological theory. In John A. Goldsmith (ed.), *The handbook of phonological theory*, 206–244. Cambridge, MA: Blackwell.

Brown, Roger. 1973. *A first language: The early stages*. Cambridge, MA: Harvard University Press.

Bruce, D. J. 1964. The analysis of word sounds by young children. *British Journal of Educational Psychology* 34(2). 158–170. doi:10.1111/j.2044-8279.1964.tb00620.x.

Burt, Lucy, Alison Holm & Barbara Dodd. 1999. Phonological awareness skills of 4-year-old British children: An assessment and developmental data. *International Journal of Language & Communication Disorders* 34(3). 311–335.

Calfee, Robert C. 1977. Assessment of independent reading skills: Basic research and practical applications. In A. S. Reber & D. L. Scarborough (eds.), *Toward a psychology of reading*, 289–323. Hillsdale, NJ: Erlbaum Associates.

Carroll, Julia M., Margaret J. Snowling, Charles Hulme & Jim Stevenson. 2003. The development of phonological awareness in preschool children. *Developmental Psychology* 39(5). 913–923. doi:10.1037/0012-1649.39.5.913.

Castiglioni-Spalten, Maria L. & Linnea C. Ehri. 2003. Phonemic awareness instruction: Contribution of articulatory segmentation to novice beginners' reading and spelling. *Scientific Studies of Reading* 7(1). 25–52. doi:10.1207/S1532799XSSR0701_03.

Chard, David J. & Shirley V. Dickson. 1999. Phonological awareness: Instructional and assessment guidelines. *Intervention in School and Clinic* 34(5). 261–270.

Clarke, Sandra. 2010a. *Newfoundland and Labrador English*. (Dialects of English). Edinburgh: Edinburgh University Press.

Clarke, Sandra. 2010b. *A Newfoundland and Labrador English bibliography*. St. John's, NL: Linguistics Department, Memorial University. http://www.mun.ca/linguistics/research/language/NL_English_bibliography.pdf.

Clements, George N. 1990. The role of the sonority cycle in core syllabification. In John Kingston & Mary E. Beckman (eds.), *Between the grammar and physics of speech*, 283–333. (Papers in Laboratory Phonology I). Cambridge: Cambridge University Press.

Clements, George N. & Samuel Jay Keyser. 1983. *CV phonology: A generative theory of the syllable*. Cambridge, MA: MIT Press.

Core, Cynthia, Erika Hoff, Rosario Rumiche & Melissa Señor. 2013. Total and conceptual vocabulary in Spanish-English bilinguals from 22 to 30 months: Implications for assessment. *Journal of Speech, Language, and Hearing Research* 56(5). 1637–1649. doi:10.1044/1092-4388(2013/11-0044).

Cronin, Virginia S. 2013. RAN and double-deficit theory. *Journal of Learning Disabilities* 46(2). 182–190. doi:10.1177/0022219411413544.

Davis, Stuart & Michael Hammond. 1995. On the status of onglides in American English. *Phonology* 12(2). 159–182. doi:10.1017/S0952675700002463.

Demuth, Katherine, Jennifer Culbertson & Jennifer Alter. 2006. Word-minimality, epenthesis and coda licensing in the early acquisition of English. *Language and Speech* 49(2). 137–174.

Demuth, Katherine & E. Jane Fee. 1995. Minimal prosodic words in early phonological development. Unpublished manuscript. Brown University, Providence, RI, Dalhousie University, Halifax, Nova Scotia, Canada, ms. https://ling.mq.edu.au/cll/publications/1995%20Demuth%20&%20Fee%20Minimal%20Prosodic.pdf.

Demuth, Katherine & Elizabeth McCullough. 2009. The prosodic (re)organization of children's early English articles. *Journal of Child Language* 36(1). 173–200. doi:10.1017/S0305000908008921.

Dörnyei, Zoltán. 2007. *Research methods in applied linguistics: Quantitative, qualitative, and mixed methodologies*. Oxford; New York: Oxford University Press.

Dyck, Murray & Jan Piek. 2010. How to distinguish normal from disordered children with poor language or motor skills. *International Journal of Language & Communication Disorders* 45(3). 336–344. doi:10.3109/13682820903009503.

Edwards, Jan, Mary E. Beckman & Benjamin Munson. 2004. The interaction between vocabulary size and phonotactic probability effects on children's production accuracy and fluency in nonword repetition. *Journal of Speech, Language, and Hearing Research* 47(2). 421–436.

Ettlinger, Marc & Jennifer Zapf. 2011. The role of phonology in children's acquisition of the plural. *Language Acquisition* 18(4). 294–313. doi:10.1080/10489223.2011.605044.

Fikkert, Paula. 1994. *On the acquisition of prosodic structure*. (HIL Dissertations in Linguistics 6). The Hague: Holland Academic Graphics.

Forrest, Karen, Daniel A. Dinnsen & Mary Elbert. 1997. Impact of substitution patterns on phonological learning by misarticulating children. *Clinical Linguistics & Phonetics* 11(1). 63–76. doi:10.1080/02699209708985183.

Fowler, Anne E. 1991. How early phonological development might set the stage for phoneme awareness. In Susan A. Brady & Donald P. Shankweiler (eds.), *Phonological processes in literacy: A tribute to Isabelle Y. Liberman*, 97–117. Hillsdale, NJ: Lawrence Erlbaum Associates.

Fox, Barbara & Donald K. Routh. 1975. Analyzing spoken language into words, syllables, and phonemes: A developmental study. *Journal of Psycholinguistic Research* 4(4). 331–342.

Foy, Judith G. & Virginia A. Mann. 2001. Does strength of phonological representations predict phonological awareness in preschool children? *Applied Psycholinguistics* 22(3). 301–325.

Gass, Susan. 2010. Experimental research. In Brian Paltridge & Aek Phakiti (eds.), *Continuum companion to research methods in applied linguistics*, 7–21. London: Continuum International Publishing Group.

Goad, Heather. 2012. sC clusters are (almost always) coda-initial. *The Linguistic Review* 29(3). 335–373. doi:10.1515/tlr-2012-0013.

Goad, Heather & Yvan Rose. 2004. Input elaboration, head faithfulness, and evidence for representation in the acquisition of left-edge clusters in West Germanic. In René Kager, Joe Pater & Wim Zonneveld (eds.), *Constraints in phonological acquisition*, 109–157. Cambridge: Cambridge University Press.

Goldman-Eisler, Frieda. 1964. Hesitation, information, and levels of speech production. In A. V. S. de Reuck & Maeve O'Connor (eds.), *Disorders of Language*, 96–114. Boston: Little, Brown.

Gombert, Jean Émile. 1992. *Metalinguistic development*. Chicago: University of Chicago Press.

Goswami, Usha & Peter Bryant. 1990. *Phonological skills and learning to read*. (Essays in Developmental Psychology). Hove, UK: Lawrence Erlbaum Associates.

Gravetter, Frederick J. & Larry B. Wallnau. 2009. *Statistics for the behavioral sciences (8th edition)*. Belmont, CA: Wadsworth, Cengage Learning.

Helfgott, Joan A. 1976. Phonemic segmentation and blending skills of kindergarten children: Implications for beginning reading acquisition. *Contemporary Educational Psychology* 1(2). 157–169. doi:10.1016/0361-476X(76)90020-5.

Hogan, Tiffany P., Hugh W. Catts & Todd D. Little. 2005. The relationship between phonological awareness and reading: Implications for the assessment of phonological awareness. *Language, Speech, and Hearing Services in Schools* 36(4). 285–293.

Huffman, Marie K. 2005. Segmental and prosodic effects on coda glottalization. *Journal of Phonetics* 33(3). 335–362. doi:10.1016/j.wocn.2005.02.004.

Hultzén, Lee S. 1965. Consonant clusters in English. *American Speech* 40(1). 5–19.

Ingram, David. 1976. *Phonological disability in children*. London: Edward Arnold.

Inkelas, Sharon & Yvan Rose. 2007. Positional neutralization: A case study from child language. *Language* 83(4). 707–736.

Itô, Junko. 1988. *Syllable theory in prosodic phonology*. (Outstanding Dissertations in Linguistics). New York: Garland.

Kahn, Daniel. 1976. *Syllable-based generalizations in English phonology*. Bloomington, IN: Indiana University Linguistics Club.

Kaminski, Ruth A. & Roland H. Good, III. 1996. Toward a technology for assessing basic early literacy skills. *School Psychology Review* 25(2). 215–227.

Kehoe, Margaret & Carol Stoel-Gammon. 1997. Truncation patterns in English-speaking children's word productions. *Journal of Speech, Language, and Hearing Research* 40(3). 526–541.

Kessler, Brett & Rebecca Treiman. 1997. Syllable structure and the distribution of phonemes in English syllables. *Journal of Memory and Language* 37(3). 295–311. doi:10.1006/jmla.1997.2522.

Kuhn, Melanie R., Paula J. Schwanenflugel & Elizabeth B. Meisinger. 2010. Aligning theory and assessment of reading fluency: Automaticity, prosody, and definitions of fluency. (Ed.) Betty Ann Levy & Timothy V. Rasinski. *Reading Research Quarterly* 45(2). 230–251. doi:10.1598/RRQ.45.2.4.

Ladefoged, Peter & Ian Maddieson. 1996. *The sounds of the world's languages*. Oxford: Blackwell.

Liberman, Isabelle Y., Donald Shankweiler, F. William Fischer & Bonnie Carter. 1974. Explicit syllable and phoneme segmentation in the young child. *Journal of Experimental Child Psychology* 18(2). 201–212. doi:10.1016/0022-0965(74)90101-5.

Lin, Susan & Katherine Demuth. 2015. Children's acquisition of English onset and coda /l/: Articulatory evidence. *Journal of Speech, Language, and Hearing Research* 58(1). 13–27. doi:10.1044/2014_JSLHR-S-14-0041.

Linklater, Danielle L., Rollanda E. O'Connor & Gregory J. Palardy. 2009. Kindergarten literacy assessment of English only and English language learner students: An examination of the predictive validity of three phonemic awareness measures. *Journal of School Psychology* 47(6). 369–394. doi:10.1016/j.jsp.2009.08.001.

Macken, Marlys A. & David Barton. 1980. The acquisition of the voicing contrast in English: A study of voice onset time in word-initial stop consonants. *Journal of Child Language* 7(1). 41–74. doi:10.1017/S0305000900007029.

Magnusson, Eva. 1983. *The phonology of language disordered children: Production, perception, and awareness*. (Travaux de l'Institut de Linguistique de Lund XVII). Lund, Sweden: CWK Gleerup.

Mann, Virginia A. 1986. Phonological awareness: The role of reading experience. *Cognition* 24(1). 65–92. doi:10.1016/0010-0277(86)90005-3.

Mann, Virginia A. & Judith G. Foy. 2003. Phonological awareness, speech development, and letter knowledge in preschool children. *Annals of Dyslexia* 53(1). 149–173.

Mann, Virginia A. & Judith G. Foy. 2007. Speech development patterns and phonological awareness in preschool children. *Annals of Dyslexia* 57(1). 51–74.

Manolitsis, George & Eufimia Tafa. 2011. Letter-name letter-sound and phonological awareness: Evidence from Greek-speaking kindergarten children. *Reading and Writing* 24(1). 27–53. doi:10.1007/s11145-009-9200-z.

Mateus, Maria Helena & Ernesto d'Andrade. 2000. *The phonology of Portuguese*. (The Phonology of the World's Languages). Oxford; New York: Oxford University Press.

Mayer, Mercer. 1969. *Frog, where are you?* New York: Dial Books for Young Readers.

McBride-Chang, Catherine, Phil D. Liu, Terry Wong, Anita Wong & Hua Shu. 2012. Specific reading difficulties in Chinese, English, or both: Longitudinal markers of phonological awareness, morphological awareness, and RAN in Hong Kong Chinese children. *Journal of Learning Disabilities* 45(6). 503–514. doi:10.1177/0022219411400748.

Melby-Lervåg, Monica & Charles Hulme. 2010. Serial and free recall in children can be improved by training: Evidence for the importance of phonological and semantic representations in immediate memory tasks. *Psychological Science* 21(11). 1694–1700. doi:10.1177/0956797610385355.

Moyle, Maura Jones, John Heilmann & S. Sue Berman. 2013. Assessment of early developing phonological awareness skills: A comparison of the preschool individual growth and development indicators and the phonological awareness and literacy screening–preK. *Early Education and Development* 24(5). 668–686. doi:10.1080/10409289.2012.725620.

Muter, Valerie, Charles Hulme, Margaret Snowling & Sara Taylor. 1997. Segmentation, not rhyming, predicts early progress in learning to read. *Journal of Experimental Child Psychology* 65(3). 370–396.

Nation, Kate & Charles Hulme. 1997. Phonemic segmentation, not onset-rime segmentation, predicts early reading and spelling skills. *Reading Research Quarterly* 32(2). 154–167.

Núñez-Cedeño, Rafael. 2007. The acquisition of Spanish codas: A frequency/sonority approach. *Hispania* 90(1). 147–163. doi:10.2307/20063476.

Pater, Joe & Jessica A. Barlow. 2003. Constraint conflict in cluster reduction. *Journal of Child Language* 30(3). 487–526. doi:10.1017/S0305000903005658.

Polo Cano, Nuria. 2013. Interacción del desarrollo fonológico y morfológico en la adquisición del español: el desarrollo de las codas en la lengua materna. Madrid: Universidad Complutense de Madrid Ph.D. dissertation.

Preston, Jonathan & Mary Louise Edwards. 2010. Phonological awareness and types of sound errors in preschoolers with speech sound disorders. *Journal of Speech, Language, and Hearing Research* 53(1). 44–60.

Preston, Jonathan L., Margaret Hull & Mary Louise Edwards. 2013. Preschool speech error patterns predict articulation and phonological awareness outcomes in children with histories of speech sound disorders. *American Journal of Speech-Language Pathology* 22(2). 173–184. doi:10.1044/1058-0360(2012/12-0022).

R Core Team. 2017. *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. https://www.R-project.org.

Read, Charles, Zhang Yun-Fei, Nie Hong-Yin & Ding Bao-Qing. 1986. The ability to manipulate speech sounds depends on knowing alphabetic writing. *Cognition* 24(1). 31–44. doi:10.1016/0010-0277(86)90003-X.

Rose, Yvan. 2000. Headedness and prosodic licensing in the L1 acquisition of phonology. Montréal, Canada: McGill University Ph.D. dissertation.

Rose, Yvan. 2009. Internal and external influences on child language productions. In François Pellegrino, Egidio Marsico, Ioana Chitoran & Christophe Coupé (eds.), *Approaches to phonological complexity*, 329–351. Berlin: Mouton de Gruyter.

Rose, Yvan & Brian MacWhinney. 2014. The PhonBank project: Data and software-assisted methods for the study of phonology and phonological development. In Jacques Durand, Ulrike Gut & Gjert Kristoffersen (eds.), *The Oxford handbook of corpus phonology*, 380–401. Oxford: Oxford University Press.

Rose, Yvan, Brian MacWhinney, Rodrigue Byrne, Gregory Hedlund, Keith Maddocks, Philip O'Brien & Todd Wareham. 2006. Introducing Phon: A software solution for the study of phonological acquisition. In David Bamman, Tatiana Magnitskaia & Colleen Zaller (eds.), *Proceedings of the 30th annual Boston university conference on language development*, 489–500. Somerville, MA: Cascadilla Press.

Rosner, Jerome & Dorothea P. Simon. 1971. The auditory analysis test: An initial report. *Journal of Learning Disabilities* 4(7). 384–392. doi:10.1177/002221947100400706.

Runge, Timothy J. & Marley W. Watkins. 2006. The structure of phonological awareness among kindergarten students. *School Psychology Review* 35(3). 370–386.

Rvachew, Susan. 2006. Longitudinal predictors of implicit phonological awareness skills. *American Journal of Speech-Language Pathology* 15(2). 165–176.

Scarpino, Shelley E., Frank R. Lawrence, Megan D. Davison & Carol S. Hammer. 2011. Predicting bilingual Spanish-English children's phonological awareness abilities from their preschool English and Spanish oral language: Predicting bilingual phonological awareness. *Journal of Research in Reading* 34(1). 77–93. doi:10.1111/j.1467-9817.2010.01488.x.

Selkirk, Elisabeth O. 1982. The syllable. In Harry van der Hulst & Norval Smith (eds.), *The structure of phonological representations*, vol. 2, 337–383. Dordrecht, The Netherlands: Foris.

Shriberg, Lawrence D. 1993. Four new speech and prosody-voice measures for genetics research and other studies in developmental phonological disorders. *Journal of Speech and Hearing Research* 36(1). 105–140.

Shriberg, Lawrence D. & Joan Kwiatkowski. 1980. *Natural process analysis (NPA): A procedure for phonological analysis of continuous speech samples*. New York: John Wiley & Sons.

Smit, Ann Bosma. 1993a. Phonologic error distributions in the Iowa-Nebraska articulation norms project: Consonant singletons. *Journal of Speech and Hearing Research* 36(3). 533–547.

Smit, Ann Bosma. 1993b. Phonologic error distributions in the Iowa-Nebraska articulation norms project: Word-initial consonant clusters. *Journal of Speech and Hearing Research* 36(5). 931–947.

Smith, Neilson V. 1973. *The acquisition of phonology: A case study*. Cambridge: Cambridge University Press.

Solé, Maria-Josep. 2010. Effects of syllable position on sound change: An aerodynamic study of final fricative weakening. *Journal of Phonetics* 38(2). 289–305. doi:10.1016/j.wocn.2010.02.001.

Song, Jae Yung, Stefanie Shattuck-Hufnagel & Katherine Demuth. 2015. Development of phonetic variants (allophones) in 2-year-olds learning American English: A study of alveolar stop /t, d/ codas. *Journal of Phonetics* 52. 152–169. doi:10.1016/j.wocn.2015.06.003.

Spere, Katherine & Mary Ann Evans. 2009. Shyness as a continuous dimension and emergent literacy in young children: Is there a relation? *Infant and Child Development* 18(3). 216–237.

Stanovich, Keith E., Anne E. Cunningham & Barbara B. Cramer. 1984. Assessing phonological awareness in kindergarten children: Issues of task comparability. *Journal of Experimental Child Psychology* 38(2). 175–190. doi:10.1016/0022-0965(84)90120-6.

Sutherland, Dean & Gail T. Gillon. 2005. Assessment of phonological representations in children with speech impairment. *Language, Speech, and Hearing Services in Schools* 36(4). 294–307.

Sutherland, Dean & Gail T. Gillon. 2007. Development of phonological representations and phonological awareness in children with speech impairment. *International Journal of Language & Communication Disorders* 42(2). 229–250. doi:10.1080/13682820600806672.

Swanson, H. Lee, Guy Trainin, Denise M. Necoechea & Donald D. Hammill. 2003. Rapid naming, phonological awareness, and reading: A meta-analysis of the correlation evidence. *Review of Educational Research* 73(4). 407–440. doi:10.3102/00346543073004407.

Templin, Mildred C. 1957. *Certain language skills in children: Their development and interrelationships*. Minneapolis, MN: University of Minnesota Press.
Thomas, Eleanor & Monique Sénéchal. 2004. Long-term association between articulation quality and phoneme sensitivity: A study from age 3 to age 8. *Applied Psycholinguistics* 25(4). 513–541.
Torgesen, Joseph K. & Patricia G. Mathes. 2000. *A basic guide to understanding, assessing, and teaching phonological awareness*. Austin, TX: PRO-ED.
Vandewalle, Ellen, Bart Boets, Tinne Boons, Pol Ghesquière & Inge Zink. 2012. Oral language and narrative skills in children with specific language impairment with and without literacy delay: A three-year longitudinal study. *Research in Developmental Disabilities* 33(6). 1857–1870. doi:10.1016/j.ridd.2012.05.004.
Wagner, Richard K. & Joseph K. Torgesen. 1987. The nature of phonological processing and its causal role in the acquisition of reading skills. *Psychological Bulletin* 101(2). 192–212.
Wagner, Richard K., Joseph K. Torgesen, Carol A. Rashotte, Steve A. Hecht, Theodore A. Barker, Stephen R. Burgess, John Donahue & Tamara Garon. 1997. Changing relations between phonological processing abilities and word-level reading as children develop from beginning to skilled readers: A 5-year longitudinal study. *Developmental Psychology* 33(3). 468–479. doi:10.1037/0012-1649.33.3.468.
Webster, Penelope E., Amy Solomon Plante & L. Michael Couvillion. 1997. Phonologic impairment and prereading: Update on a longitudinal study. *Journal of Learning Disabilities* 30(4). 365–375.
Wolk, Lesley, Mary Louise Edwards & Edward G. Conture. 1993. Coexistence of stuttering and disordered phonology in young children. *Journal of Speech and Hearing Research* 36(5). 906–917.
Yopp, Hallie Kay. 1988. The validity and reliability of phonemic awareness tests. *Reading Research Quarterly* 23(2). 159–177. doi:10.2307/747800.
Zamuner, Tania S., Louann Gerken & Michael Hammond. 2004. Phonotactic probabilities in young children's speech production. *Journal of Child Language* 31(3). 515–536. doi:10.1017/S0305000904006233.
Zamuner, Tania S., Annemarie Kerkhoff & Paula Fikkert. 2012. Phonotactics and morphophonology in early child language: Evidence from Dutch. *Applied Psycholinguistics* 33(3). 481–499. doi:10.1017/S0142716411000440.
Zar, Jerrold H. 1972. Significance testing of the Spearman rank correlation coefficient. *Journal of the American Statistical Association* 67(339). 578–580. doi:10.2307/2284441.
Zec, Draga. 1995. Sonority constraints on syllable structure. *Phonology* 12(1). 85–129.
Zifcak, Michael. 1981. Phonological awareness and reading acquisition. *Contemporary Educational Psychology* 6(2). 117–126.

Appendix A: Phoneme Isolation Scores

Participant	Time in Kindergarten (Months)	Rimes	Onsets	Codas	Combined Score
T02	6	0	7	15	22
D05	6	0	8	17	25
D08	7	0	10	0	10
D09	7	0	0	3	3
D10	7	0	5	6	11
D11	7	10	11	16	37
T12	7	11	7	18	36
T17	7	7	5	11	23
T18	7	0	8	17	25
T19	7	0	8	9	17
T21	8	11	7	10	28
T22	1	0	6	13	19
D23	-1	2	10	0	12
T34	2	1	3	1	5
D37	8	4	5	15	24
D38	8	0	8	8	16
T42	2	0	10	16	26
D43	3	2	0	0	2
T44	2	0	7	1	8
T49	3	4	6	13	23
D52	4	2	6	18	26
T55	4	0	6	17	23
T58	5	0	6	17	23
T65	8	8	7	12	27
T67	8	2	0	0	2
T68	8	10	6	16	32

Appendix B: Verbal Fluency Combined Scores

Participant	Time in Kindergarten (Months)	Semantic Associations	Rhyming Words
T02	6	11	6
D05	6	22	13
D08	7	14	4
D09	7	22	12
D10	7	12	0
D11	7	13	7
T12	7	23	12
T17	7	21	14
T18	7	13	11
T19	7	14	11
T21	7	27	7
T22	-1	19	11
D23	-1	12	13
T34	2	21	3
D37	8	25	10
D38	8	15	8
T42	2	15	8
D43	2	16	9
T44	2	18	8
T49	3	21	6
D52	4	13	10
T55	4	19	8
T58	4	13	7
T65	8	12	11
T67	8	15	6
T68	8	17	13

Appendix C: Letter Naming Errors

Participant	Time in Kindergarten (Months)	Upper-case	Lower-case	Total
T02	6	0	3	3
D05	6	0	3	3
D08	6	0	4	4
D09	6	4	8	12
D10	7	0	2	2
D11	6	0	0	0
T12	6	0	3	3
T17	7	1	6	7
T18	7	0	0	0
T19	7	1	7	8
T21	7	0	2	2
T22	-1	0	4	4
D23	-2	4	12	16
T34	1	3	8	11
D37	7	0	2	2
D38	7	0	1	1
T42	2	4	7	11
D43	2	0	5	5
T44	2	0	2	2
T49	2	1	8	9
D52	3	0	0	0
T55	4	0	3	3
T58	4	0	5	5
T65	8	0	3	3
T67	8	2	9	11
T68	8	0	4	4

Appendix D: Semi-Directed Narrative - Singleton Onsets (Initial)

		Participant																									
Target IPA		T02	D05	D08	D09	D10	D11	T12	T17	T18	T19	T21	T22	D23	T34	D37	D38	T42	D43	T44	T49	D52	T55	T58	T65	T67	T68
[p]	Attempts	19		3	7			2	2		10	15	4	6	8	6	1	1	3	1	2	3	5	6	3		
	Errors	0		0	1			0	0		1	1	0	0	0	0	0	0	0	0	0	0	0	0	0		
[b]	Attempts	25	16	25	31	27	12	8	20	8	34	22	12	3	19	9	7	17	25	22	10	24	20	20	26	4	8
	Errors	0	0	0	1	2	1	0	0	0	4	2	0	0	1	1	0	0	1	3	0	0	2	0	1	0	0
[t]	Attempts	15	6	7	7		2	4	4	1	8	12	5	1	5	6	2	5	1	4	9	10	5	8	14	2	4
	Errors	2	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
[d]	Attempts	35	14	18	21	18	17	13	8	16	42	26	11	12	19	11	8	10	20	12	21	19	12	11	12	5	6
	Errors	0	0	0	0	16	0	2	0	0	2	0	0	0	0	0	0	0	0	2	1	1	0	0	0	0	1
[k]	Attempts	6	7	9	6		9	6	7	8	3	11	5	5	10	8		8	1	4	11	16	3	7	9	9	1
	Errors	0	0	0	2		0	0	0	0	0	0	0	0	1	0		0	0	0	0	0	0	0	0	0	0
[g]	Attempts	8	6	10	5	2	7	6	5	7	9	10	1	4	5	3	3	1	6	3	3	6	6	9	8	5	3
	Errors	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
[f]	Attempts	9	7	11	9	6	7	11	6	4	7	19	5	4	17	5	6	7	5	5	3	10	5	8	7	5	6
	Errors	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
[v]	Attempts										2				1												
	Errors										0				1												
[θ]	Attempts	5		3	7				1		1	4	1		3	2			1		4	1		1	1		1
	Errors	0		2	1				0		0	0	0		2	0			1		0	0		0	0		1
[s]	Attempts	11	5	5	14	4	3	5	5	5	11	30	3	2	10	1	6	1	7	5	5	5	5	7	7	1	1
	Errors	0	0	0	1	1	1	0	0	0	1	2	0	0	1	0	2	0	2	0	0	0	0	0	0	0	0
[ʃ]	Attempts		1	1	3		2	1	1	1	2	1	1			1										1	1
	Errors		0	0	2		0	0	0	0	0	0	0			0										0	0
[ʧ]	Attempts	1				2	4	1		1	3	1	1		1	6		1	2		4	1	1	1	1	2	1
	Errors	0				1	0	0		0	0	0	0		0	2		0	1		0	1	0	0	0	0	0
[ʤ]	Attempts	7	1	4	1	1	1	2	2	1	3	5	7		4	3	1	1		4	3	1		2	3	1	4
	Errors	1	0	1	0	0	1	0	0	0	1	0	0		1	1	0	0		1	2	0		0	0	0	1
[m]	Attempts	2	2	1	10		1	5	7	4	7	13	10	3	7	8		4	4	1	1	3	1	3	6	1	
	Errors	0	0	0	0		0	0	0	0	0	1	1	1	0	0		0	0	0	0	0	0	0	0	0	
[n]	Attempts	3	3	9	9		6	3		5	10	11	5	8	5	4	1	15	3		17	8	7	2	1	4	4
	Errors	0	0	0	0		0	0		0	0	1	0	0	0	0	0	0	0		0	0	0	0	0	0	0
[l]	Attempts	21	7	22	3	8	5	4	11	9	13	21	10	1	17	7	8	7	7	9	3	17	9	10	11	2	13
	Errors	1	0	0	0	1	0	0	0	1	1	2	0	0	3	0	0	0	1	0	0	0	2	1	0	0	0
[ɹ]	Attempts	7	4	8	8	4	4	5	3	1	10	8	4	1	10	6	4	3	2	1	3	2	7	9	6	1	2
	Errors	0	0	0	1	3	0	0	0	0	0	0	0	1	0	5	0	0	2	0	0	1	0	0	0	0	0
[w]	Attempts	48	23	22	26	12	9	9	23	22	9	41	16	2	33	23	9	4	20	8	10	20	29	20	31	13	11
	Errors	1	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	1	1	0
[j]	Attempts	5	6	4	4	2		2	1	2	6	10	1	2	3	1	2		2			3	2	3	1		1
	Errors	0	0	0	0	0		0	0	0	0	0	0	1	1	0	0		0			1	0	1	1		0
Total Attempts		227	108	162	171	86	89	87	106	95	190	260	102	54	177	110	58	85	109	79	109	149	117	127	147	56	67
Total Errors		5	0	3	11	25	4	2	0	1	10	9	1	3	11	11	2	0	9	8	4	4	4	3	3	2	4

Appendix E: Semi-Directed Narrative - Singleton Onset (Initial) Errors

	Target IPA																		
Participant	[p]	[b]	[t]	[d]	[k]	[g]	[f]	[v]	[θ]	[s]	[ʃ]	[ʧ]	[ʤ]	[m]	[n]	[l]	[ɹ]	[w]	[j]
T02			Ø (x2)										[d]			[w]		Ø	
D08									[f] (x2)				[d]						
D09	[v]	[β]			[h] [t]	[d] [j]			[f]	Ø	[ʧ] (x2)						[m]		
D10		[v] [β]		[j] [g](x15)			[b]			[θ]		[t]				[w]	[w] (x3)		
D11		[v]								[f]			[d]					[v]	
T12				Ø (x2)															
T18																[f]			
T19	[f]	[v] [ɸ] [β](x2)		[n] Ø						[t]			[ʃ]			[d]			
T21	[f]	[f] [v]								[t] (x2)				[p]	[d]	[v] [w]			
T22														[w]					
D23														[ɹ]			[g]		Ø
T34		[ɸ]			Ø			[ɹ]	[f] [v]	[t]			[d]			[h] [w] [ɹ]			[g]
D37		[w]										[t] (x2)	[d͜j]				[f] [v] [w] (x3)	[v] Ø	
D38										[ʃ] [θ]									
D43		[v]				[ð]			[s]	[h] [t]		[t͜j]				[b]	[w] Ø		
T44		[β] (x3)		[n] [z]									[d]					Ø [ɹ]	
T49			[ʃ]	Ø									[ʒ] (x2)						
D52				Ø								[t]					[w]		Ø
T55		[m] Ø														Ø (x2)			
T58			[ʧ]													Ø			Ø
T65		[v]																Ø	[ʒ]
T67						[d]												[h]	
T68				[ʤ]			[b]		[d]				[d]						

Appendix F: Semi-Directed Narrative - Singleton Onsets (Medial)

		Participant																									
Target IPA		T02	D05	D08	D09	D10	D11	T12	T17	T18	T19	T21	T22	D23	T34	D37	D38	T42	D43	T44	T49	D52	T55	T58	T65	T67	T68
[p]	Attempts	8	2	1	4	1		1			6		4	6	1	2		1	1	1	1		8	3	1	1	1
	Errors	0	0	0	0	0		0			0		0	0	0	0		0	0	0	0		0	0	0	0	0
[b]	Attempts	8		7	5		4		2	1	2	3	1	2		1		4	4			3	2	2	1		2
	Errors	0		1	1		0		0	0	0	0	0	0		1		0	0			0	0	0	0		0
[t]	Attempts	5	5	1	4	1	3	3	2	1	11	9	2		7	8	2	2			1	4		4	2	1	
	Errors	1	0	0	0	0	0	0	0	0	1	1	0		0	1	0	0			0	0		0	0	0	
[d]	Attempts	13	4	4	7	9	3	1	1	1	2	7	3	1	11	6	1	1	1	2	4	5	4	5	4	3	4
	Errors	0	0	1	1	3	1	0	0	0	2	3	0	0	4	1	0	0	1	0	0	0	0	0	0	0	0
[k]	Attempts	6		1	5	2		1	9	6	10	3			5	7	2	3	7	4	4	9	4	3	3	5	4
	Errors	0		0	1	0		0	0	0	1	0			0	0	0	0	0	0	1	0	0	0	0	1	0
[g]	Attempts	5	1	1			11		3		9	4		3	2	4	2		1		2	3	2	2	2	1	
	Errors	0	0	0			0		0		2	0		1	0	1	0		0		0	0	0	0	0	0	
[f]	Attempts	2	2		2							2				1			1					1		1	
	Errors	0	0		1							0				0			0					0		0	
[v]	Attempts	9	2		4	2	1	4	1	1	2	8	1	1	2		1	2	2	1	3	1	7	2	5		6
	Errors	0	0		0	0	0	0	0	0	0	1	0	0	0		0	0	0	0	0	0	0	0	0		1
[θ]	Attempts	1			2	1		4			1	2	2	1	1						2		2	3	1	2	
	Errors	1			2	1		2			0	1	0	0	1						1		1	2	0	0	
[s]	Attempts	14				1	1		1	5		5	1		4	3		2	1	1	1	1	1	1	2	1	1
	Errors	0				0	0		0	2		0	0		0	1		0	0	0	0	0	0	0	0	0	0
[z]	Attempts	1					1	1					2					1	1		3				4	1	
	Errors	0					0	0					0					0	1		0				0	0	
[ʃ]	Attempts	2			1				1			1			2	1						2		1	1		
	Errors	0			1				0			0			1	0						0		0	0		
[ʧ]	Attempts	1		1											1		3					2					
	Errors	0		0											0		3					0					
[ʤ]	Attempts			1											1	1					1						
	Errors			0											0	0					1						
[m]	Attempts			1	3		1		1	2	1	5		1	3	2			2	1		3	1	2	1		
	Errors			0	0		0		0	0	0	0		0	0	0			1	0		0	0	0	0		
[n]	Attempts	4	3	5	6	1	2	2	4	2	4	6			6	3	1	2	2	3	4	2	5	3	2	2	2
	Errors	0	0	0	0	0	1	0	0	1	1	1			0	0	0	0	0	0	0	0	0	2	0	0	0
[l]	Attempts	5	4	2	4			3	1	1	6	14	1	3	7	2		3	3	2	4	4	6	3	1	7	2
	Errors	2	0	0	0			1	0	0	1	0	0	0	0	0		0	0	0	0	0	1	0	0	0	0
[ɹ]	Attempts	6		1	2	1		1			2	3		1	4					1				1	4	1	1
	Errors	0		0	0	1		0			0	0		0	0					0				0	0	0	0
[w]	Attempts	5	1	5	4	2	3	5	2	2	4	10	2	2	6	3	2	2		2	3	5	2	3	3	1	1
	Errors	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	1	0
[j]	Attempts											1															
	Errors											0															
Total Attempts		95	24	31	53	21	30	26	28	22	60	83	19	21	63	44	14	23	26	18	33	44	44	39	37	27	24
Total Errors		4	0	3	7	5	2	3	0	3	8	7	0	1	6	5	3	0	3	0	3	0	2	4	0	2	1

Appendix G: Semi-Directed Narrative - Singleton Onset (Medial) Errors

	Target IPA																	
Participant	[b]	[t]	[d]	[k]	[g]	[f]	[v]	[θ]	[s]	[z]	[ʃ]	[ʧ]	[ʤ]	[m]	[n]	[l]	[ɹ]	[w]
T02		Ø						[d]								[w] (x2)		
D08	[g]		[ɾ]															[ʊ]
D09	[β]		Ø	[h]		[ɾ]		[m] Ø			Ø							
D10			[b] Ø [g]					[t]									Ø	
D11			Ø												Ø			
T12								[t] (x2)								Ø		
T18									[t] Ø						[ɾ]			
T19		[z]	Ø (x2)	[m]	[j] [ʔ]										Ø	[ð]		
T21		[n]	[z] Ø (x2)				[ɾ]	Ø							Ø			
D23					[b]													
T34			Ø (x4)					[f]			[j]							
D37	[w]	Ø	Ø		[j]				[t]									
D38												[ʃ] (x3)						
D43			Ø							Ø				Ø				
T49				[h]				Ø					[ɾ]					
T55								[p]								[ð]		
T58								Ø (x2)							Ø [ɾ]			
T67				[ʔ]														[h]
T68							[p]											

Appendix H: Semi-Directed Narrative - Branching Onsets

		Participant																									
Target IPA		T02	D05	D08	D09	D10	D11	T12	T17	T18	T19	T21	T22	D23	T34	D37	D38	T42	D43	T44	T49	D52	T55	T58	T65	T67	T68
[pl]	Attempts	3	1	1				1				1						1	1								
	Errors	0	0	0				0				0						1	1								
[bl]	Attempts	1			1																				1		
	Errors	0			1																				0		
[kl]	Attempts	3		1	1		1	1	2	2	1	4	3	2	2	4	1			1	3	1	7	6	3		1
	Errors	0		0	0		0	0	0	0	0	0	0	0	0	1	0			0	1	1	0	0	0		1
[gl]	Attempts								1																		
	Errors								0																		
[fl]	Attempts			1	1				1				1	1		1		1		1		1	1		2		
	Errors			1	1				0				1	0		0		0		0		1	0		0		
[pɹ]	Attempts				2							1				1											
	Errors				0							0				0											
[bɹ]	Attempts			1	1	1	3	1	4			1	1						1					1			
	Errors			0	0	1	0	0	0			0	0						1					1			
[tɹ]	Attempts	6		2		1	4	3	3	2	7	1	5	1	1	1	2	1	1	5	7	2	9	4	5	2	2
	Errors	0		0		0	0	1	1	1	1	0	1	0	0	0	0	1	0	4	0	1	1	0	0	1	0
[dɹ]	Attempts	1				1						2		1		2											
	Errors	0				0						0		0		1											
[kɹ]	Attempts		1	1				1		1	2		1						1								
	Errors		0	0				0		0	0		0						1								
[gɹ]	Attempts		2	2	2	1	4				1	1				1			1				1			1	
	Errors		0	0	0	1	2				0	0				0			1				0			1	
[fɹ]	Attempts	21	16	6	10	4	12	7	8	8	8	13	3	5	7	5	7	12	6	4	7	22	4	6	13	5	7
	Errors	0	0	1	1	4	0	0	1	0	1	0	0	0	0	4	3	0	5	0	0	20	0	0	0	0	1
[vɹ]	Attempts	1		1				1				1			2		1	1			1		1				
	Errors	1		1				0				0			1		0	0			0		0				
[θɹ]	Attempts	1	1		1																	1	2	1	1		
	Errors	0	1		1																	1	0	1	1		
[kw]	Attempts							1			1	1												1		1	
	Errors							0			0	0												0		0	
Total Attempts		37	21	16	19	8	24	16	19	13	20	26	14	10	12	15	11	16	11	11	18	27	25	19	25	9	10
Total Errors		1	1	3	4	6	2	1	2	1	2	0	2	0	1	6	3	2	9	4	1	24	1	2	1	2	2

Note: This table reports on the number of clusters that each child attempted and the number of clusters containing errors.

Appendix I: Semi-Directed Narrative - Branching Onset Errors

1. Single Consonant Errors

	Target IPA																		
Participant	[pl]	[bl]	[kl]		[fl]		[bɹ]	[tɹ]		[dɹ]	[kɹ]	[gɹ]		[fɹ]		[vɹ]		[θɹ]	
T02																	[vw]		
D05																			[fɹ]
D08						[fɹ]								[f]			[vw]		
D09		[m^l][a]			[f]										[fw]				[pɹ]
D10							[bw]						[gw]		[fw] (x4)				
D11												[ɹ] (x2)							
T12									[ʧ]										
T17									[ʧəɹ]						[fw]				
T18									[kɹ]										
T19									[ʃɹ]					[f]					
T22						[fw]			[ʧɹ]										
T34																[ɹ]			
D37			[k]							[ʤ]				[f] (x3) [v]					
D38														[f]	[ʃɹ]				
T42	[pw]							[t]											
D43	[pəɹ]										[kw]		[gw]	[f]	[fw] (x3)				
T44									[ʧ] (x2) [ʧɹ]										
T49				[kɹ]															
D52				[kw]		[fw]			[tw]					[f] (x6)	[fw] (x14)			[θ]	
T55									[tw]										
T58							[vɹ]												[səɹ]
T65																			[fɹ]
T67												[ɹ]							
T68				[gɹ]										[ɹ]					

[a]/bl/ → [m^1] occurred in probably, and included resyllabification: [ˈpɹɑbəm^ˈleɪ].

2. CC Errors

	Target IPA											
Participant	[pl]	[bl]	[kl]	[fl]	[bɹ]	[tɹ]	[dɹ]	[kɹ]	[gɹ]	[fɹ]	[vɹ]	[θɹ]
D38										[ɹ͜l]		
D43					[w]					[ɸw]		
T44						[ʃ]						
T67						[ʃ]						

Appendix J: Semi-Directed Narrative - Singleton Codas

		Participant																									
Target IPA		T02	D05	D08	D09	D10	D11	T12	T17	T18	T19	T21	T22	D23	T34	D37	D38	T42	D43	T44	T49	D52	T55	T58	T65	T67	T68
[p]	Attempts	11	6	2	4	2	2	4	4	6	7	8	7	1	4	1	2	2	3	2	2	7	4	4	2		
	Errors	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0		
[t]	Attempts	32	24	25	35	10	22	19	16	16	25	38	6	7	31	20	5	15	17	9	12	18	16	20	20	14	10
	Errors	2	3	1	5	0	2	0	0	2	2	1	1	0	2	3	0	1	1	0	0	3	1	0	0	0	2
[d]	Attempts	18	5	4	11	2	5	6	7	9	6	25	6	3	8	11	2	3	3	2	2	3	2	7	16	0	3
	Errors	1	1	0	3	0	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	1	0	2	0	0
[k]	Attempts	8	3	9	8	5	3	7	12	3	7	8	6		8	9	2	5	7	2	2	12	5	10	4		2
	Errors	0	0	1	0	0	1	0	0	0	1	0	1		1	0	0	0	0	0	0	1	1	0	0		0
[g]	Attempts	43	17	6	18	20	7	14	11	11	19	21	12	9	12	9	8	17	14	10	9	29	11	9	22	4	11
	Errors	0	0	0	2	0	1	0	0	0	0	0	2	0	0	0	1	0	0	0	0	5	1	1	0	0	1
[f]	Attempts	1		4	1	3	2	3	5		3	16	1	2	5	2	2	2	1	2	4	5	1	6	11	1	
	Errors	0		0	0	0	0	0	0		0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	1	
[v]	Attempts	7	6	2	4	1	3	1	8		3	5	3	1	5	7	5		2	1		10	2	5	5		
	Errors	0	1	0	0	0	0	0	0		0	0	2	0	1	1	0		0	0		0	0	0	1		
[θ]	Attempts	6	2	1	1		2		1		1	4	1			4		2	3	2		3	3	1	1		1
	Errors	5	2	1	1		1		0		0	3	0			2		0	2	2		2	0	0	0		0
[s]	Attempts	7	2	1	3		4	2	3	7	10	4	9	3	1	6	1	3	6	2	1		7		4	1	1
	Errors	0	0	0	1		0	0	0	2	0	0	0	0	0	1	0	0	0	0	0		1		0	0	0
[z]	Attempts	35	23	27	39	10	12	28	32	20	49	28	13	20	18	21	5	33	24	17	34	36	27	37	31	19	13
	Errors	5	0	1	3	0	1	1	1	2	6	1	1	5	3	3	1	4	1	2	5	5	4	0	0	0	0
[ʃ]	Attempts			1					1			1								1			1	1			
	Errors			0					0			0								1			1	0			
[ʧ]	Attempts	1	1		2							1	1							1		1		1	1		
	Errors	0	0		0							1	1							0		0		0	0		
[ʤ]	Attempts		1								2	3	1		1						1						
	Errors		0								0	1	1		0						0						
[m]	Attempts	26	8	12	16	4	9	12	9	6	18	21	7	3	10	9	1	6	5	3	13	11	12	11	12	10	8
	Errors	0	0	1	4	0	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
[n]	Attempts	137	23	41	54	29	54	53	37	52	70	79	33	20	58	70	28	22	38	15	21	70	73	58	56	7	20
	Errors	0	0	2	2	2	0	2	2	3	5	3	1	1	2	3	0	0	2	0	0	6	2	3	1	0	2
[ŋ]	Attempts	19	5	9	26	6	4	5	8	8	29	12	8	11	4	13	6	17	17	15	18	20	14	19	9	14	15
	Errors	0	0	2	4	1	0	0	1	0	3	1	0	0	1	1	0	1	4	1	1	2	0	0	0	0	1
[ɫ]	Attempts	15	14	10	12	8	17	7	8	7	20	21	7	6	23	7	5	9	4	4	9	12	8	12	12	3	9
	Errors	0	0	1	1	0	2	0	0	1	4	0	0	0	2	0	0	0	0	0	1	1	0	2	1	1	0
[ɹ]	Attempts	47	21	25	30	11	9	16	15	14	17	36	8	4	21	12	15	14	18	3	15	26	25	18	23	7	22
	Errors	0	0	2	0	6	1	0	0	0	0	3	0	0	1	5	2	0	10	1	1	6	3	0	0	1	0
Total Attempts		413	161	179	264	111	155	177	177	159	286	331	129	90	209	201	87	150	162	91	143	263	211	219	229	80	115
Total Errors		13	7	12	26	9	12	3	4	10	23	17	11	6	13	19	4	6	20	9	8	33	16	6	5	3	6

Non-Errors	T02	D05	D08	D09	D10	D11	T12	T17	T18	T19	T21	T22	D23	T34	D37	D38	T42	D43	T44	T49	D52	T55	T58	T65	T67	T68
[t] → [ʔ]	0	1	1	0	0	5	2	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0
[ŋ] → [n]	2	0	1	1	4	0	0	0	0	0	2	0	10	0	9	1	3	8	1	1	11	8	4	0	1	5

Appendix K: Semi-Directed Narrative - Singleton Coda Errors

1. Coda Deletions

	Target IPA												
Participant	[t]	[d]	[k]	[g]	[v]	[θ]	[z]	[ʃ]	[m]	[n]	[ŋ]	[ɫ]	[ɹ]
T02	Ø (x2)					Ø (x2)	Ø (x2)						
D05	Ø (x3)				Ø								
D08	Ø		Ø				Ø			Ø		Ø	Ø (x2)
D09	Ø (x3)	Ø (x2)		Ø			Ø		Ø	Ø	Ø (x2)	Ø	
D10										Ø			Ø (x4)
D11	Ø	Ø							Ø			Ø (x2)	Ø
T12							Ø			Ø			
T17										Ø			
T18	Ø (x2)						Ø			Ø (x3)		Ø	
T19	Ø (x2)		Ø				Ø			Ø (x4)	Ø (x3)	Ø (x3)	
T21	Ø	Ø (x2)					Ø						Ø (x3)
T22	Ø		Ø	Ø	Ø					Ø			
D23							Ø (x3)			Ø			
T34	Ø (x2)						Ø			Ø (x2)	Ø	Ø	
D37	Ø (x3)				Ø		Ø			Ø	Ø		Ø (x5)
D38				Ø									Ø
T42	Ø												
D43	Ø						Ø				Ø (x3)		Ø (x9)
T44								Ø					
T49							Ø (x3)				Ø	Ø	
D52	Ø (x2)	Ø		Ø (x4)		Ø	Ø (x3)			Ø (x3)	Ø	Ø	Ø (x5)
T55	Ø		Ø	Ø			Ø		Ø	Ø			Ø (x2)
T58				Ø						Ø (x2)		Ø (x2)	
T65		Ø (x2)								Ø		Ø	
T67												Ø	Ø
T68	Ø (x2)			Ø							Ø		

2. Coda Substitutions

	Target IPA																	
Participant	[p]	[t]	[d]	[k]	[g]	[f]	[v]	[θ]	[s]	[z]	[ʃ]	[ʧ]	[ʤ]	[m]	[n]	[ŋ]	[ɫ]	[ɹ]
T02			[v]					[d] [t] (x2)		[d] (x3)								
D05			[n]					[v] (x2)										
D08								[t]						[n]	[d]	[n] [g]		
D09		[p] [g]	[v]		[ʔ]			[t]	[k]	[ð] [g]				[n] (x2) [v]	[d]	[j] [k]		
D10															[m]	[d]		[j] (x2)
D11		[j]		[ʔ]	[ʔ]			[v]		[d]				[n]				
T12															[m]			
T17										[ɫ]					[ŋ]	[j]		
T18									[f] [θ]	[ɾ]								
T19										[t] [ʃ] [ʣ] (x3)				[n] (x2)	[m]		[b]	
T21						[p]		[t] (x3)				[ʦ]	[ʒ]		[m] (x3)	[z]		
T22	[ʔ]				[d]		[ð]			[ʃ]		[s]	[ʒ]					
D23										[d] (x2)								
T34				[t]			[ʔ]			[d] (x2)							[d]	[j]
D37								[d] [s]	[p]	[ð] [ʣ]					[m] [d]			
D38										[g]								[w]
T42										[v] [n] [t] [ʦ]						[k]		
D43								[t] [ʃ]							[m] [ŋ]	[n]		[ɫ]
T44	[ʔ]					[ʃ]		[t] (x2)		[t] (x2)						[d]		[f]
T49										[d] [ʣ]								[j]
D52		[ʃ]		[t]	[d]	[s]		[s]		[d] [n]					[m] (x3)	[m]		[j]
T55			[n]						[ʧ]	[d] [t] [ʣ]	[h]				[m]			[d]
T58															[m]			
T65							[d]											
T67						[ʔ]												
T68															[d] (x2)			