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A Comparison Of Nonwords And Tier Two Vocabulary Words In Speech Treatment

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A COMPARISON OF NONWORDS AND TIER TWO VOCABULARY WORDS IN SPEECH TREATMENT

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This thesis, submitted by Janet Babchishin in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done and hereby approved.

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the inspiration for my imagination.

ABSTRACT

The purpose of the current study was to evaluate the role of word lexicality between Tier Two vocabulary (T2) words and nonwords (NWs) in effecting phonological change in children's sound systems. Often children with functional speech sound disorders (SSD) make slow progress in the treatment of their SSD due to their prior experiences with the words used in treatment. One way to avoid possible biases associated with life experience and semantics (Leonard, Newhoff, & Mesalam, 1980) in the treatment of SSD is to use NWs (e.g. Bryan & Howard, 1992; Gierut & Morrisette, 1998; Gierut, Morrisette, & Champion, 1999; Storkel, 2004). NWs have been shown to cause change in the children with SSD because they are low frequency and have not been improperly produced repeatedly by the child prior to treatment. Gierut and Morrisette (2010) suggested that treatment of a sound in NWs leads to levels of articulation proficiency that are equal to if not better than those of production accuracy levels achieved in treatment with real words. Thus, NWs serve a critical role in causing system wide change in children with SSD.

The fact that NWs can cause system wide change due to the elimination of previous life experiences suggests that T2 words might also be promising treatment targets. Specifically, T2 words can eliminate participant familiarity and frequency since they are by definition, acquired later in development. Yet, T2 words appear frequently

a wide variety of texts, and in oral and written language of mature language users. The biggest advantages of using T2 words over NWs is that they have lexical value and promote early academic success. While T2 words are good for vocabulary instruction, they might also be useful for SSD treatment. Young children interpret T2 words as novel words due to their low frequency. Moreover, T2 words are better treatment targets than NWs due to their lexicality, in that they are meaningful and children will have opportunities to hear and use them in and outside of the therapy setting.

The current study recruited four 3- to 6-year-old children with functional speech sound disorders (SSD). Treatment was provided two times weekly in 1-hour sessions, for a total of 10 sessions. The participants were randomly assigned to two treatment groups: NWs and T2 words. The participants in both treatment groups received the same amount of exposure to the targeted treatment words through the presented story. The children in the T2 treatment group were provided with a brief definition through an incidental learning approach in addition to the exposure of each targeted word. The two word types differ in terms of their lexicality, in that the T2 words were real, meaningful words while NWs do not have any meaning in the ambient English language.

The first aim of the study was to examine phonological change in the participants in both treatment groups. The low frequency of NWs has been proven to be efficacious in the treatment of SSD because the words have not been repeatedly produced and used incorrectly by the children. Since T2 words and NWs are both low frequency, they were predicted to make similar changes to a child's sound system. T2 words showed greater changes on some aspects of the children’s sound system but not all. The second aim of

the study was to examine vocabulary expansion through incidental learning. Positive changes did occur in the T2 word treatment group in terms of vocabulary expansion, while the NW group participants did not add any of the treatment words to their repertoires. T2 vocabulary words appeared to promote later academic achievement and the evidence of T2 vocabulary expansion in the T2 treatment group adds to the efficacy of using T2 words in the treatment of SSD. Children with SSD often have lower expressive language scores and unintelligible communication, which can have a negative impact on their lexical development (Camarata, 1996; Smith & Camarata, 1999), putting them at risk for early academic failure. This study illustrates the efficacy of using T2 vocabulary in speech treatment.

CHAPTER I

INTRODUCTION

A speech sound disorder (SSD) is a significant delay in the acquisition of articulate speech sounds (Lewis, Shriberg, Hansen, Stein, Taylor, & Iyengar, 2006). A functional SSD affects a speaker's production and/or mental representation of speech sounds of the target language (Bernthal & Bankson, 1993; Edwards & Shriberg, 1983; Ferguson, Menn, & Stoel-Gammon, 1992; Fey, 1992; Folkins & Bleile, 1990; Grunwell, 1981, 1982; Harris & Cotam, 1985; Hoffman & Daniloff, 1990; Ingram, 1989b; Leonard, 1973; Locke, 1983a; Shriberg & Kwiatkowski, 1982a). Children with functional SSD have no known cause for their communication breakdowns, as they present with normal hearing, intelligence, and social, emotional, and behavioral skills. A SSD reflects an inability to articulate speech sounds that often involves a motoric component (Dinnsen, 1984; Elbert 1992; Hoffman, Schuckers, & Daniloff, 1989; Stoel-Gammon, 1985), and it could also affect the way in which speech sound information is stored and represented in the mental lexicon or is accessed and retrieved cognitively (Bernhardt, 1992a, 1992b; Chiat, 1994; Dean, Howell, Waters, & Reid, 1995; Dinnsen, 1984; Dodd, Leahy, & Hambly, 1989; LaRiviere, Winitz, Reeds, & Herriman, 1974; Leonard, Schwartz, Swanson, & Loeb, 1987; McGregor & Schwartz, 1992; Schwartz, 1992; Stackhouse & Wells, 1993).

Thus, a SSD can have a broad impact on both a child's articulation (performance) and internalized knowledge (competence) of the sound system of the target language (Gierut, 1990b; Kamhi, 1992). Two kinds of sound inventories are often discussed when children's sound competence and performance are assessed. The *phonetic inventory* is a list of all the sounds (i.e., phones) a child produces in his speech, including those produced accidentally (that is, non-target-appropriately). Importantly, the sounds in the phonetic inventory are not restricted to the child's native language; they can also be sounds found only in languages outside the child's target language (e.g., Dinnsen, Chin, Elbert, & Powell, 1990). Thus, the phonetic status of a sound is established following the criteria of the phone occurring twice in the speech sample in any position of a word, regardless of whether they are correct relative to adult production (Gierut, Simmerman, & Neumann, 1994). For example, if the child produced the words 'dog' and 'mad' the phoneme /d/ would be considered in the child's phonetic inventory.

Conversely, the *phonemic inventory* is a more specific list of sounds, in that it only includes the sounds (i.e., phonemes) that are used *contrastively* by the child (e.g., the child knows that *tall* and *doll* are two different concepts, and accordingly uses /t/ and /d/ in a contrastive manner). Thus, a phoneme is a distinctive and contrastive sound in a sound system. As with the phonetic inventory, the phonemic inventory of a child's sound system might include phonemes found only in languages outside his target language (e.g., Gierut et al., 1994). The phonemic status of a sound is established following the criterion of two unique sets of minimal pairs (e.g. 'sing'-'ring' or 'run'-'rub'), regardless of whether they are correct relative to adult production (Gierut et al., 1994). Based on the phonemic analyses, the target sounds that are excluded from a child's phonemic inventory are identified, having not been produced in the presence of minimal pairs.

Thus, the phonemic inventory has more stringent inclusionary criteria than the phonetic inventory. In other words, the child has a higher level of understanding and production of sounds in their phonemic inventory than sounds in his/her phonetic inventory. The phonemic inventories are always smaller or the same as the participant's phonetic inventory, as a higher level of understanding and use of each phoneme must be demonstrated to be included in the phonemic inventory.

Lexical Development.

It has been argued that children build a mental lexicon based on templates of known phonological structure (Velleman & Vihman, 2002). A lexicon is referred to as the internal mental vocabulary of an individual speaker. An individual's lexicon is made up of words within their everyday vocabulary that they use and understand. The mental lexicon of a child with SSD might include words produced in error due to their inadequate sound system and previous inaccurate performance (Gierut, 1990b; Kahmi, 1992). Thus, both the perceptual and production aspects of a SSD play a role in how the lexicon is formed and used. If a child does not perceive sounds correctly, they are also stored incorrectly. Children continue to build and reinforce their lexicon throughout development and if their sound system is in error, it can disrupt their mental lexicon or representation.

It is frequently observed that semantic, syntactic, and pragmatic disorders occur in conjunction with functional SSDs (Camarata & Schwartz, 1985; Campbell & Shriberg, 1982; Fey, Cleave, Ravida, Long, Dejmal, & Easton, 1994; Himmelwright-Gross, St.Louis, Ruscello, & Hull, 1985; Panagos & Prelock, 1982; Paul & Jennings, 1992; Paul & Shriberg, 1982; Ruscello, St.Louis, & Mason, 1991; Schwartz, Leonard, Folger, & Wilcox, 1980; Tyler, 1992; Tyler & Sandoval, 1994; Tyler & Watterson, 1991). As such, it is important to determine if these conglomerate disorders are exacerbated by a sound system in error, which have been found to negatively impact the child's mental lexicon or representation.

Children with SSD often have lower expressive language scores and unintelligible communication, which negatively impacts their lexical development (Camarata, 1996; Smith & Camarata, 1999), putting them at risk for early academic failure. There is an observed relationship between early SSD and subsequent reading, writing, spelling, and mathematics abilities (Bird, Bishop, & Freeman, 1995; Catts, 1993; Catts & Kamhi, 1986; Clarke-Klein & Hodson, 1995; Hoffman, 1990; Hoffman & Norris, 1989; King, Jones, & Lasky, 1982; Lewis & Freebairn, 1992; Webster & Plante, 1992). Thus, these children might be at risk of future academic and socio-emotional difficulties (McCormack, McLeod, McAllister, & Harrison, 2009) and have the best chance of achieving their full potential if they are provided with effective and efficient intervention before starting school (Beitchman, Wilson, Johnson, Atkinson, Young, Adalf, et al., 2001; Nathan, Stackhouse, Goulandris, & Snowling, 2004). Early detection and treatment for children with SSD is critical due the potential academic risks. Luckily because children with SSD often have highly unintelligible speech, they are likely to be identified as preschoolers (Shriberg, Kwiatkowski, & Gruber, 1994) and receive treatment early.

Learning in Treatment.

Treatment is expected to be maximally efficient when behaviors that are likely to result in the most widespread generalization patterns are taught. Generalization is related to treatment efficacy and efficiency, and the selection of treatment targets might have a profound impact upon the amount and degree of generalization (Elbert, 1989). The patterns of generalization are representative of the kinds of change observed in evaluations of implication laws (Gierut, 2007). Generalization gains are determined relative to children's baseline performance in order to establish the effects on the input or dependent variables on learning. Children with functional misarticulation rarely generalize to untrained and/or phonologically unknown targets (Powell, Elbert, & Dinnsen, 1991), suggesting a need to directly target complex nonstimulable sounds.

The current study approaches SSD treatment with a complexity approach (Gierut, 1998, 1999, 2001, 2002, 2003; Gierut, Morrisette, Hughes, & Rowland, 1996; Gierut & O'Connor, 2002; Gierut & Champion, 2001; Lleó & Prinz, 1992; Dinnsen, O'Connor, Gierut, 2001). Complex sounds contain less common phonological features that are considered to be more "marked" (O'Grady, Archibald, Aronoff, & Rees-Miller, 2005). Thus, the existence of a more marked feature at a higher level implied the existence of a less marked feature at a lower level. It is a hierarchical organization in which the existence of one implies the existence of the other but not vice versa. In other words, complexity theory includes a broad systematic way of selecting treatment targets and implementing treatment to cause the most systemic change to a child's sound system.

The hierarchical representation of the complexity theory is based on individual phonemes' phonetic characteristics and age of acquisition of the sounds. Phonemes can be classified in terms of their place, manner, and voicing of articulation. Place of articulation refers to the location of articulation of the phoneme within the mouth. For example, the place classification of the phoneme /θ/ or “th” is “inter-dental” because the tongue position during production is between the front teeth.

Manner of articulation refers to the formant structure of the vocal tract. All phonemes have a manner in which they are produced. Phonemes can be classified by several manners including: a stop where airflow is blocked completely (e.g., /b/ or /k/ in ‘book’), a nasal where there is occlusion of the oral tract but air passes through the nose (e.g., /m/ in ‘mom’), a fricative where there is continuous friction due to a partially blocked oral vocal tract causing turbulent airflow (e.g., /f/ and /ʃ/ in ‘fish’), a affricate which begins like a stop but releases into an fricative (e.g., /tʃ/ in ‘chips’), a liquid which is produced with the sides of the tongue and has little obstruction (e.g., /l/ in ‘love’), and a glide which is produced like a vowel but tongue placement is closer to the roof of the mouth in order to cause slight turbulence (e.g., /w/ in ‘wow’).

Finally, phonemes can be classified by voicing. Voicing refers to whether or not the vocal folds vibrate during phoneme production, with voiced sounds involving vibration. All phonemes are either voiced as the /b/ in ‘bat’ or voiceless as the /p/ in ‘pat’.

The complexity theory is based on a hierarchical system of acquisition of phonemes according to their place, manner, and voicing. For example, stops are early-acquired sounds in speech acquisition due to their motoric simplicity and learnability. The second factor that determines sound complexity is the age of acquisition when most children acquire these sounds. Children with SSD have the least knowledge of later acquired or more complex sounds. According to the Shriberg (1993) profile of consonant mastery of children with speech delays, the eight sounds acquired latest in development for children with SSD include (ʃ, θ, s, z, ð, l, ɹ, ʒ).

Following claims of complexity theory, teaching children sounds that they have the least amount of knowledge of will cause changes to earlier acquired, less complex sounds, thus causing system-wide change. Thus, more complex input beyond or outside a child's existing knowledge will facilitate phonological learning (Gierut, 2007). The complexity approach to treatment has been proven efficacious in a variety of studies (e.g., Gierut, 1992, 1999; Gierut & Champion, 2001). The complexity approach might be efficacious in promoting the most widespread and immediate phonological change because not only are changes made to the treatment sound, but earlier or unmarked sounds might also change.

When applying complexity theory to SSD, it is important to consider the child's stimulability for these sounds. Stimulability refers to the child's ability to accurately produce a sound when provided with an auditory-visual model (Klein, Lederer, & Cortese, 1991). Stimulability for a sound is done to test the child's ability to produce a particular sound. Previous studies credited participants as being stimulable for sounds produced with at least 10% accuracy during a nonsense syllable task (Elbert, Dinnsen, & Powell, 1984; Carter & Buck, 1958), whereas others had a criterion of 30% accuracy (Glaspey & Stoel-Gammon, 2005). For example, in order for the clinician to report that the child is nonstimulable for that sound (at the 30% criterion), the child would need to produce a target sound such as /r/ in less than 30% of occurrences or less than in 3 out of 10 productions. The current study considered sounds to be nonstimulable if the participant produced them with 30% or less accuracy.

The nonstimulable sounds for a child are the sounds in which the child has the least sound knowledge. Targeting the sounds that the child has the least amount of knowledge of has the potential to create the largest impact on the child's overall sound system. Through direct treatment of nonstimulable, later-acquired sounds, the child's accuracy of untreated, less complex sounds, is also predicted to change. With treatment children with low stimulability scores tend to have higher gains in their scores than do children with high stimulability scores (Carter & Buck, 1958; Sommers, Leiss, Delp, Gerber, Fundrelia, Smith, Revucky, Ellis, & Haley, 1967). In other words, if a child has multiple nonstimulable sounds, he/she is more likely to benefit from treatment targeting nonstimulable sounds than children who are stimulable for sounds. By targeting nonstimulable sounds in treatment, children can learn about new sounds and/or sound classes and then generalize that knowledge to their entire sound system.

A child with a SSD will most likely have many sounds in error but might be stimulable for some of these sounds, illustrating an emerging awareness of the sounds. If a child is stimulable for a sound, it is indicative of an emerging awareness of that particular sound. Powell (1991) & Miccio (1995) found that sounds that were stimulable were most likely to be added to a child's sound inventory regardless of the sounds selected for treatment while, nonstimulable sounds were not likely to be acquired without direct treatment (Miccio, 1995; Powell, 1991). Teaching nonstimulable sounds results in acquisition of the treated sound as well as untreated stimulable sounds (Powell, Elbert, & Dinnsen, 1991).

It is important to note that a child can be stimulable for a sound and not be a 100% accurate in producing that sound. Thus, if an earlier acquired or stimulable sound that the child produced in error 50% of the time was selected in treatment, the child would only learn that sound and it will not facilitate phonological learning of more complex/later acquired sounds. Thus, the child would spend more total time in treatment focusing on each sound in error because less complex, stimulable, or earlier acquired sounds do not cause generalization to other later sounds (Gierut, 1987; Gierut, 1989; Powell et al., 1991; Tyler & Figurski, 1994). By selecting later acquired nonstimulable sounds for treatment, the child might make changes to less complex sounds indirectly through the complexity of the nonstimulable sounds. Therefore, it is important to assess a child's stimulability for sounds in error because it is predicted that they will cause system-wide change in the child's sound system and promote phonological learning.

Target Word Selection.

In order to effectively treat a SSD, both the child's articulation and internalized phonological knowledge need to be targeted due to their inaccurate performance and inaccurate sound system. First, the child needs to learn how to produce a specific sound and have the motoric ability to produce the sound. Then, the child has to use the sound in everyday communication in place of the old incorrect sound. Thus, the child is learning a new sound and having to change their incorrect productions in order to have a positive impact on his/her overall communication system.

While the articulation and phonological factors of treatment words can impact treatment progress, children's prior experiences with the words used in treatment can also affect their sound change. For example words that occur infrequently[1] in a language have

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[1] Word frequency is the amount of times a particular word shows up within an adults written and spoken language. A word is considered high frequency if it has a frequency score of 100 or more and considered low frequency if it has a frequency score of 99 or less Readings:(Gierut, Morrisette, & Champion, 1999;

been shown to elicit greater amounts of sound change in treatment (Gierut & Dale, 2007), suggesting that lexical frequency of a word can affect speech treatment outcomes. Selecting words that are low frequency in treatment might promote phonological change to treatment sounds, treatment words, untreated sounds, and untreated words because of the novelty of infrequent words in terms of processing and production. In other words, low frequency words might promote sound change because of their ability to avoid a child's previous exposure and practice in producing the words incorrectly.

One way to avoid possible biases associated with life experience (Leonard, Newholff, & Mesalam, 1980) in treatment of SSD is to use nonwords (NWs) (e.g., Bryan & Howard, 1992; Gierut & Morrisette, 1998; Gierut, Morrisette, & Champion, 1999; Storkel, 2004). NWs are defined as novel, phonotactically permissible sound strings that are affiliated with novel referents. NWs have been shown to cause change in children with SSD because they are free of real word familiarity, frequency, and age of acquisition confounds (Munson, 2001; Schwartz & Leonard, 1982; Storkel, 2001). Thus, NWs eliminate confounding effects associated with English words as they have zero frequency within a language and have never been practiced by the child because they are nonsense words.

NWs have been proven at least as efficacious as real words or perhaps better in promoting rapid, system wide phonological gains (Gierut, Morissette, & Zeimer, 2010; Leonard, 1973; McNeil & Stone, 1965; Winitz & Bellerose, 1965). The use of NWs in

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Morrisette & Gierut, 2002) on the Washington University in Saint Louis Speech and Hearing Lab Neighborhood Database (http://neighborhoodsearch.wustl.edu/Neighborhood/SearchHome.asp). The words in this database were selected from the Hoosier Mental Lexicon (Nusbaum, Pisoni, & Davis, 1984), which is based on a 20,000 word on-line dictionary; The HML database provides information on word frequency (1.014 million words based on adult reading material; Kucera & Francis, 1967).

promoting generalization is consistent with general complexity approaches to treatment efficacy as NWs are a more complex stimuli thus promotes greater generalization in treated and untreated aspects of a sound system (Thompson, 2007; Gierut, 2001, 2007).

Tier Two (T2) words might also be promising speech treatment targets because like NWs, they are low in frequency for young children due to their later age of acquisition. More specifically, T2 words are academic words, which means they are low frequency words to young children because literate individuals and mature language users acquire them later in life. Thus, T2 words appear frequently in a wide variety of texts, and in oral and written language of mature language users. Moreover, T2 words appear in academic literature, which is a major advantage in promoting early academic success.

Besides T2 words, there are two other tiers of words found in the vocabulary of mature language users of English (Beck, McKeown, & Omanson, 1987). The first tier of words consists of the most basic words that typically appear in oral conversation at a high frequency. Children hear Tier One words at early ages and readily become familiar with these words, such as *warm, dog, tired, run, talk, party, swim, look*, and so on.

Alternatively, Tier Three words are the lowest frequency words and are often limited to specific topics and domains. Some examples of Tier Three words might be *filibuster, pachyderm,* and *pantheon*. These words are extremely field- or topic-specific and do not hold as high value for most English learners. In an academic setting, Tier Three words would be taught within a specific unit to provide a rich understanding of the content, such as the content words in science and/or social studies classes. Outside of these specific contexts, these words are extremely low in frequency and do not typically occur in other academic literature or are used within a field-specific context by mature language users.

Beck, McKeown, and Kucan (2013) determined that 15,000 word families comprised Tier One (8,000) and Two (7,000) words, which are acquired during the first ten years of school (kindergarten through 9th grade). The 8,000 Tier One words are most familiar and used most frequently, thus need little instruction. Therefore, the 7,000 T2 word families are typically used in academic instruction through the first ten years of school. To be clear, T2 words are not directly taught in classroom instruction though they are frequently used within academic literature and academic instruction. In order to learn and increase the understanding of T2 words, Beck et al. (2013) suggests that learning an average of 400 words per year would make a significant contribution to an individual's verbal functioning. As by the time children enter kindergarten, they are expected to have an understanding of basic Tier One words. Moreover, they are expected to learn T2 vocabulary through classroom exposure and instruction at a fast rate of 400 words a year.

Since T2 words have a strong academic focus, children are less likely to learn these words independently, compared with Tier One words, which are steadily being used within conversation and within everyday contexts. Rich knowledge of words in the second tier can have a great impact on verbal functioning (expressive vocabulary, expressive language, and overall intelligibility) within an academic setting because they are high utility for mature literate language users since they are high frequency across a variety of written domains. T2 words are high utility because of their ability to build language and promote academic success; thus, they are fundamental to higher learning within the school or academic setting. T2 words are used across all academic subjects such as Mathematics, History, Science, English, etc., as well as being used in classroom instruction. T2 words' high utility within school instruction and academic literature, while being low frequency outside of the academic realm suggests that they might be good speech treatment targets. Moreover, T2 words might be better treatment targets than NWs due to their lexicality, in that they are meaningful and children potentially will have the opportunity to hear and use them.

Thesis Layout.

Chapter One presents an in-depth overview of T2 vocabulary words, NWs, incidental learning, and previous research studies that have used word lexicality to treat children with SSD. Chapter Two describes the children chosen to participate in this research study, providing information about the children's eligibility requirements, phonological characteristics, and other pertinent information that might have influenced the study's outcomes. Chapter Three discusses the methods of the treatment study developed for the children with SSD. Chapter Four discusses the results the treatment study had on the phonological and lexical systems of children in the study. Chapter Five completes the thesis by discussing theoretical and clinical implications for this work, as well as laying out a plan for future research to address questions either left unanswered or unearthed by the current research study.

CHAPTER II

REVIEW OF THE LITERATURE

The current study investigated both word frequency and lexicality in order to understand the effects of treatment word selection in producing phonological change with children with SSD by analyzing the effects of T2 words and NWs. The rationale for investigating treatment word selection is because of the overarching effects it can have on a child's learning in treatment and a child's ability to transfer what is learned within the treatment room into everyday communication. In order to compare NWs and T2 words, the similar and contrasting features of these words must be considered.

Stages of Word Learning.

Word learning typically involves two steps: lexical configuration and lexical engagement (Leach & Samuel, 2007; Gaskell & Dumay, 2003). Lexical configuration is the assembly of a word (e.g., its phonetic and phonemic composition, syllable structure, stress, meaning, and/or orthographic representation, etc.). Thus, lexical configuration focuses on the sublexical (phonological) processing of words (Vitevitch, Armbrüster & Hogan, 2006). Lexical configuration deals with the perception and production of words at the phonological level. Alternatively, lexical engagement describes how a given word becomes an embedded representation in the mental lexicon, and then functions and interacts with other lexical entries. Therefore, lexical engagement deals with how the stored phonological forms take on lexical value and function within a meaningful way with other grammatical structures.

To clarify, a word's phonological form is first decoded and represented within a child's lexical configuration. The phonological form is without meaning and focuses on the phonotactic probability[2] of the sounds and how they are combined to form a holistic word. When the child is able to decode the sound properties of a word, the child will associate the phonological form of those sounds with a word, which forms the child's lexical configuration. Once lexical configuration is complete, lexical engagement begins with the child processing the semantic and syntactic properties of the new word. Thus, in order for a word to be added to the child's lexicon both lexical configuration and lexical engagement need to be applied to the new word.

To clarify, both the phonological properties of the word (i.e., the phonological level) and the semantic and syntactic information (i.e., the lexical level) of the word impact word learning. This means that the more information about a word that is available and accessible by a child, the more likely it is that the word will be learned quickly. The two-representation model of word learning (Luce, Goldinger, Auer, & Vitevitch, 2000; Gupta & MacWhinney, 1997; Storkel & Morrisette, 2002) describes this process of word learning as an interaction between phonological and lexical levels. It is critical to understand how the phonological and lexical processes of word learning function and whether the processes can be manipulated to promote word learning at different times. Both phonological and lexical processing can have very important implications in the effectiveness of speech treatment, as different types of words might cause varying amounts of phonological change. For example, T2 words contain both

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[2] Phonotactic probability refers to the frequency with which a phonological segment, such as /s/, and a sequence of phonological segments, such as /sa/, occur in a given position in a word (Jusczyk, Luce & Charles-Luce, 1994).

phonological and lexical features that can aid in word learning, while NWs only have phonological features. Since word learning encompasses both phonological and lexical features, T2 words might be more beneficial to children as the T2 words also contain lexical information, which can support word learning.

In the absence of a lexical representation, the two-representation model predicts that phonological processing will be most influential in word learning (Storkel & Morrisette, 2002) because children do not initially know the meaning of the words. Children first need to identify the novel word through recognizing and storing the phonological form, thus focusing on phonological processing. In order to avoid lexical influences when selecting a treatment word, words that the child has had previous encounters with should be avoided. This suggests that NWs might be better suited to promote phonological processing in treatment because they are nonsense words with no lexical value. Since NWs are not acquired in development, and T2 words are acquired later in development, children most likely do not know the meaning of either word type. If children are initially unfamiliar with the meaning of T2 words and/or NWs, they could instead focus initially on the words' phonological forms (Storkel et al., 2002). This approach could be useful for children with SSD because they have difficulty processing the phonological forms of words. Learning words that contain no lexical information would allow them to focus completely on the phonological structure of the words.

Alternatively, if phonological forms and lexical properties are incorporated simultaneously in treatment, such as in the use of T2 words, they both could aid in word learning. The additional phonological and lexical information for a particular word could strengthen the word's lexical representation (i.e., lexical configuration and lexical engagement). Thus, T2 words could be superior treatment targets because they can advance both the child's lexical configuration and engagement since NWs do not have the capability to support the lexical engagement.

Since both phonological form and lexical features are inherently engrained in word learning, it is inevitable that no matter the focus of treatment, both phonological features and lexical features will play some role. But, both phonological processing and lexical features can be controlled or influenced through word selection (Storkel & Morrisette, 2002). These ideas are explored below.

Word Learning: Lexical Influences.

When selecting speech treatment word targets, it is critical to examine word frequency and speech sound production accuracy, as these features can be highly interactive in lexical learning as noted in the two-representation model (Luce, Goldinger, Auer, & Vitevitch, 2000; Gupta & MacWhinney, 1997; Storkel & Morrisette, 2002). Recall that word frequency refers to the number of times a given word occurs in written and spoken English for a language (Kučera and Francis, 1967). It has been observed that high frequency words are perceived and produced more quickly and more efficiently than low-frequency words (Balota & Chumbley, 1984; Jescheniak & Levelt, 1994; Monsell, Doyle, & Haggard, 1989; Rayner & Duffy, 1986). This suggests that children can learn high-frequency words through everyday exposures because of their increased frequency of occurrence. Not surprisingly then, frequently heard words tend to be those that are acquired earlier (Goodman, Dale, & Li, 2008; Storkel, 2004). Thus, high-frequency words might not need to be directly taught in instruction because children can naturally learn them in their environment.

Alternatively, low frequency words are often considered to be novel by children, perhaps on syllabic, segmental, prosodic or semantic grounds (Peters & Strömqvist, 1996). The novelty of low frequency words might make them more noticeable, thus attracting a child's attention during learning or speech treatment. Interestingly, as compared to high-frequency words, low-frequency words are more likely to be recognized when they had been studied and less likely to be recognized when they had not been studied (Schulman, 1967; Shepard, 1967; Wixted, 1992). Thus, children pay more attention to low-frequency words. The ability of low frequency words to attract a child's attention might also allow the child to focus directly on target word form, thus highlighting the phonological and lexical features of a word, and thus promote word learning. Since low-frequency words need to be explicitly taught to children in order to help them, word lexicality should be considered. A low-frequency word that is semantically rich or has functional meaning for the child might better promote word learning and use. Thus, the frequency and lexicality of the word might both be beneficial to the child in speech treatment.

Word Learning: Phonological Influences.

Language perception and production tasks are dominated by phonological processing, which influences lexical development, including the phonotactic probability of the novel word (Storkel & Morrisette, 2002; Leonard, Schwartz, Morris, & Chapman, 1981; Schwartz & Leonard, 1982; Storkel, 2001; Storkel & Rogers, 2000). Phonological processing entails both high frequency phonemes and phonotactic probability. Both phonotactic probability and frequency of phonemes are discussed in the following paragraphs in terms of their ability to influence word learning at a phonological level.

Phonotactics are underlying constraints or rules that govern sound combinations in a given language. An example of an English phonotactic constraint is the phoneme /h/, which begins many English syllables but never ends them. Adult speakers of a language use phonotactics to determine word boundaries (McQueen, 1998; Norris, McQueen, Cutler, & Butterfield, 1997), identify speech sounds (Massarao & Cohen, 1983; Pitt, 1998), and process novel sound sequences (Vitevitch & Luce, 1998). The phonotactic constraints guide novel word learning through the predictability of the rules of English. In word production, children are more accurate at producing sound sequences that are permissible in the ambient language than those that are not (Messer, 1967). For example, an English speaking child would be more accurate in producing the English word "apple" than the German word "selbst" because the German word has an impermissible in English final four element cluster /lbst/ that is not easily recognized and produced by English speakers.

Not only do children more readily produce more permissible sounds in words but children are more accurate in their production of words containing sounds they can produce. For example, children produce new words containing sounds that they produce (IN sounds) more readily than words containing sounds that they do not produce (OUT sounds; Schwartz & Leonard, 1982). Lexical representations and phonotactic constraints are highly interactive with one another. If children are not producing vocabulary containing OUT phonemes and have many sounds in error or a particular OUT phoneme is of high frequency in the English language this can have a negative impact their expressive language and acquisition of language as a whole. Thus, it is important to consider treatment of OUT phonemes at a global or systematic level.

Recognition of NWs composed of common sound sequences is facilitated relative to NWs composed of rare sound sequences, supporting the dominance of phonological processing (Vitevitch & Luce, 1998, 1999). Because spoken word processing typically involves lexical words not NWs, lexical processing generally should dominate recognition and production (Vitevitch, 2001b). The word-learning literature has shown that novel NWs initially transfer onto other real words in the lexicon, particularly those that share similar phonological structure (Dunmay & Gaskell, 2007; Gaskell & Dumay, 2003; Magnuson, Tanenhaus, Aslin, & Dahan, 2003). This has an immediate and facilitating effect on NW learning.

NWs have the ability to avoid frequency, phonotactic constraints, and lexical features of words within a child's repertoire. A child with an incorrect phonological representation has practiced producing words incorrectly and formed their own phonotactic constraints due to their incorrect phonological representations. In other words, children with SSD have formed their own set of rules or phonological representation governing which sounds can be produced together due to their SSD. These incorrect phonological representations are called 'frozen' phonological representations (Bryan and Howard, 1992), and it is a possibility that a child's production of a sound in a 'frozen' word might not change with treatment, even if his/her ability to produce that same sound in other words does improve.

For example, if a child continually produced the word 'sun' as 'tun' repeatedly multiple times, he/she might store 'tun' as his/her lexical representation for the bright hot thing in the sky. As a result, he/she might continue to produce 'sun' incorrectly even if his/her ability to produce the /s/ singleton changed due to treatment. Thus, the child might be able to conceptually produce a sound correctly, but due to prior practice and over learned incorrect productions, he/she might not produce those sounds correctly in previous incorrectly practiced words due to his/her frozen phonological representation.

Thus, when selecting a word for speech treatment, word frequency needs to be considered to overcome the effects of a 'frozen' phonological representation. The higher the frequency of a word, the more chances the child has previously had to produce it incorrectly and form an incorrect phonological representation of that word, thus forming a stronger behavior to be changed. Thus, high frequency words are arguably not good treatment targets because children with SSD have incorrect phonological representations of these words.

In other words, if a child has a frozen phonology, he/she might benefit from the use of low frequency words. These low frequency words could help change a child's conceptual understanding of new sounds in order to avoid the over-learned frozen phonological forms that inhibited sound learning. By selecting low frequency words, SSD treatment could focus strictly on improving the child's phonological knowledge. The lowest frequency words are those that have no meaning or use in a language: NWs. While NWs typically are useless to language learners and users, they have served a unique purpose in speech treatment. Essentially, NWs allow a child to focus his/her attention exclusively on articulatory routines, without competition from syntactic, semantic, or lexical information because the child has no previously stored lexical information or awareness about the NWs (Storkel, & Morrisette, 2002). The production of a NW enables the encoding of phonemic information, particularly when that NW is assigned meaning and is pictorially displayed (Leach & Samuel, 2007).

NWs can serve a distinct purpose in speech treatment because they allow the child to focus on primarily the phonological form due to no previous exposure. NWs have no frequency and no lexical meaning because they are nonsense words which eliminate a child's previous exposure to the words. Thus, NWs might promote greater gains in speech treatment than real words. Studies comparing lexicality between NWs and real words have used pictures and/or stories to present NWs (Gierut, Morissette, Zeimer, 2010; Cummings & Barlow, 2011); thus, applying a representation and context for the NW.

Gierut and colleagues (2010) evaluated the effects of NW and real word stimuli in treatment of 60 children between the ages of 3 and 7 years with functional SSDs, with 30 participants assigned to the real word group and 30 assigned to the NW group. A single-subject design, using multiple baselines (McReynolds & Kearns, 1983) was used to ensure experimental control. All of the children received up to 19 one-hour treatment sessions targeting sounds in the initial position of words, which were differentially affiliated with either pictures of novel referents (NW treatment group) or pictures of legitimate referents (real word treatment group).

The generalization of treated and untreated sounds was measured in both groups were measured immediately post-treatment and 55 days after the end of treatment. Consistent with previous findings, the generalization accuracy of the treated sounds in untreated words and contexts exceeded that of untreated sounds for both treatment groups (Dean, Howell, Waters, & Read, 1995; Dinnsen & Elbert, 1984). Interestingly, while the NW generalization was immediate, the real word generalization was not identified until the later post-treatment assessment.

These results of Gierut and colleagues (2010) suggest that the novelty of the NWs created fairly immediate phonological change in real words. In other words, the generalization might have been due to the immediate phonological focus of children when presented with novel new words (Gierut et al, 2010; Leonard, 1973; McNeil & Stone, 1965; Winitz & Bellerose, 1965). Thus, it might be assumed that NWs' (lack of) age of acquisition and word frequency are the key components of phonological change. If it is the case that age of acquisition and frequency are the main features of NWs that cause change, then manipulating both frequency and age of acquisition in lexical items could cause the similar changes.

Alternatively, the finding that children treated with real words made consistent and gradual phonological gains beyond the duration of treatment suggests that real words have an inherent ability to effect phonological properties beyond the treatment room (Labov, 1994; Gierut et al., 2010). These findings might suggest that children are able to use the lexical properties of real words used in treatment outside the treatment room, which allows them to continue generalizing sound knowledge even after speech treatment has ended. Though the real word treatment group made slower generalizations in treatment initially, which might have been due to their additional added lexical content, the real world application of the words was beneficial in the long-run.

In summary, the implications of Gierut et al. (2010) suggest that words that have minimal to no word frequency, but still have lexical meaning might be the most efficacious speech treatment targets. Indeed, word frequency and age of acquisition can be controlled in real words. Individual differences in lexical frequency tend to be more substantial for young children than for older children or adults, and such variance can have a direct impact on children's vocabulary development, such as acquisition order of individual words (Huttenlocher, Haight, Bryk, Seltzer & Lyons, 1991). Thus, it is less evident which words are acquired early on since children's exposures to words vary.

Cummings and Barlow (2010) also evaluated the effects of word lexicality in the treatment of speech sound disorders with 4 children between the ages of 3;0 and 3;11 with functional SSDs, with 2 participants assigned to the real word group and 2 participants assigned to the NW group. A single-subject design, using multiple baselines (McReynolds & Kerns, 1983) was used to ensure experimental control. All of the children received up to 19 one-hour treatment sessions targeting sounds in the initial position of words, which were differentially affiliated with either pictures of novel referents (NW treatment group- low frequency words) or pictures of legitimate referents (real word group-high frequency words) within a storybook context and picture cards.

The generalization of treated and untreated sounds was measured in both groups were measured immediately post-treatment and 2-weeks after the end of treatment. Consistent with Gierut et al. (2010), Cummings and Barlow (2010) found a NW advantage in generalization accuracy of treated sounds to untreated words and generalization of the untreated sound to untreated words. Interestingly, the NW treatment condition showed much larger reductions in the number of sound substitutions produced in their NW treatment target, with both children demonstrating change, whereas only one child in the real word condition demonstrated a reduction in error patterns.

The results of Cummings and Barlow (2010) suggest that NWs helped children better establish their treatment target sound, by limiting the number of sounds determined to be 'acceptable' substitutions for their treated sound. In other words, children had fewer sound substitutions for their treatment target sound illustrating their increased awareness of the accurate production of the target sound. Thus, the phonological form for the treated sounds were more stable for the NW condition, as the NW treatment might have helped children form more adult-like phonological representations to the treated and untreated sounds. In other words, post-treatment the NW group produced fewer incorrect substitutions for adult sounds. The positive phonological changes associated with NW treatment might have been potentially due to the decreased lexical processing load associated with very low frequency, unfamiliar words.

In summary, the implications of the Cummings and Barlow (2010) and Gierut et al. (2010) suggest that words such as NWs that have minimal to no frequency and lexical meaning might be the most efficacious speech treatment targets due to low frequency words' ability to allow children to focus on the articulation of treated sounds, without having to deal with the frozen phonological forms (Bryan and Howard, 1992). Thus, low frequency novel words with lexical meaning might be the most efficacious treatment targets in speech treatment, as long as the target word is able to contain all of these features.

T2 Words: Low frequency, later acquired words.

T2 words are low frequency in spoken English, are acquired later in life, and provide a strong lexical foundation for children who are acquiring language. T2 words are novel to young children and contain low-frequency lexical information necessary to cause phonological change to a child's sound system. With age and exposure to written academic literature and oral language children's vocabulary and language become more homogenous due to academic standards and similar exposures within the academic or school setting. Thus, academic words such as T2 words have little to no frequency with young children because they are preliterate and have not learned or used these words yet because they cannot read. Since young children are preliterate, T2 words have essentially no frequency within the child's lexicon, potentially making T2 words comparable to NWs. And, based on the above evidence (Cummings & Barlow, 2010; Gierut et al., 2010), since NWs have been proven to be efficacious treatment targets, T2 words might also be effective speech treatment targets.

Moreover, if real world application does indeed promote later sound generalization, T2 words could even be more beneficial than NWs in treatment. T2 words contain semantic properties that provide a functional use outside of the treatment room. Alternatively, when NWs are given lexical status, they can potentially engage in competition with real words (Storkel, & Morrisette, 2002). For example, it has been found that children assign meaning to NWs early, with lasting and persisting competition effects being observed as long as 8 months following first exposure to a NW form (Tamminen & Gaskell, 2008). Thus, when NWs that hold no lexical value are added to a child's lexicon, a child's generalization of a treatment sound might be inhibited. For example, if children are trying to use NWs in real world scenarios, they might become discouraged and stop practicing their newly mastered target sound within treatment words because NWs will be unknown and unfamiliar to their communication partners. Thus sound/word generalization might be counterproductive because the NWs do not hold meaning and were not intended to have meaning applied outside the treatment room. Although NWs can serve a critical function within the treatment room, a low frequency word that future communication partners understand might be more practical.

Need for lexical development in SSD treatment.

Individuals with a SSD are more likely to demonstrate language problems (Bernthal, Bankson, & Flipsen, 2009) and are at risk for academic problems in reading and spelling during the elementary years (Justice, Gillon, & Schuele, 2009; Kirk & Gillon, 2007; Lewis, Freebairn, Hansen, Iyengar, & Taylor, 2007; Rvachew, Chiang, & Evans, 2007). Since academic language strongly correlates to T2 vocabulary knowledge and early vocabulary knowledge is the best predictor of later academic performance, children with SSD are at risk for later academic failure (e.g., reading). Thus, incorporating T2 vocabulary into speech treatment could support learning for children with SSD.

Children with SSD are considered an at risk population for vocabulary deficits due to their inability to produce novel new words composed of sounds that are out their phonetic inventory (Leonard, Schwartz, Morris, & Chapman, 1981; Schwartz & Leonard, 1982). The need for early vocabulary treatment with at risk populations is evident as first-grade vocabulary predicts students' reading achievement in their junior year of high school (Cunningham & Stanovich, 1997). Thus, an early academic focus on vocabulary can promote later academic success.

Treatment of SSD in preschool and early-elementary aged children can opportunities for exposure to T2 vocabulary instruction, which can help prevent the vocabulary gap that is established in the early developmental years (Hart & Risley, 1995). In addition, it has been shown that by increasing a child's expressive vocabulary in treatment, the child will have subsequent improvements in phonological diversity (Girolametto, Pearce, & Weitzman, 1997; Whithurst, Fischel, Lonigan, Valdez-

Menchaca, Arnold, & Smith, 1991). Thus, children with SSD can benefit from treatment involving T2 words both in terms of both phonological development and vocabulary expansion.

Word Learning: Word Presentation.

To support word learning beyond the phonological form and to promote vocabulary acquisition, words need to be taught within a context that can carry word meaning (Biemiller & Boote, 2006). Thus, in order to teach words, it is important to incorporate natural exposures or experiences with the new words since young children naturally learn through their experiences (Rice, 1990). For example, young children talk about things within his or her environment, thus the environment provides a context for new word exposure and adults provide them with quick incidences of words through talking about the context.

Previous research incorporating natural exposure techniques into treatment to help children learn treatment target words have shown to be efficacious. Specifically, many studies involving “fast-mapping” or “quick incidental learning” (QUIL) paradigms have demonstrated that young children can learn and remember the phonological form and some of the semantic and syntactic characteristics of words after even a single exposure (Bedore & Leonard, 2000; Carey & Bartlett, 1978; Dollaghan, 1985, 1987; Oetting, Rice, & Swank, 1995; Rice, Buhr, & Nemeth, 1990; Rice, Oetting, Marquis, Bode, & Pae, 1994; Rice & Woodsmall, 1988). For example, by providing new words to children with quick definitions and rich contexts, children are able to begin processing the words phonological forms and through increased exposure of the word within familiar contexts children are able to apply syntactic and semantic knowledge to new words.

In speech treatment, children not only produce treatment words, but also hear the word modeled to them by the clinician multiple times. Thus, speech treatment provides many opportunities for children to hear and use words and a QUIL approach should be applicable in this context. Speech treatment can specifically integrate vocabulary or treatment words into adult-child storybook interactions, which is a natural way in which children learn. Along with exposing words to children through reading, presenting words verbally within a context and having the child use the words when talking about the story or referents might lead to a deeper kind of word knowledge (Beck et al., 2002). The more children hear, see, and engage with words, the better they will learn them (Armbruster, Lehr, Osborn, & Adler, 2001).

In order to teach T2 words, QUIL approach, along with teaching word consciousness[3], might best impact a child's intelligibility, expressive language development, and vocabulary development. Incidental learning from context has been identified as a main cause of vocabulary growth among children. Children are remarkably skilled at learning new words from unstructured contexts (Akhtar, Jipson, & Callanan, 2001; Nagy, Herman, & Anderson, 1985; Rice, Buhr, & Oetting, 1992). This effortless acquisition of word knowledge happens through oral communication and casual reading without direct instruction (Nagy et al., 1985; Oetting, Rice, & Swank, 1995). Thus, speech treatment instruction needs to take advantage of adult-children interactions to model the use of more sophisticated language such as T2 vocabulary (Beck et al., 2002; Graves & Watts-Taffe, 2002).

[3] Word consciousness involves being aware and interested in words and word meanings (Anderson & Nagy, 1992; Graves & Watts-Taffe, 2002), and noticing when and how new words are used (Manzo & Manzo, 2008).

Selecting T2 words that are more sophisticated labels for familiar concepts expands both vocabulary breadth and depth[4]. In terms of T2 vocabulary instruction, vocabulary breadth or scope of knowledge is expanded because T2 words add to the number of words a child already knows. For example, when using the T2 word "rigid" in treatment along with the QUIL definition, "stiff, not moving", children are exposed to both a T2 word ("rigid") and tier one words ("stiff", "not moving"). By directly targeting and teaching the word "rigid", the clinician indirectly targets the words "stiff" and "moving", along with the functional grammatical for of negation ("not"). Thus, targeting the T2 word "rigid" treatment can increase a child's vocabulary depth or quality because "rigid" is linked to familiar words such as "stiff, not moving", thus enhancing the child's understanding of both the new and familiar words.

Incorporating T2 words consistently into literacy activities, adult-child games, and conversation can facilitate both vocabulary breadth and depth while encouraging ongoing expansion due to strengthening word consciousness. Teaching later acquired or more advanced vocabulary provides children with the opportunity to hear and use academic language within a natural environment, which can facilitate a deeper understanding of words. If parents or adults focus on teaching T2 academic words within the environment, they can model in a variety of contexts with a variety of tenses, promoting vocabulary depth and breadth.

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[4] Vocabulary breadth refers to the range of vocabulary an individual knows; thus, a person with a wider range of vocabulary relating to a variety of topic areas would have a breadth of vocabulary knowledge. Vocabulary depth refers to the level of understanding an individual has on vocabulary words within his or her lexicon; thus, a person with a quality understanding of a word may be able to use it within multiple contexts with a variety of tenses (e.g., verb "rescue"; verb + ing "rescuing", etc.) illustrating his or her depth of vocabulary knowledge.

For example, when teaching the word ‘rigid’, the parent could say, “Billy, you are *rigid* (tense 1: adjective) in your thoughts today. I cannot change (QUIL definition) your mind.” in reference to the child not wanting to do something. Or, the parent could say, “Billy, are you sitting *rigidly* (tense 2: adverb) because you’re so upset that you cannot move (QUIL definition)?” in reference to the child sternly pouting on the chair. Examples can also be more explicit, such as in reference to a story the adult could comment by saying, “Grandma is *rigid*! That means Grandma is stiff, not moving (QUIL definition).” while pairing the exposure with an action or pointing to the referent. The opportunities for T2 word exposure within the natural environment are abundant, and the more times T2 words are incorporated into parent-child interactions, the more word conscious the child will become. Thus, the potential benefits of speech treatment involving T2 words extend beyond the phonological level and into lexical development.

Current Study Aims.

It is evident that more controlled studies on word lexicality in speech treatment are needed. NWs have been shown to be effective treatment targets, perhaps due to the effects of phonological processing (Vitevitch & Luce, 1998, 1999) and the novelty of items (Storkel, Armbrüster, & Hogan, 2006). However, NWs lack lexical properties that help child learn word representations as a whole, which might inhibit a child’s ability to practice NW treatment targets within functional contexts. Also, children might assign meaning to NWs in the same way they would any novel new word, especially when a NW is assigned meaning and is pictorially displayed (Leach & Samual, 2007), which would be counterintuitive to the rationale for using NWs in treatment. Alternatively, T2 words might cause the same or more phonological gains than NWs because they have semantic and syntactic information, which provides children with more information to strengthen his/her lexical representation.

The current study investigates the roles of NWs and T2 words in SSD treatment to determine the effects of treatment word lexicality in causing phonological gains. It is proposed that both T2 words and NWs might create widespread phonological change due to their low-to-no frequency of occurrence in the English language. The current study aims to examine phonological change and vocabulary development. The specific aims of the study were:

1. To assess the phonological changes in each participant's sound system through the measurement of: learning during treatment, generalization of the treated sound in untreated words, generalization of untreated sounds in untreated words, and variability in sound substitutions for treated and untreated sounds.
2. To assess vocabulary expansion and knowledge of T2 words through a Zero-One-Two (ZOT; Robinson, 2013) Vocabulary Assessment by evaluating the child's vocabulary knowledge of the targeted words over the course of treatment.

It was hypothesized that T2 words, with their low frequency and lexical meaning, would create greater phonological change than will NWs. Children might initially treat both NWs and T2 words as novel words, which theoretically might allow the children to focus on the words' phonological properties that could promote system-wide phonological change (Gierut, Morrissette, & Ziemer, 2010). Children might also form a lexical representation of the NWs in treatment, but this lexical representation would be temporary (Tamminen & Gaskell, 2008). Alternatively, the T2 words' lexical representations would be established and practiced in everyday situations. In other words, the T2 words might provide a lexical foundation for the phonological forms to be practiced in real life experiences, thus promoting more phonological generalization to treated words and sounds.

Vocabulary expansion was promoted in speech treatment using a QUIL approach where the T2 participants were provided with a quick definition of the target T2 word within the storybook. The QUIL definitions were used to promote lexical learning of the T2 words. It was predicted that the QUIL definition would help the children form representations of the T2 words faster, which would aid T2 participants in the learning of treatment target sounds and words. Thus, if the T2 participants made more changes to their sound systems and obtained higher ZOT scores than the NW participants, it would suggest that T2 words would be more optimal targets for SSD treatment than NWs.

CHAPTER III

PARTICIPANTS

Participants consisted of four 3- to 6-year-old children with functional speech sound disorders (SSD). These children were recruited to participate in the study through a variety of means including referrals from the University of North Dakota Speech-Language Hearing Clinic, community out-reach programs, public announcements to area schools, and child-care centers, as well as referral from the clinician's supervisor and other speech-language pathologists in the Grand Forks Public School system.

When a possible participant was referred to this research study, his or her parents were contacted via a phone interview by the clinician's supervisor. Children who were reported to have trouble producing speech sounds, had normal hearing, had typical language development, and appeared to be functioning at normal developmental levels were eligible to participate in further screening measures.

With written permission (Institutional Review Board consent forms approved by the University of North Dakota) from the child's parents, the clinician completed a formal battery of screening measures in order to determine if the children were eligible for this research study (see below for more details). Inclusionary criteria were established to guide participant selection, although due to participant availability exceptions were made to inclusionary criteria. All four participants that were screened were selected to participate in this study. The inclusionary criteria of this study are listed below.

Inclusionary criteria:

- Resided in a monolingual English-speaking household. It was important to control for different language systems containing different sounds and phonological rules.
- Performed at or below the 25th percentile on the *Goldman Fristoe Test of Articulation, 2nd edition* (GFTA-2; Goldman & Fristoe, 2000) relative to age- and gender-matched peers. The GFTA-2 allowed for broad sampling of the consonant sounds and clusters used in Standard American English. The percentile score rank cut off criteria allowed for a consistent speech severity boundary between participants in the study.
- Oral-facial structure and function were within typical limits on the protocol developed by Shipley (2009). The oral peripheral mechanism examination (OPME) ruled out structural or functional factors that related to a communicative disorder. In addition, a Diadochokinetic (DDK) assessment evaluated the client's ability to make rapidly alternating speech movements. A slower or more variable DDK rate can suggest ataxia, dysarthria, childhood apraxia of speech, and/or stuttering. Since the current study examined children with functional SSD, and no child presented with any of the disorders listed above.
- Hearing within normal limits as determined by a standard audiometric screening (American National Standards Institute, 1991). A hearing loss of any degree, including mild bilateral (in both ears) and unilateral (in one ear), has been shown to adversely affect speech, language, and academic and psychosocial development (Bess et al., 1998; Bess and Tharpe, 1986 and 1988; Blair et al., 1985; Bovo et al.,

1988; Brookhouser, et al., 1991; Culbetson and Gilbert, 1986; Davis et al., 2001; Davis et al., 1986; Klee and Davis-Dansky, 1986; Lieu, 2004; Moeller, 2000; Oyler et al., 1987; Yoshinaga-Itano et al., 1998). Children with a hearing loss demonstrate different speech characteristics and require different treatment approaches than children with functional SSD. The current study focused on children with functional SSD of unknown causes; thus, no participants had a hearing loss.

- Nonverbal cognitive skills were within normal limits as assessed by a Brief IQ screener on the *Leiter International Performance Scale-Revised* (Leiter-R; Roid & Miller, 1997). All participants in the current study were determined able to generalize information and deemed cognitively able to comprehend the information and instructions provided during treatment as measured by the Leiter.
- Receptive vocabulary skills were within normal limits as assessed by the *Peabody Picture Vocabulary Test - 4th edition* (PPVT-4; Dunn & Dunn, 2007). Participants' receptive vocabulary skills were required to be within the normal range with standard scores between 85-115, in order to demonstrate their potential to acquire new vocabulary words.
- Core language skills (morphology, syntax, semantics, pragmatics, and phonological awareness) were required to be within normal limits as assessed by the *Clinical Evaluations of Language Fundamentals, Preschool- Second Edition* (CELF-P2; Semel, Wiig, & Secord, 2003) in order to ensure general language ability and determined the presence or absence of a language disorder. Since the current study examined the treatment of children with functional SSD and not

children with language disorders, it was necessary to rule out any child having confounding language impairments to ensure treatment efficacy.

- Each child's selected treated sound was produced with less than 10% accuracy on the *Assessment of English Phonology* (AEP; Barlow, 2003; Appendix 9). The AEP is an in-depth assessment probe, which allowed the clinician to characterize each participant's sound systems in English. Each participant was administered the 256-word probe which sampled all English sounds in each of their viable word positions at least five times. Participants' spontaneous word productions were elicited using an electronic picture-naming task and digitally recorded. This ensured that the child did not have much, if any, phonological knowledge of his/her selected treatment sound.

All participants passed inclusionary criteria for normal oral-motor facial structure and function and passed their hearing screenings. While not ideal, one of the four children (AG) had receptive vocabulary skills and core language skills that were outside of the normal range. However, this situation did provide an opportunity to examine the efficacy of using T2 words in treatment of children with both language and speech disorders. An additional strict inclusionary criterion was that all participants needed to have his/her AEP probe analyzed prior to starting treatment so that his/her baseline phonological performance would be adequately measured. All pre-treatment analysis completed from the AEP are discussed in the following paragraphs.

The AEP allowed for a pre-treatment analysis of each participant's phonemic and phonetic inventories, as well as his/her overall Percent Phonemes Correct (PPC) and

Percent Consonants Correct[5] (PPC; Shriberg, Austin, Lewis, McSweeny, & Wilson, 1997). Summaries of all participants' phonetic and phonemic inventories are summarized below in tables 2 and 3, respectively. Recall that for a sound to be considered in the child's phonetic inventory it had to occur at least twice, and in this situation it was measured during productions during the AEP probe. Again, the phonemic inventory has a stricter criterion than the phonetic inventory, as in order to be included, a sound must occur within at least two minimal pairs. PCC and PPC scores were also calculated on the AEP probes. Accuracy percentage scores for each sound occurring in the AEP words was calculated using the *Logical International Phonetic Programs 2.02* (LIPP; Oller & Delgado, 1999) PC computer transcription program (Intelligent Hearing Systems, 2000), each consonant and vowel sound was point-by-point identified as being correct or incorrect according to typical adult language.

The PPC metric expresses the percentage of intended consonant sounds in the GFTA-2 that were articulated correctly. Clinical distortions, deletions, or substitutions of any consonant or vowel were scored as incorrect. For example, if the target word was 'cat' /kæt/ and the child produced 'gad' [gæd], the child would have two phonemes in error (/k/ → [g] and /t/ → [d]) and one phoneme correct (/æ/ → [æ]). PPC scores tend to be larger than the PCC scores because they include vowel productions and children are more accurate with vowels than consonants.

[5] The Percent Phonemes Correct (PPC) is a calculation [Number Correct/ (Number Correct + Number Incorrect) x 100] used to measure the child's total number of correct sounds (vowels and consonants) in a speech or language sample in relation to an adult target word. The Percent Consonants Correct (PCC) is a calculation [same as PPC formula] used to measure the child's total number of correct consonants (consonants only; vowels excluded) in a speech or language sample in relation to an adult target word. A severity rating can be calculated from the PCC score.

The PCC measures the percentage of consonants correct as compared a speaker with an adult model. This allows for an accurate means of comparison between the child's consonant productions only; vowels are excluded from this analysis. For example, if the target word was 'cat' /kæt/ and the child produced 'gad' [gæd], the child would have two consonants in error (/k/ → [g] and /t/ → [d]); the correct vowel production would not considered in this analysis. A summary of all the participants' pre-treatment PPC and PCC scores on the AEP are summarized below in figures 1 and 2.

The following information supplies a detailed profile for each of the 4 participants, including their phonetic and phonemic inventories, phoneme substitutions, percent phonemes correct, CELF-4, Leiter-R, and other factors that may have impacted the effectiveness of the treatment. A summary of each participant's inclusionary scores on the GFTA-2, KLPA-2, PPVT-4, and CELF is provided on table 1. A detailed discussion of each of the participant's pre-treatment performance scores and analysis follow the summary tables below.

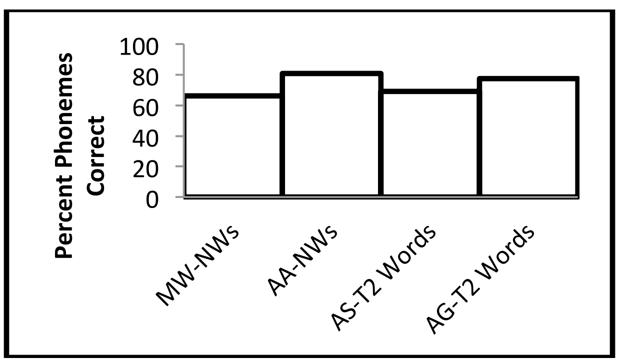


Figure 1. All participants' Pre-Tx AEP PPC

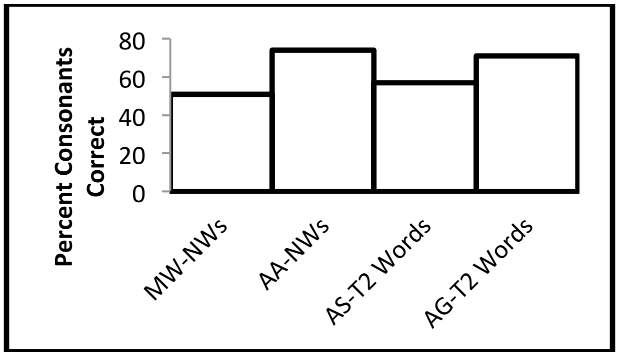


Figure 2. All participants' Pre-Tx AEP PCC

Table 1. A summary of each participant's pre-treatment scores on the following standardized assessments: GFTA-2, KLPA-2, PPVT-4 and CELF-P2/CELF-4*.

	NW Group		T2 Word Group	
Participant Inclusionary Criteria	**MW**	**AA**	**AS**	**AG**
Gender	Female	Male	Female	Female
Age at start of Treatment	3:3	4:10	3:9	6:0
Treatment Sound	/r/	/θ/	/r/	/r/
Goldman-Fristoe Test of Articulation-2				
Raw Score	37	27	36	26
Standard Score	85	83	81	71
Percentile Score	24	16	15	2
Khan-Lewis Phonological Analysis-2				
Raw Score	57	31	43	29
Standard Score	83	86	87	70
Percentile Score	14	16	18	5
Peabody Picture Vocabulary Test-4th Ed.				
Raw Score	69	95	62	79
Standard Score	119	111	101	85
Percentile Score	90	77	53	16
Clinical Evaluation of Language Fundamentals				
Raw Score	39	30	33	21*
Standard Score	118	100	106	72*
Percentile Score	88	50	66	3*

Table 2. Each participant's Phonetic Inventory Pre-Treatment. No distortions or non-adult sounds are included in this inventory. Sounds the child was missing from their phonetic inventory pre-Tx are marked with an "X".

Phonemes	MW	AA	AS	AG
/p/				
/b/				
/t/				
/d/				
/k/	X			
/g/	X			
/f/				
/v/				
/s/				
/z/			X	
/θ/	X	X	X	
/ð/	X	X	X	
/ʃ/		X		
/ʧ/			X	
/ʤ/			X	
/m/				
/n/				
/ŋ/				
/w/				
/j/			X	
/r/			X	X
/l/				
/h/			X	

Table 3. Each participant's Phonemic Inventory Pre-Treatment. No distortions or non-adult sounds are included in this inventory. Sounds missing from the child's phonemic inventory Pre-Tx are marked with an "X".

Phonemes	MW	AA	AS	AG
/p/				
/b/				
/t/				
/d/				
/k/	X			
/g/	X	X		
/f/				
/v/	X	X		X
/s/				X
/z/			X	X
/θ/	X	X	X	X
/ð/	X	X	X	X
/ʃ/		X		
/ʧ/			X	
/ʤ/	X		X	
/m/		X		
/n/		X		
/ŋ/	X	X	X	X
/w/		X		
/j/	X	X	X	
/r /			X	X
/l/	X	X		
/h/	X		X	

2.1 SSD01_MW Profile.

MW, a three-year, four-month female, was the youngest child of in a family of five, with older two sisters. Her race/ethnic group was Asian or Pacific Islander but her Caucasian family adopted her. MW spoke English at home with her monolingual English speaking family. MW had previously received speech therapy services through an outside agency (Altru Rehabilitation) and through the Grand Forks Public Schools. Due to MW's young age, she was hesitant to be alone with the clinician during the first evaluation session. MW's mother stayed in the room until MW acclimated to the clinical setting. MW was attentive and fully able to participate in all assessment measures.

Articulation Skills. The *Goldman-Fristoe Test of Articulation – 2* (GFTA-2) (Goldman & Fristoe, 2000) was administered to assess MW's production of speech sounds; her results are summarized below in table 2. Fifty-three items were presented to MW to label. Of the possible 77 target consonant sounds, MW produced 37 sounds in error. The following lists the sounds produced in error; the word positions in which they were incorrect are marked with an "X".

Table 4. MW's Pre-Tx sounds in error on the GFTA-2

Sound symbol	**Letter and example**	**Word Initial**	**Word Medial**	**Word Final**
/θ/	"th" in "thumb"	X	X	X
/ð/	"th" in "feather"	X	X	
/g/	"g" in "girl"	X	X	X
/k/	"k" in "cup"	X	X	X
/tʃ/	"ch" in "watches"		X	
/dʒ/	"j" in "jumping"			X
/z/	"z" in "zipper"	X		X
/l/	"l" in "ball"			X
/v/	"v" in "vacuum"			X
/j/	"y" in "yellow"	X		
/r/	"r" in "rabbit"	X	X	

The following sound blends were also produced in error in word initial position: "bl", "br", "dr", "fl", "fr", "gl", "gr", "kl", "kr", "kw", "pl", "sl", "sp", "st", "sw", and "tr". Her raw score converted to a standard score of 85, which placed MW in the 25th percentile for children her age.

Using MW's production of words on the GFTA-2, the Khan-Lewis Phonological Analysis -2 (KLPA-2; Khan & Lewis, 2002) was completed to assess her phonological patterns/processes. MW produced 57 separate phonological processes in the 53 words of the *GFTA-2* (Goldman & Fristoe, 2000). This raw score of 57 converted to a standard score of 83, which placed MW at the 14th percentile for children her age. The 10 phonological processes (sound patterns) that were used to calculate MW's raw score and her percentage of occurrences are summarized in table 5.

Table 5. Participant MW's Pre-treatment KLPA-2 percent occurrence of processes

	Target Word → Process	Pre-Tx
Deletion of final Consonants	"scissors" → "scissor-"	11%
Syllable Reduction	"banana" → "nana"	0%
Stopping of Fricatives/Affricates	"this" → "dis"	6%
Cluster Simplification	"spoon" → "poon"	73%
Liquid Simplification	"rabbit" → "wabbit"	29%
Velar Fronting	"cup" → "tup"	79%
Palatal Fronting	"chair" → "sair"	0%
Deaffrication	"watches" → "washes	33%
Initial Voicing	"telephone" → "delephone"	0%
Final Devoicing	"five" → "fife"	16%

A PPC calculation was used to measure the percentage of phonemes correct as compared to the GFTA-2 target words. MW received a PPC score of 67%. Also, a PCC score was calculated from her GFTA-2, which was used to measured the percentage of consonants correct as compared to an adult model or the target words on the GFTA-2; vowels excluded. MW received a PCC score of 55%, which converted to a severity rating of Moderate-Severe (Shriberg & Kwiatkowski, 1982).

A phonemic and phonetic inventory was calculated from the AEP (Barlow, 2003) probe to measure current sounds MW had within her inventories to compare in order to measure system-wide change. All adult sounds in MW's pre-treatment phonetic and phonemic inventories are included in tables 2 and 3 above. MW's pre-treatment phonetic inventory included the following sounds: /p, b, t, d, f, v, s, z, ʃ, ʧ, ʤ, ts, dz, m, n, ŋ, l, r, w, j, h/. Of these sounds both the /ts/ and /dz/ were considered to be incorrect alveolar affricate productions of adult /ʧ/ and /ʤ/ palate-alveolar affricate sounds. MW's pre-treatment phonemic inventory included the following sounds: /p, b, t, d, f, s, z, ʃ, ʧ, m, n, r, w /.

A participant was considered stimulable for sounds they were able to produce at 10% accuracy during a nonsense syllable task (Elbert, Dinnsen, & Powell, 1984; Carter & Buck, 1958). MW's ability to produce specific speech sounds was assessed in a stimulability evaluation. Specific sounds were targeted in isolation, CV, VC, and CVC formats using the following three vowels: /i/, /u/, and /a/. MW was told to "watch the clinician, listen, and say what she said". Stimulability testing was done on late eight sounds /θ, r/ that were noted in error during the administration of the GFTA-2. Only the late eight sounds (ʃ, θ, s, z, ð, l, r, ʒ; Shriberg, 1993) noted in error were checked for stimulability because late eight sounds are likely to cause the most system wide sound change due to their complexity and most likely to be in error for all participants within the study.

MW's stimulability for consonants in error is represented in table 6. Both the /r/ and /θ/ phonemes were late eight sounds noted in error during the GFTA-2. In order for participants to be considered stimulable for a sound they needed to be able to produce it with greater than 30% accuracy (Glaspey & Stoel-Gammon, 2005), thus MW was not stimulable for /r/ and /θ/. MW was only stimulable for the post-vocalic /r/ ("r" at the end of words "hunger") and not the pre-vocalic /r/ ("r" in "rake"). Although both the /r/ and /θ/ were noted in error, the /r/ was selected as a target treatment sound due to its complexity (as MW only had a post-vocalic /r/) and the high frequency of /r/ in English. The /r/ was selected because it was judged to cause the most changes to MW's sound system.

Table 6. MW's stimulability for sounds she produced in error on the GFTA-2

Sound symbol	**Letter and example**	**Percentage Correct**
/r/	"r" in "rabbit"	30%
/θ/	"th" in "thumb"	0%

As compared to other children her age, these results suggested that MW had a mild SSD.

Language and Conversational Skills. Receptive Language. MW was administered Form A of the *Peabody Picture Vocabulary Test – Fourth Edition* (PPVT-4; Dunn & Dunn, 2007) to assess her comprehension of single words (objects and actions) represented with color line drawings. MW responded incorrectly 39 times, resulting in a raw score of 69. Her raw score converted to a standard score of 119, which placed MW at the 90th percentile for children her age. As compared to other children her age, MW had picture vocabulary skills that were above average.

MW was administered the *Clinical Evaluation of Language Fundamentals Preschool – 2nd Edition* (CELF-P2) to evaluate MW's overall receptive and expressive language skills. Three of the CELF-P2 subtests were administered. MW's raw scores (i.e., the number of items she got correct), scaled scores (on a scale from 1-19), and percentile scores (50th percentile is typical) for each of the subtests are presented below in table 7.

Table 7. MW's Raw score, Scaled Score, and Percentile Scores Pre-Tx on the CELF-P2

Subtest	**Raw Score**	**Scaled Score**	**Percentile Score**
Sentence Structure	16	15	95
Word Structure	14	12	75
Expressive Vocabulary	26	12	75

These three individual subtests of the CELF-P2 are also combined to create a "Core Language Score". The sum of the subtest scaled scores was 39, which converted to a standard score of 118, placing MW in the 88th percentile for children her age. This assessment suggested that MW had receptive and expressive language skills that were above average.

Nonverbal Cognitive Skills. MW's nonverbal cognitive skills were assessed using the *Leiter International Performance Scale-Revised* (Leiter-R; Roid & Miller, 1997). The Leiter-R assessed participants' nonverbal cognition through visual picture recognition and pattern recognition. Given MW's young age, the standard nonverbal administration techniques suggested by the *Leiter-R* were not followed. Instead, the clinician demonstrated physically and gave verbal prompts and instructions to MW in an attempt to make her better understand the various tasks. Four of the Leiter-R subtests were administered. MW's raw scores (i.e., the number of items she got correct), and scaled scores (on a scale from 1-19) for each subtest are presented below in table 8.

Table 8. MW's Pre-Tx Raw and Scaled Scores for the Leiter-R subtests

Subtest	**Raw Score**	**Scaled Score**
Figure Ground	13	16
Form Completion	20	16
Sequential Order	7	12
Repeated Patterns	4	12

The individual subtests of the Leiter-R were also combined to create a Nonverbal Cognition score. The sum of the subtest scaled scores was 52, which converted to a standard score of 121, placing MW in the 94th percentile for children her age. This assessment suggested that MW had high nonverbal cognitive abilities for children her age.

Voice and Fluency. Voice and fluency were measured informally throughout the assessment. MW was observed to maintain appropriate oro-nasal resonance balance and fluency during the various assessment tasks. Based on this brief assessment, there was no evidence of pathological factors influencing voice and fluency. Thus, MW's voice and fluency measures were typical of children her age.

Oral-Peripheral Mechanism Evaluation: Structural Integrity. MW's face, cheeks, lips, teeth, tongue, jaw, hard and soft palate all appeared typical in size, color, shape, symmetry and/or overall appearance and were judged, upon visual inspection, to be adequate for speech production purposes.

Oral-Peripheral Mechanism Evaluation: Oral-Motor Functions. MW had no difficulties with vegetative function (e.g., suck, swallow, breathe, bite, chew). Non-speech functions (e.g., smile, lip pucker, cheek puff, tongue protrusion and lateralization, jaw excursion, glottal closure) appeared typical with regard to speed, strength, range of motion, and/or mobility.

Oral-Peripheral Mechanism Evaluation: Feeding Reflexes. No retained feeding reflexes were observed.

Oral-Peripheral Mechanism Evaluation: Speech-Motor Functions. MW's motor-speech functions appeared typical with regard to respiration; onset, duration, and cessation of phonation; velar elevation, pharyngeal movement, adequacy of oro-nasal resonance balance; and overall prosody. MW's articulation abilities were preliminarily measured with diadochokinetic tasks (e.g., "puh-tuh-kuh"). MW was unable to say the three different syllables correctly in succession (e.g., instead of "puh-tuh-kuh", she produced, "puh-duh-duh"). No visible signs of effort during articulation were observed.

2.2 SSD02_AA Profile.

AA, a four-year, ten-month male, was an only child and lived with his birth parents. His race/ethnic group was Caucasian, Non-Hispanic. AA spoke only English at home. AA had not previously been receiving speech therapy services through any other agency.

Articulation Skills. The GFTA–2 was administered to assess AA's production of speech sounds, his results are summarized below in table 9. Fifty-three items were presented to AA to label. Of the possible 77 target consonant sounds, AA produced 27 sounds in error. The following lists the sounds produced in error; the word positions in which they were incorrect are marked with an "X".

Table 9. AA's pre-treatment sounds in error on the GFTA-2

Sound symbol	Letter and example	Word Initial	Word Medial	Word Final
/θ/	"th" in "thumb"	X	X	X
/ð/	"th" in "feather"	X	X	
/tʃ/	"ch" in "watches"		X	X
/dʒ/	"j" in "jumping"			X
/z/	"z" in "zipper"			X
/ʃ/	"sh" in "shovel"		X	X
/l/	"l" in "ball"	X		X
/v/	"v" in "vacuum"	X	X	

The following sound blends were also produced in error in word initial position: "dr", "fl", "fr", "gl", "gr", "kl", "kw", "pl", "sp", "sw", and "tr". His raw score converted to a standard score of 83, which placed AA in the 16th percentile for children his age. In addition, based on his GFTA-2 productions, AA received a PPC score of 77% and a PCC score of 69%, which converted to a severity rating of Moderate (Shriberg & Kwiatkowski, 1982).

AA's ability to produce specific speech sounds was assessed in a stimulability evaluation. Stimulability testing was done on the late eight developmental sounds (ʃ, θ, s, z, ð, l, r, ʒ; Shriberg, 1993) noted in error during the GFTA-2 and AEP. AA's stimulability for consonants in error is represented in table 10. In order for participants to be considered stimulable for a sound they needed to be able to produce it with greater than 30% accuracy (Glaspey & Stoel-Gammon, 2005), thus AA was not stimulable for the /θ, tʃ, l/ sounds.

Table 10. AA's stimulability for sounds he produced in error on the GFTA-2

Sound symbol	Letter and example	Percentage Correct
/θ/	"th" in "think"	0%
/tʃ/	"ch" in "watch"	30%
/l/	"l" in "ball"	70%
/r/	"r" in "rabbit"	40%

Language and Conversational Skills: Receptive Language. AA was administered Form A of the PPVT-4 to assess his comprehension of single words (objects and actions) represented with color line drawings. AA responded incorrectly 37 times, resulting in a raw score of 95. His raw score converted to a standard score of 111, which placed AA at the 77th percentile for children his age. As compared to other children his age, AA had picture vocabulary skills that were within the normal range.

Also, AA was administered the CELF-P2 to evaluate AA's overall receptive and expressive language skills. Three of the CELF-P2 subtests were administered. AA's raw scores, scaled scores, and percentile scores for each of the subtests are presented in table 11.

Table 11. AA's Raw score, Scaled Score, and Percentile Scores pre-treatment on CELF-P2

Subtest	Raw Score	Scaled Score	Percentile Score
Sentence Structure	18	12	75
Word Structure	15	9	37
Expressive Vocabulary	28	9	37

The individual subtests of the CELF-P2 were also combined to create a "Core Language Score". The sum of the subtest scaled scores was 30, which converted to a standard score of 100, placing AA in the 50th percentile for children his age. This assessment suggests that AA had receptive and expressive language skills that were within the normal range.

Nonverbal Cognitive Skills. AA's nonverbal cognitive skills were assessed using the Leiter-R. The Leiter-R assessed AA's ability to cognitively comprehend information and instructions. Given AA's young age, the standard nonverbal administration techniques suggested by the *Leiter-R* were not followed. Instead, the clinician demonstrated physically and gave verbal prompts and instructions to AA in an attempt to make him better understand the various tasks. Four of the Leiter-R subtests were administered. AA's raw scores and scaled scores for each subtest are presented in table 12.

Table 12. AA's pre-treatment Raw and Scaled Scores for the Leiter-R subtests

Subtest	Raw Score	Scaled Score
Figure Ground	15	12
Form Completion	23	14
Sequential Order	12	14
Repeated Patterns	20	17

The individual subtests of the Leiter-R were combined to create a Nonverbal Cognition score. The sum of the subtest scaled scores was 57, which converted to a standard score of 131, which placed AA in the 98^{th} percentile for children his age. This assessment suggested that AA had high nonverbal cognitive abilities for children his age.

Voice and Fluency. Voice and fluency were measured informally throughout the assessment. AA was observed to maintain an appropriate oro-nasal resonance balance during the various assessment tasks. Based on this brief assessment, there was no evidence of pathological factors influencing voice. Thus, AA's voice measures were typical of children his age.

AA's speech delivery rate at times was abnormally fast. It was noted that he failed to maintain normally expected sound, syllable, phrase, and pausing patterns. AA's fluency was monitored throughout the course of treatment. AA's fluency patters are covered in chapter 5.

Oral-Peripheral Mechanism Evaluation: Structural Integrity. AA's face, cheeks, lips, teeth, tongue, jaw, hard and soft palate all appeared typical in size, color, shape, symmetry and/or overall appearance and were judged, upon visual inspection, to be adequate for speech production purposes.

Oral-Peripheral Mechanism Evaluation: Oral-Motor Functions. AA had no difficulties with vegetative function (e.g., suck, swallow, breathe, bite, chew). Non-speech functions (e.g., smile, lip pucker, cheek puff, tongue protrusion and lateralization, jaw excursion, glottal closure) were typical with regard to speed, strength, range of motion, and/or mobility. Although, AA's range of motion was adequate, AA had needed multiple cues to get achieve adequate placement. For example, AA needed several attempts to push out his cheeks on both sides of his mouth using his tongue to complete the task. AA was given several models from the clinician on where to place his tongue and provided tactile feedback (using a tongue depressor to show where he needed to place his tongue), in order to successfully complete the task.

Oral-Peripheral Mechanism Evaluation: Feeding Reflexes. No retained feeding reflexes were observed.

Oral-Peripheral Mechanism Evaluation: Speech-Motor Functions. AA's motor-speech functions appeared typical with regard to respiration; onset, duration, and cessation of phonation; velar elevation, pharyngeal movement, adequacy of oro-nasal resonance balance; and overall prosody. AA's articulation abilities were preliminarily measured with diadochokinetic tasks (e.g., "puh-tuh-kuh"). AA was unable to say the three different syllables correctly in succession (e.g., instead of "puh-tuh-kuh", he produced, "tuh-tuh-tuh"). No visible signs of effort during articulation were observed.

2.3 SSD03_AS Profile.

AS, a three-year, nine-month female, was the middle child in a family of five, as she had an older sister and a younger sister in her home. Her race/ethnic group was Caucasian, Non-Hispanic. AS spoke only English at home with her family. AS had never received speech therapy prior to being enrolled in the current study. AS was able to adapt to the clinical testing setting and fully participated in all assessment measures.

Articulation Skills. The GFTA-2 was administered to assess AS's production of speech sounds, her results are summarized below in table 2.12. Fifty-three items had been presented to AS to label. Of the possible 77 target consonant sounds, AS produced 36 sounds in error. Table 13 lists the sounds produced in error; the word positions in which they were incorrect are marked with an "X".

Table 13. AS's pre-treatment sounds in error on the GFTA-2

Sound symbol	Letter and example	Word Initial	Word Medial	Word Final
/θ/	"th" in "thumb"	X	X	X
/ð/	"th" in "feather"	X	X	
/ʃ/	"sh" in "shovel"	X	X	X
/tʃ/	"ch" in "watches"	X	X	X
/dʒ/	"j" in "jumping"	X	X	X
/z/	"z" in "zipper"	X	X	X
/s/	"s" in "scissors"	X	X	X
/v/	"v" in "vacuum"	X		X
/r/	"r" in "rabbit"	X	X	

The following sound blends were also produced in error in word initial position: "br", "dr", "fl", "fr", "gr", "kr", "kw", "sl", "sp", "sw", and "tr". Her raw score converted to a standard score of 79, which placed AS in the 13th percentile for children her age. In addition, based on her GFTA-2 productions, AS received a PPC score of 71% and a PCC score of 62%, which converted to a severity rating of Moderate-Severe (Shriberg & Kwiatkowski, 1982).

Only the late eight sounds (ʃ, θ, s, z, ð, l, r, ʒ; Shriberg, 1993) noted in error were checked for stimulability. In order for participants to be considered stimulable for a sound they needed to be able to produce it with greater than 30% accuracy (Glaspey & Stoel-Gammon, 2005), thus AS was not stimulable for /ð, θ, r/ sounds during a nonsense syllable task. AS's stimulability for consonants in error is represented in table 14.

Table 14. AS's stimulability for sounds she produced in error on the GFTA-2

Sound symbol	**Letter and example**	**Percentage Correct**
/ θ /	"th" in "think"	0%
/ ð /	"th" in "feather"	0%
/r/	"r" in "rabbit"	0%

As compared to other children her age, these results suggest that AS had a mild SSD.

Language and Conversational Skills: Receptive Language. AS was administered Form A of the PPVT-4 to assess her comprehension of single words (objects and actions) represented with color line drawings. AS responded incorrectly 22 times, which resulted in a raw score of 62. Her raw score converted to a standard score of 101, which placed AS at the 53rd percentile for children her age. As compared to other children her age, AS had picture vocabulary skills that were within the normal range.

AS was administered the CELF-P2 to evaluate AS's overall receptive and expressive language skills. Three of the CELF-P2 subtests were administered. AS's raw scores, scaled scores, and percentile scores, for each of the subtests are presented below in table 15.

Table 15 AS's Raw Score, Scaled Score, and Percentile Scores pre-treatment on the CELF-P2

Subtest	Raw Score	Scaled Score	Percentile Score
Sentence Structure	13	11	63
Word Structure	16	12	75
Expressive Vocabulary	15	10	50

The individual subtests of the CELF-P2 were combined to create a "Core Language Score". The sum of the subtest scaled scores were 33, which converted to a standard score of 106, which placed AS in the 66th percentile for children her age. This assessment suggested that AS's receptive and expressive language skills were within the normal range.

Nonverbal Cognitive Skills. AS's nonverbal cognitive skills were assessed using the Leiter-R. The Leiter-R assessed AS's ability to cognitively comprehend information and instructions. Given AS's young age, the standard nonverbal administration techniques suggested by the *Leiter-R* were not followed. Instead, the clinician demonstrated physically and gave verbal prompts and instructions to AS in an attempt to make her better understand the various tasks. Four of the Leiter-R subtests were administered. AS's raw scores, and scaled scores for each subtest are presented below in table 16.

Table 16. AS's pre-treatment Raw Scores and Scaled Scores for the Leiter-R subtests

Subtest	Raw Score	Scaled Score
Figure Ground	12	13
Form Completion	16	11
Sequential Order	5	9
Repeated Patterns	8	13

The individual subtests of the Leiter-R were combined to create a Nonverbal Cognition score. The sum of the subtest scaled scores was 46, which converted to a standard score of 111, which placed AS in the 77th percentile for children her age. This assessment suggested that AS had average nonverbal cognitive abilities for children her age.

Voice and Fluency. Voice and fluency were measured informally throughout the assessment. AS was able to maintain appropriate oro-nasal resonance balance and fluency during the various assessment tasks. Based on this brief assessment, there was no evidence of pathological factors influencing fluency. Thus, AS's fluency measures were typical for children her age.

Throughout the assessments, AS had a 'hoarse' voice quality that was indicative of vocal abuse. AS's mother reported that AS screamed a lot at home and tended to talk at loud volumes but did not notice a difference in her voice quality. AS's voice was monitored throughout treatment but did not perceptually change. It was unclear as to whether she had always presented with a forced vocal quality, or whether it was caused by vocal abuse. It was recommended that AS seek medical attention for her voice quality but no further reports were received. AS's voice quality did not negatively impact her ability to participate in the current study, although it did suggest possible vocal abuse.

Hearing. A pure-tone hearing screening was administered to assess AS's auditory acuity to sounds produced during the typical range of normal speech. Test results indicated her hearing was adequate for spoken language.

A tympanometry test was performed to evaluate AS's ear canal volume, middle ear air pressure, and tympanic membrane (eardrum) compliance (mobility). She had a flat tympanogram reading, which meant she had fluid built up in her middle ear that is typically indicative of an ear infection. An otoscope was used to view AS's tympanic membrane. The tympanic membrane of her right ear was red, which also suggested an ear infection. Her left ear's tympanic membrane was not visible using the otoscope due to AS's behavior, as she would not allow the audiologist to view her left ear. AS had abnormally low middle ear pressure in both ears, which suggested Eustachian tube dysfunction. Her mother reported that AS had a history of ear infections and she had ear tubes put in over a year prior to beginning treatment. AS's tympanometry test results indicated that her ear tubes were not working or had fallen out over the past year. It was recommended that AS see her family doctor for an ear check up.

Oral-Peripheral Mechanism Evaluation: Structural Integrity. AS's face, cheeks, lips, teeth, tongue, jaw, hard and soft palate all appeared typical in size, color, shape, symmetry and/or overall appearance and were judged, upon visual inspection, to be adequate for speech production purposes.

Oral-Peripheral Mechanism Evaluation: Oral-Motor Functions. AS had no difficulties with vegetative function (e.g., suck, swallow, breathe, bite, chew). Non-speech functions (e.g., smile, lip pucker, cheek puff, tongue protrusion and lateralization, jaw excursion, glottal closure) were judged to be typical with regard to speed, strength, range of motion, and/or mobility.

Oral-Peripheral Mechanism Evaluation: Feeding Reflexes. No retained feeding reflexes were observed.

Oral-Peripheral Mechanism Evaluation: Speech-Motor Functions. AS's motor-speech functions appeared typical with regard to respiration; onset, duration, and cessation of phonation; velar elevation, pharyngeal movement, adequacy of oro-nasal resonance balance; and overall prosody. AS's articulation abilities were preliminarily measured with diadochokinetic tasks (e.g., "puh-tuh-kuh"). AS was able to say the three different syllables correctly in succession. No visible signs of effort during articulation were observed.

2.4 SSD04_AG Profile.

AG, a six-year, one-month female, was the oldest child in a family of six, with two younger sisters and one younger brother in her home, along with her biological parents. Her race/ethnic group was Caucasian, Non-Hispanic. AG spoke only English at home with her family. AG had previously received speech and language therapy services through Little Miracles, Phoenix Elementary School, Century Elementary School, and the University of North Dakota Speech, Language, and Hearing Clinic. All other speech services ceased over the entire duration of the current study from pre-treatment to post-treatment evaluations. AG was attentive and fully able to independently participate in all assessment measures.

Articulation Skills. The *GFTA-2* was administered to assess AG's production of speech sounds; her results are summarized below in table 17. Fifty-three items were presented to AG to label. Of the possible 77 target consonant sounds, AG produced 26 sounds in error. The table below lists the sounds produced in error; the word positions in which they were incorrect are marked with an "X".

Table 17. AG's pre-treatment sounds in error on the GFTA-2

Sound symbol	Letter and example	Word Initial	Word Medial	Word Final
/θ/	"th" in "thumb"	X	X	X
/ð/	"th" in "feather"	X	X	
/g/	"g" in "girl"	X	X	X
/k/	"k" in "cup"	X	X	X
/tʃ/	"ch" in "watches"		X	
/dʒ/	"j" in "jumping"			X
/z/	"z" in "zipper"	X		X
/s/	"s" in "scissors"	X	X	X
/l/	"l" in "ball"			X
/v/	"v" in "vacuum"			X
/j/	"y" in "yellow"	X		
/r/	"r" in "rabbit"	X	X	

The following sound blends were also produced in error in word initial position: "bl", "br", "dr", "fl", "fr", "gl", "gr", "kr", "pl", "sl", "sp", "sw", and "tr". Her raw score converted to a standard score of 71, which placed AG in the 2nd percentile for children her age. In addition, based on her GFTA-2 productions, AG received a PPC score of 79% and a PCC score of 68%, which converted to a severity rating of Moderate-Severe (Shriberg & Kwiatkowski, 1982).

Only the late eight sounds (ʃ, θ, s, z, ð, l, r, ʒ; Shriberg, 1993) noted in error were checked for stimulability. Stimulability testing was done on late eight sounds /l, θ, r/ that were noted in error during the administration of the GFTA-2. AG's ability to produce specific speech sounds was assessed using a stimulability evaluation. In order for participants to be considered stimulable for a sound they needed to be able to produce it with greater than 30% accuracy (Glaspey & Stoel-Gammon, 2005), thus AG was not stimulable for /θ, r/ sounds during a nonsense syllable task. AG's stimulability for consonants in error is represented below in table 18.

Table 18. AG's stimulability for sounds she produced in error on the GFTA-2

Sound symbol	Letter and example	Percentage Correct
/ θ /	"th" in "think"	0%
/l/	"l" in "ball"	90%
/r/	"r" in "rabbit"	20%

As compared to other children her age, these results suggest that AG had a severe SSD.

Language and Conversational Skills: Receptive Language. AG was administered Form A of the PPVT-4 in order to assess her comprehension of single words (objects and actions) represented with color line drawings. AG responded incorrectly 17 times, resulting in a raw score of 79. Her raw score was converted to a standard score of 85, which placed AG at the 16th percentile for children her age. As compared to other children her age, AG's picture vocabulary skills were at the low end of the normal range.

The *Clinical Evaluation of Language Fundamentals – 4th edition* (CELF-4) was administered to evaluate AG's overall receptive and expressive language skills. Four of the CELF-4 subtests were administered. AG's raw scores, scaled scores, and percentile scores for each of the subtests are presented in table 19.

Table 19. AG's Raw Score, Scaled Score, and Percentile Scores pre-treatment on the CELF-4

Subtest	Raw Score	Scaled Score	Percentile Score
Concepts & Following Directions	9	3	1
Word Structure	16	6	9
Recalling Sentences	18	5	5
Formulated Sentences	13	7	16

The individual subtests of the CELF-4 were combined to create a "Core Language Score". The sum of the subtest scaled scores was 21, which converted to a standard score of 72, which placed AG in the 3rd percentile for children her age. This assessment suggested that AG had a moderately-severe receptive and expressive language impairment.

Nonverbal Cognitive Skills. AG's nonverbal cognitive skills were assessed using the Leiter-R. The Leiter-R assessed AG's ability to cognitively comprehend information and instructions. Given AG's young age, the standard nonverbal administration techniques suggested by the *Leiter-R* were not followed. Instead, the clinician demonstrated physically and gave verbal prompts and instructions to AG in an attempt to make her better understand the various tasks. Four of the Leiter-R subtests were administered. AG's raw scores and scaled scores for each subtest are presented in table 20.

Table 20. AG's pre-treatment Raw Scores and Scaled Scores for the Leiter-R subtests

Subtest	**Raw Score**	**Scaled Score**
Figure Ground	13	7
Form Completion	24	10
Sequential Order	7	6
Repeated Patterns	4	9

The individual subtests of the Leiter-R were combined to create a Nonverbal Cognition score. The sum of the subtest scaled scores was 32, which converted to a standard score of 85, which placed AG in the 16th percentile for children her age. This assessment suggested that AG had low-average nonverbal cognitive abilities for children her age.

Voice and Fluency. Voice and fluency were measured informally throughout the assessment. AG maintained appropriate oro-nasal resonance balance and fluency during the various assessment tasks. Based on this brief assessment, there were no evidence of pathological factors influencing voice and fluency. Thus, AG's voice and fluency measures were typical of children her age.

Oral-Peripheral Mechanism Evaluation: Structural Integrity. AG's face, cheeks, lips, teeth, tongue, jaw, hard and soft palate all appeared typical in size, color, shape, symmetry and/or overall appearance and were judged, upon visual inspection, to be adequate for speech production purposes.

Oral-Peripheral Mechanism Evaluation: Oral-Motor Functions. AG had no difficulties with vegetative function (e.g., suck, swallow, breathe, bite, chew). Non-speech functions (e.g., smile, lip pucker, cheek puff, tongue protrusion and lateralization, jaw excursion, glottal closure) appeared typical with regard to speed, strength, range of motion, and/or mobility.

Oral-Peripheral Mechanism Evaluation: Feeding Reflexes. No retained feeding reflexes were observed.

Oral-Peripheral Mechanism Evaluation: Speech-Motor Functions. Motor-speech functions appeared typical with regard to respiration; onset, duration, and cessation of phonation; velar elevation, pharyngeal movement, adequacy of oro-nasal resonance balance; and overall prosody. AG's articulation abilities were preliminarily measured with diadochokinetic tasks (e.g., "puh-tuh-kuh"). AG was unable to say the three different syllables correctly in succession (e.g., instead of "puh-tuh-kuh", she produced, "puh-kuh-kuh"). No visible signs of effort during articulation were observed.

Enrollment of Participants.

Each of the participants' inclusionary criteria were analyzed and interpreted to ensure adequate enrollment into the study. Along with the standardized testing inclusionary criteria, all participants could not to be concurrently enrolled in other speech, language, or other special education services. The strict inclusionary criteria and terms of enrollment into the study controlled for extraneous factors that would have skewed treatment results. Once each of the participants were tested and agreed to receive treatment, the children were randomly assigned to two treatment groups: nonwords (NWs) and tier two vocabulary (T2) words.

CHAPTER IV

METHODS

The simplest way to test the effectiveness of T2 words and NWs in treatment was to directly compare the two in traditional speech treatment. Specifically, children with SSD were trained on a target sound presented either in T2 words or NWs within a storybook context. The targeted treatment words were presented in a storybook in order to establish lexical and semantic representations. The target words were chosen based on their T2 classification, with each respective NW matching a T2 word in terms of phonological structure (i.e., syllable shape, vowel and consonant composition, etc.) and lexical representation (i.e., noun, adjective, and verb).

3.1 Treatment Design. The present study followed the single-subject multiple baseline design methodology of previous treatment studies of children with SSD (Gierut et al, 2010; Gierut, 1999, 2001, 2007; Cummings & Barlow, 2011). The decision to use this treatment design was based on studies that have shown it to be useful in the study of treatment of communicative disorders (Connell & Thompson, 1986; Kearns, 1986; McReynolds & Kearns, 1983; McReynolds & Thompson, 1986). Single-subject designs are particularly useful for evaluating the relationships between independent and dependent variables, and for evaluating inter- and intra-subject variability, which is common among individuals with communicative disorders (McReynolds & Thompson, 1986). This design also allows for replication across subjects within a given treatment condition.

Following the procedures for this design, the participants with SSD were randomly assigned to two treatment groups: non-word (NW) or tier two vocabulary words (T2 words). These groups were evaluated independently and in combination. Every child was evaluated in a baseline period in which no treatment was provided. The purpose of the baseline period was to measure generalization across sound systems to show the most important effects of treated sounds due to the overall effects of the treatment to other non-treated sounds, which ultimately impacted intelligibility. Each child first completed a full baseline assessment of his/her phonological knowledge, which consisted of the Assessment of English Phonology (AEP; Barlow, 2003).

All of participants completed at least one additional baseline session prior to beginning treatment, with half of the participants completing a third baseline session prior to beginning treatment. These additional baseline assessments were developed by choosing words from the AEP that contained the treatment target sound. The assumption behind the multiple baseline design is that each child's sound system will remain stable during the baseline phase and once treatment begins, any change or improvements in the child's performance can be directly attributed to the treatment itself (Gierut et al., 1999).

3.2 Stimuli. While there are many different factors that can be manipulated in word selection, this study focused on addressing the lexicality of the treatment words while controlling (as well as possible) the frequency effects of the target words.

Both NWs and T2 words are low frequency words; more specifically, NWs do not occur in the ambient English language while T2 words occur rarely (having a frequency score of less than 100). The values of the study's stimuli (Appendix 1) were gathered from the University of Washington, St. Louis, written and adult spoken word frequency database, which was based on Kučera and Francis' (1967) written word database (http://128.252.27.56/Neighborhood/Home.asp). Thus, while there were subtle word frequency differences between T2 words and NWs, it was predicted to be negligible due to the children's young ages.

The purpose of choosing NWs and T2 words was to compare the lexicality effects on children with SSD. The two word types differed in terms of their lexicality, in that the T2 words were real, meaningful words while NWs did not have any meaning in the ambient English language.

The study's sound targets, /r/ and /θ/, were selected based on the complexity theory of age acquisition and/or later acquired sounds, which suggests that by exposing a child to more complex sounds in treatment, other less complex sounds might also be acquired (Gierut, 2007, 2001; Gierut, Morrisette, Hughes, & Rowland, 1996). Later acquired or more complex sounds that clients have the least knowledge of will be targeted in treatment of the current study. According to the Shriberg (1993) profile of consonant mastery of children with speech delays, the eight sounds acquired latest in development for children with SSD include (ʃ, θ, s, z, ð, l, r, ʒ), thus motivating the selection of treatment sounds of the present study /r/ and /θ/.

Treatment Procedure

In order to measure the efficacy of NWs and T2 words as targets for children with SSD, both were presented in a story tell-retell format. The story targeted seven words containing word-initial /r/ or /θ/ sounds (Appendix 1). In addition, the story presentations corresponding to the T2 target words were paired with an incidental learning approach of teaching (Bedore & Leonard, 2000; Carey & Bartlett, 1978; Dollaghan, 1985, 1987;

Oetting, Rice, & Swank, 1995; Rice, Buhr, & Nemeth, 1990; Rice, Oetting, Marquis, Bode, & Pae, 1994; Rice & Woodsmall, 1988).

In other words, the participants in both treatment groups received the same amount of exposure to the targeted treatment words through the presented story. The /r/ or /θ/ treatment storybooks, treatment word stimuli, and incidental definitions are provided in appendices 2, 3, 4, and 5. The children in the T2 treatment group were provided with a brief definition through the incidental learning approach in addition to the exposure of each targeted word. The incidental learning approach was designed to help facilitate the learning of T2 words, which would in turn help to promote vocabulary expansion. The NW treatment group did not receive the incidental teaching, but it was assumed that children were learning the "meaning" of the NWs through general exposure to the words in the story.

The corresponding story was read to the children in both treatment groups at the beginning of every session, with all four participants either being presented with the target T2 words or NWs. In the case of the NW group they were given additional T2 words within the storybook context though the T2 words presented within the NW treatment story were not used directly in speech treatment or used within a QUIL approach but simply read within the story narrative. Throughout treatment both the NW and T2 word participants were familiarized with their treatment targets within the story context. To encourage the children's use of their respective words, the clinician would pause periodically in her reading of the storybook so that the children could help tell the story. For example, the clinician would pause during the storybook readings to allow clients to fill in the appropriate text or tell the story. For example, the clinician would say, "After a long drive Alexander arrives at the farm. Alexander rushed out of the car to see his… (pause)." Participant AA responded "thedvil" (θɛdvɪl) grandparents." Also, to elicit spontaneous productions and judge word learning, the clinician supplied incorrect or unfamiliar information to the story so that the children could make narrative corrections using the previously learned story narratives. In addition, the clinician asked open-ended questions or story prediction questions to elicit the treatment target words. Throughout both NW and T2 word treatment sessions, the children would fill in the storybook text or make narrative corrections using their treatment target words suggesting learning of the treatment words' lexical and syntactical forms. Thus, children in the NW group were associating both lexical and syntactic information to the treatment NWs, as they were able to use the NWs in grammatically correct sentences to talk about the story. However, since the degree of lexical knowledge the NW participants applied to the NWs was not formally measured; thus, the amount of meaning children applied to the NWs cannot be stated by the current study.

Treatment was provided two times weekly in 1-hour sessions, for a total of 10 sessions; however, two participants (AA & AS) received an additional treatment session due to behavior issues affecting their treatment productivity. Treatment was planned to occur in two phases, imitation followed by spontaneous production of the treated sound in the word stimuli. The imitation phase was to be continued until production accuracy of the treated sound in the treated word stimuli reached 75% accuracy over two consecutive treatment sessions or until all 10 sessions were completed. No participant moved past the imitation phase. During the imitation phase, each child was given a model and feedback on their productions. Models consisted of the clinician saying the targeted word and/or sound, with the child then repeating the word. The clinician then provided corrective feedback to the child on his/her production related to his/her articulation (e.g., pull your tongue back, smile, show me your teeth, etc.).

The clinician provided placement and sound-shaping therapy, which included visual, verbal, tactile, and physical cues to shape the child's target sound. First, the clinician sat side-by-side with the clients in front of a mirror to model the treatment targets and paired her sound production with simplified verbal and visual cues. For example, when shaping the tongue tip /r/ the clinician's verbal instructions were, "smile-teeth", "pull tongue back", and "angry dog sound." The verbal directions "smile-teeth" were paired with the clinician's over exaggerated smile to prevent the /w/ for /r/, along with a picture of an angry dog showing his teeth. The verbal directions "pull tongue back" were paired with the clinician modeling gliding the tongue tip back with an open mouth posture from an anterior alveolar ridge position to a posterior soft palate mouth position, along with a picture of a person pulling and the clinician pairing her arm movement of pulling back with her posterior tongue movement. The verbal directions "angry dog sound" was used to turn on sound voicing in order to make the production of the /r/. The "angry dog sound" or /r/ was also paired with the picture of the dog showing his teeth (appendices 8) and a growling "grrr" sound. The posterior position of the /g/ helped the clients with their production of /r/ which may be due to the /g/ posterior position. The amount of sound placement and shaping in the treatment sessions varied between clients as seen in table 22, with AA and MW receiving the most direction related to their speech sound productions.

Once the clients were able to produce their target sounds in isolation the clinician would use the previously taught sound parts to elicit the correct production of the target sound. For example, if the client produced a /w/ for /r/, the clinician would give corrective feedback using the visual representation of the angry dog and pair it with the verbal cues “remember, smile-teeth”. Another example, when the clients produced a /j/ for /r/, the clinician used a tongue depressor to touch in the participant's mouth so they are able to feel where their tongue needs to go or have the client say, “ah” with the mouth wide open and tap their tongue starting at the front of their mouth (alveolar ridge) and moving back along the palate to where the /r / sound is produced. Another consideration taken into account when selecting /r/ target words was the vowel context present in each word. The prevocalic /r/ was targeted with anterior unrounded vowels (e.g., /i/ “retreat”; /ɛ/ “respond”; /ɪ/ “rigid”) to allow for a more visual target for the client and to get rid of lip rounding that is commonly present in /w/ productions, thus aiding in sound understanding.

The rest of each imitation session consisted of drill-play activities that involved picture cards from the story. For example, in one treatment activity, the child picked plastic eggs from a nest. Each of the eggs contained one picture representation a target NW/T2 word. Each time the child removed a plastic egg from the nest he/she had to say the target word inside. In another drill-play activity, the child had to produce five target words before “digging for dinosaurs” and then received the reinforcement of digging in a container of beans to find a dinosaur. Many of the drill-play activities were paired with the story’s themes or elicited the T2 vocabulary word use. During the drill play activity of removing the “angry chicken’s” eggs the clinician would use a parallel play paradigm to elicit both T2 and NW treatment targets. For example, as the client was “removing” (T2) or “renoffing” (NW) the egg, the clinician would model the word by saying “(client’s name) removed/renoffed (T2: /rimuvd/; NW: /rɛnɔfd/) the egg and retreated/redreeded (T2: /ritritɪd/; NW:/ridridɪt/) from the angry chicken!” Depending on the child, drill-play activities were modified to keep participant motivation high and to elicit maximum target production opportunities. The goal for elicited productions from each child was 100 responses per session. Due to shaping of sounds, behaviors, and age of the clients sessions averaged differed amongst participants. A summary of average word-level client responses per session is provided below in table 21.

Table 21. Each participant’s average word-level responses per session

Client	**Average responses per session**
MW	91
AS	47
AA	85
AG	69

The total number of treatment target words produced per session per child is shown in table 22 below. Word-initial target productions were identified as post-vocalic /r/ or /θ/, segmented post-vocalic and pre-vocalic /r/ or /θ/, and prolonged adult /r/ or /θ/. Any /r/ or /θ/ productions in isolation or at the syllable level were not counted in the participants’ average responses per session. All sessions allotted to the shaping of the treatment target sounds were not calculated into the average word-level client responses per session. The following Table 22 summarizes each session’s word-level productions and the total sound shaping sessions. All productions were at the imitation phase of treatment (direct model, delayed imitation, and elicited productions).

Table 22. The total number of treatment word productions per session by each participant (Sh= Shaping).

	Individual Sessions										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
MW	Sh.	Sh.	Sh./25	Sh./12	Sh./15	72	70	102	94	115	N/A
AS	Sh.	Sh.	34	N/A	27	61	21	33	65	74	60
AA	Sh.	Sh.	Sh.	Sh.	Sh./17	48	31	116	53	101	158
AG	Sh./14	81	66	42	66	39	60	81	62	121	N/A

Spontaneous Phase. No child made it to the spontaneous phase. The spontaneous production phase was to be continued until the child achieved 90% accuracy over three consecutive sessions or until all 10 sessions were completed. This phase will not be discussed further.

Dependent Variables.

Six dependent variables were measured: learning during treatment, use of target vocabulary during treatment, generalization of the treated sound in untreated words, generalization of untreated sounds in untreated words, learning new vocabulary words through definition standards, and variability in sound substitutions for treated and untreated sounds.

Learning During Treatment.

Learning during treatment was defined as the percentage accuracy of producing the word-initial sound in the seven /r/ or /θ/ treatment words. Following methods described in Cummings & Barlow (2011), each treated word during every session was judged for accuracy of the target sound. Sounds were only counted as correct if they were produced in a manner similar to that of a healthy adult in the ambient language (i.e., lengthened sounds, slightly distorted productions and so forth, were judged to be incorrect). The participants' sound changes or sound improvements, and added sounds to their inventories, were tracked over the course of treatment as a measurement of sound learning due to treatment efficacy.

All of the children completed two or three baseline sessions and 10 to 11 treatment sessions. The treatment learning curve for each child was calculated by tracking the productions of the treatment words. Daily tracking of each participants production accuracy of each target word, as well as the overall production accuracy of the treatment target sound /r/ or /θ/. It was easier for some participants to produce the post-vocalic /r/ which is in the word final position of the word "mother". For example, if the target word was "relieved" it would be produced as "err-relieved" and the participant would receive credit for the contextual use of the post-vocalic /r/, or schwar, which is a stepping stone to the overall goal of /r/. In order for the participants to master the adult /r/, the clinician would elicit the post-vocalic /r/ in the initial word position to encourage learning of the /r/ in the treatment words with the overall goal being the pre-vocalic /r/.

Generalization of the Treated Sound & Untreated Sounds in Untreated Words.

System-wide phonological generalization was measured using pre- and post-treatment AEP (Barlow, 2003) probes. Highly trained transcribers in the International Phonetic Alphabet (IPA) were used to narrowly transcribe all AEP speech samples. Approximately 15% of all AEP probe samples were reliability-checked by a second transcriber; both transcribers agreed 85-90% of the time on the speech sample transcription. Based on these transcriptions, the data was organized for standard descriptive phonological analysis according to target sound and word position (Dinnsen, 1984). Specifically, four different measures were calculated with the AEP transcriptions: phonetic and phonemic inventories (Gierut, Simmerman, & Neumann, 1994), percent phonemes correct (PPC; Shriberg et al., 1997), percent consonants correct (PCC; Shriberg et al., 1997), and error consistency indices (Tyler, 2002; Tyler, Lewis, & Welch, 2003).

Phonemic status of a sound was established following the criterion of two unique sets of minimal pairs (e.g. 'sing'-'ring' or 'run'-'rub'), regardless of whether they were correct relative to adult production (Gierut et al., 1994). Based on these analyses, the target sounds that were excluded from each child's phonemic inventory were identified, having not been produced in the presence of minimal pairs.

Variability in Sound Substitutions for Treated and Untreated Sounds.

Treated and untreated sounds were monitored for phonological change that occurred during treatment with the PPC and PCC measures. The PPC measures the percentage of phonemes correct as compared to the target word. The transcribed responses from the pre- and post- treatment AEP were used to calculate the PCC, using the criteria of Shriberg et al. (1997).

The Error Consistency Index (ECI) was computed for each child. This metric was designed to measure the overall consistency of error substitutions within a child's phonological system (Tyler, 2002; Tyler, Lewis, & Welch, 2003). In the present experiment, the ECI was a raw number that was calculated by summing the total number of different substitutions that each child made, in each word position, for his/her specific treatment sound. The ECI was calculated both pre-treatment (taking into account any substitutions the child made for each sound across the baseline probes) and post-treatment. Correct productions of the target sound was included in the ECI raw numbers and analyses, thus the ideal ECI number was 1.0.

Learning New Vocabulary Words through Definition Standards.

Participants' vocabulary knowledge of two different groups of words were measured using the ZOT Vocabulary Assessment measurement (ZOT; Robinson, 2013; Appendix 6 & 7): 1) the T2 word targeted through incidental learning during the storybook reading; And 2) the T2 vocabulary words present in the book but not targeted through incidental learning. The T2 words not targeted in treatment were tested pre- and post-treatment to serve as a control by illustrating their low frequency of occurrence and unfamiliarity in children of this age group.

More specifically, the ZOT was a decontextualized vocabulary assessment, which required higher-level language knowledge, often referred to as metalinguistic skills (Wehren, De Lisi, & Arnold, 1981; Snow, 1990). Metalinguistic tasks require 'the ability to make language forms opaque and attend to them in and for themselves' (Cazden, 1976) or 'to reflect not on what to say but how to say it' (Watson, 1985). In order for participants to complete the ZOT vocabulary assessment, they needed to define and use the T2 words within a context free testing environment. Thus, participants needed to apply their word knowledge in order to define/use the abstract T2 vocabulary words. The T2 words could not be defined or used by strictly descriptor words such as physical entities but need to be expanded upon using conceptual understanding and contexts of the words meaning/use.

T2 vocabulary knowledge was measured by the ZOT on a 0-4 point scale based on word knowledge accuracy. Knowledge was assessed in multiple ways. First, the clinician said the word and each participant defined the word to the best of his/her capabilities, with the clinician recording the responses using a scaled score of: 0 - no response or incorrect response (e.g., “I don’t know”), 1 - partially correct response (e.g., for the target word, “retreated”, the child responded with, “leave”), or 2 - Oxford Dictionary definition, adult level response (e.g., for the target word, “retreated”, the child responded with, “to get away from something”).

Then, each participant was asked to use the word in a sentence and the clinician recorded their response to score as: 0 - no response, or incorrect content (e.g., for the target word, “retreated”, the child responded with, “he was happy”), 1 - correct content but brief in the sense that it does not fully illustrate word knowledge (e.g., for the target word, “retreated”, the child responded with, “Alexander retreated”), 2 - correct content with clear demonstration of word knowledge (e.g., for the target word, “retreated”, the child responded with, “He retreated from the scary chicken).

After initial ZOT testing, it was judged by the examiner that the participants struggled with telling what a word means and using it to tell a story. In other words, it was difficult for the participants to formulate their sentences without any given context. Thus, the participants might not have fully comprehended the idea of ‘using’ the word in a sentence or had difficulty generating their own “use” of the word without a context. In addition, since all of participants had SSD, some of their responses were difficult to interpret due to unintelligible words.

Due to the children’s ages and verbal expression deficits caused by their SSD, additional testing was done using the storybook pictures to assess the participants’ word knowledge when provided a context using the storybook to look at vocabulary expansion within a context. The modified ZOT assessment was administered post-treatment to analyze the knowledge that the T2 participants had of the T2 vocabulary words targeted in treatment. Since the NWs were not taught with any linked meaning, the modified ZOT was not used with the NW participants. Only the treatment storybook pages which included treatment T2 words were used during the modified ZOT in order to provide a contextual reference for the T2 words. The modified ZOT measured word knowledge accuracy the same way as the ZOT, on a 0-4 point scale. Also, when the child was supplied with a context to define and use the word, some of the uncertainty was reduced due to contextual aids, which served as a reference.

Use of Target Vocabulary During Treatment.

All of the participants received traditional speech treatment, with the only differences in treatment being the lexicality of the treatment target words, as the T2 word group received academic words and the NW group received nonsense words. The different features of T2 words and NWs were controlled through the matching of phonological structure, as the NWs followed the same phonotactic constraints as English words, and were matched in terms of syllable shape, vowel, and consonant composition. Both the T2 words and NWs were presented within a storybook context, with the only difference being that the T2 word group received the additional quick incidental definition of the T2 word in the story (Appendix 3 & 4).

In summary, aside from the additional QUIL approach added to the T2 word treatment, both treatment groups received the same exposure to their treatment words. Thus, all phonological changes and lexical learning observed during and after treatment will be interpreted in light of the lexical differences of the treatment words. Varying results between the groups on different dependent variables such as learning during treatment, use of target vocabulary during treatment, generalization of the treated sound in untreated words, generalization of untreated sounds in untreated words, learning new vocabulary words through definition standards, and variability in sound substitutions for treated and untreated sounds might reflect the ability of either T2 words or NWs to cause or inhibit change. Pre-treatment and post-treatment measures using the AEP were PPC, PCC, phonetic and phonemic inventories, and ECI used to measure phonological change within participants and between treatment groups.

The phonological analyses should show how T2 word or NWs are able to affect participants' sound systems. Changes to treatment sounds and words during treatment were completed through the clinician's daily data tracking. This daily tracking could reveal whether T2 words or NWs can cause initially quick change, or more protracted, later change in treatment. Pre- and post-treatment analyses of participants' vocabulary knowledge were measured using the ZOT to determine whether the children in the T2 group were learned their treatment targets, as well as to see whether children in both groups learned anything about the T2 words presented within the storybook but were not targeted in treatment.

If participants within the T2 group make greater phonological and vocabulary gains, it would indicate T2 words are better SSD targets than NWs due to their lexicality, later age of acquisition, and/or frequency. If both the groups make similar phonological gains, but the T2 participants make greater gains in vocabulary scores, it might indicate that T2 words are still superior treatment targets due to their ability to promote vocabulary expansion while making positive changes to the child's sound system. If the NW group makes greater phonological changes than the T2 word group, it would indicate that T2 words lexicality might inhibit phonological change due to their lexical properties, which might take the focus of the phonological features of treatment words. Thus, the individual and group outcomes will indicate whether T2 words or NWs are better suited for SSD treatment.

CHAPTER V

RESULTS

The first aim of the study was to examine phonological change in the participants in both treatment groups. Specifically, it was predicted that both groups would demonstrate phonological change in the treated sound, /r/ or /θ/. Moreover, system-wide phonological change was predicted due to the complexity of the sound targets (Dinnsen et al., 1994; Ingram, Christensen, Veach, & Webster 1980; Schmidt & Meyers, 1995). In addition, since /r/ is a high frequency English sound, targeting it in treatment was predicted to have a large impact on the children's speech intelligibility due to its frequent occurrence in English.

In terms of treatment group differences, recall that NWs have been proven to be effective in treatment of SSD (Bryan & Howard, 1992; Gierut & Morrisette, 1998; Gierut, Morrisette, & Champion, 1999; Storkel, 2004; Cummings et al., 2011) because children have not had the opportunity to produce NWs incorrectly due to their non-occurrence in English, which instead allows children to focus on the phonological form of each NW. Like NWs, T2 words might also avoid 'frozen' phonological representations due to their low frequency with young children and later age of acquisition. The low frequency of T2 words would suggest that they could be treated initially the same as NWs or any novel new word, which would allow children to initially focus on the phonological form of words.

The difference is that NWs have no lexical meaning, as they are nonsensical words, whereas T2 words have lexical value. Thus, T2 words have both phonological features and lexical features than can help children form a stronger lexical representation of treatment words, which can be used to promote sound and word learning. Another added benefit of T2 words in treatment is their lexical value might enhance a child's opportunity to use the treatment words (Storkel & Morrisette, 2002) and promote generalization of mastered treatment sounds outside of the clinical setting. In sum, both NWs and T2 words have the potential to avoid a child's incorrectly practiced word productions. However, the lexical features of T2 words, that are absent in NWs, can make T2 words more efficient and effective speech treatment targets. Thus, the first aim of the study was to measure if T2 words would elicit greater changes in a child's sound system than NWs.

The second aim of the study was to examine vocabulary expansion through incidental learning. Children with SSD often have lower expressive language scores and unintelligible communication, which can have an impact on their lexical development (Camarata, 1996; Smith & Camarata, 1999), putting them at risk for early academic failure. Although SSD can resolve by early school age, more than half of these children encounter later academic difficulties in language, reading, and spelling (Aram & Hall, 1989; Bishop & Adams, 1990; Flax et al., 2003; Lewis, Freebairn, & Taylor 2000; Shriberg &Austin, 1998). T2 words are used in the academic literature and their use promotes later academic success, thus making them the potentially ideal treatment target for children with SSD who might be at risk for later language and/or learning disabilities.

If selected appropriately, real word targets with lexical meaning, such as T2 words, could be useful for children with SSD.

In the following sections, each participant's results will be presented individually, addressing each of the following areas: learning during treatment, generalization from treatment, sounds added to their phonetic and phonemic inventories, and error variability in their production patterns. Each child's results will be followed by an individualized discussion to describe factors that might or might not have influenced the participant's success with the treatment program.

SSD01_MW: NW Treatment Results

MW completed ten one-hour treatment sessions typically occurring twice weekly. During each session, she spent approximately ten minutes listening to target NWs that were presented within the treatment storybook. The /r/ was targeted in word-initial position, using seven NW targets: "rezgoo", "reachim", "renufs", "rezbomb", "reawaivd", "redreadit" and "reachit".

MW's progress over treatment is illustrated in Figure 3 below in terms of four different production levels in accordance to each treatment session: /r/ in isolation or shaping, a post-vocalic segmented /ɹ/ in words, a prolonged pre-vocalic /r/, and finally an adult /r/ production which were all presented in the imitation phase of treatment. Production levels progressed from easier to more difficult, with the isolation production level being the simplest while the adult production level is the most complex. Each of these different production levels are part of traditional speech treatment and serve as a hierarchy to achieving spontaneous /r/ productions in words. A summary of how long MW was in each of the four different production levels can be found above in table 22 in the methods section and MW's accuracy in each of the 4 imitation phase production levels can be found below in Figure 4.

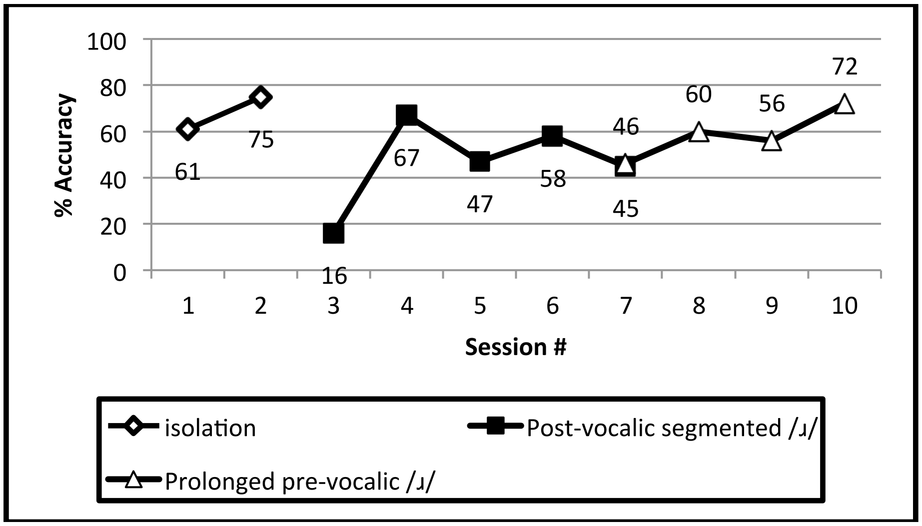


Figure 3. MW's Production Level and Accuracy for Each Session. MW was at the isolation production level of treatment for the first two sessions; the production level post-vocalic segmented /r/ from sessions 3-7; the production level prolonged pre-vocalic /r/ from sessions 7-10.

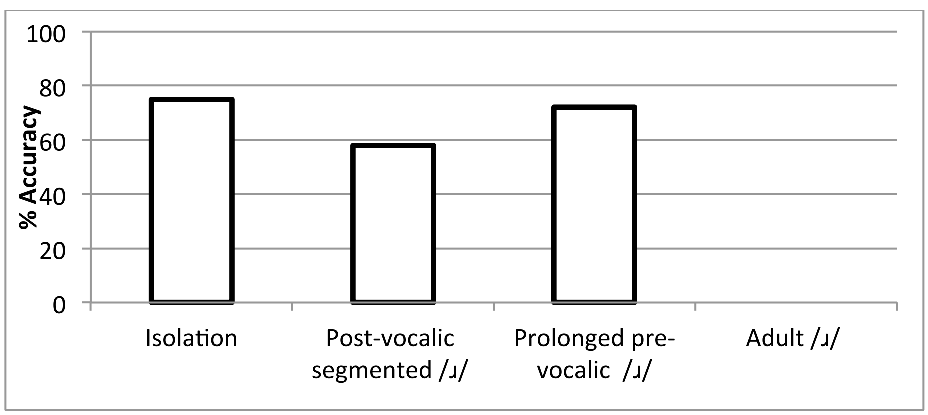


Figure 4. MW's progress in Tx through different speech sound levels (all at the imitative level). The best accuracy achieved within each of the production levels is displayed.

Behaviorally, MW was compliant with the structured clinical setting and was responsive to treatment. She was able to use clinician feedback with minimal prompting and made quicker gains in treatment than the other participants. At the end of the 10th session MW was at a level to transition into adult /r/ productions with a clinician model which would have been the final step in the treatment process, but due to the lack of time, this phase was not completed.

Although MW was in the NW treatment group and did not receive the T2 incidental learning, she was attentive to the storybook narrative. She was able to complete story predictions, ask inferential questions about the narratives, identify nonsensical or contradicting retelling of the narratives by the clinician and subsequently adequately repair the narratives, and demonstrated other pre-literacy skills such as pointing to the first word in the written text and modeling a left to right sentence reading pattern. Thus, MWs pre-literacy skills and storybook motivation were precursors to vocabulary expansion and narrative understanding. MWs pre-literacy skills, attention, and storybook engagement might have shown increased ZOT scores had she been placed in the T2 vocabulary group. In other words, if MW been in the T2 word group, it was likely that she would have had a high ZOT score illustrating vocabulary expansion.

Post-treatment assessments.

Articulation Skills. A comparison of MW's pre-treatment and post-treatment GFTA-2 (Goldman & Fristoe, 2000) scores was used to assess MW's production of speech sounds. All standardized GFTA-2 changes were minimal within the short time span of the current study, which might have been due to the standardized assessment's small sampling size. Table 23 lists the sounds produced in error in Pre-treatment and Post-treatment GFTA-2 assessments; the word positions in which they were incorrect are marked with an "X". Also noted in table 23 are sounds MW produced in error post-treatment that she was accurate for pre-treatment. For example, sounds in error post-treatment and not pre-treatment were /ŋ, h/. Replacing the /ŋ/ “-ing” at the end of certain words with “-een” (“doing” becomes “do-een”, “happening” becomes “happen-een”, something becomes “some-theen”, or “cooking” becomes “cook'n” is dialectal in certain regions (Williams & Wolfram, 1976).Since, the /ŋ/ sound is dialectal and might have changed over the course of treatment due to MW’s exposure to different speakers; many adults replace the /ŋ/ for /n/. The /h/ is a back glottal phoneme and MW had a distinctive fronting pattern. Her use of /h/ was inconsistent throughout the GFTA-2 and AEP samples; thus, MW’s inconsistencies of /h/ in initial word position might have been due to her ‘frozen’ phonological representation, as in her concept of the /h/ phoneme and her learned behaviors (fronting pattern/process) were causing her varied production accuracy. In addition, the /v/ phoneme in the initial position was noted to be in error post-treatment, but not pre-treatment.

Table 23. MW’s Pre- and Post-Tx Sound Errors in Initial, Medial, and Final Word Positions.

		Word Initial		**Word Medial**		**Word Final**	
Sound symbol	**Letter and example**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
/θ/	"th" in "thumb"	X	X	X	X	X	X
/ð/	“th” in “feather”	X	X	X	X		
/j/	“y” in “yellow”	X	X				
/tʃ/	“ch” in “watches”			X	X	X	X
/dʒ/	“j” in “jumping”					X	X
/z/	“z” in “zipper”	X				X	
/v/	“v” in “vacuum”					X	X
/r/	“r” in “rabbit”	X	X	X	X		
/l/	“l” in “ball”					X	X
/k/	“k” in “cup”	X	X	X	X	X	X
/g/	“g” in “girl”	X	X	X	X	X	
/h/	“h” in “hat”		X				
/ŋ/	“ng” in “jumping”						X

In the post-treatment assessment using the GFTA-2, the following sound blends were also produced in error in word initial position: “bl”, “br”, “fl”, “fr”, “gl”, “gr”, “kl”, “kr”, “kw”, “pl”, “sl”, “sp”, “sw”, and “tr”. The post-treatment GFTA-2 standard and percentile scores will not not reported because the GFTA-2 is a diagnostic assessment, which only samples each sound for the purpose of a diagnosis and does not provide adequate measures for speech gains when administered within the short time span of the current study. The GFTA-2 was administered post-treatment to assess the PPC and PCC to get a comparative score for the AEP results and to calculate the KLPA. The KLPA was of specific interest because it could be used to analyze each participant's system wide occurrences of phonological processes pre- compared to post-treatment. Using MW's production of words on the GFTA-2 (Goldman & Fristoe, 2000), the KLPA-2 (Khan & Lewis, 2002) was completed to assess her use of phonological patterns/processes. MW's percentage of occurrence for each of the 10 phonological processes is listed below in table 24.

Table 24. Participant MW's Pre- and Post-Tx KLPA percent occurrence of processes

	Target Word → Process	**Pre-Tx**	**Post-Tx**
Deletion of final Consonants	"scissors" → "scissor-"	11%	5%
Syllable Reduction	"banana" → "nana"	0%	0%
Stopping of Fricatives/Affricates	"this" → "dis"	6%	10%
Cluster Simplification	"spoon" → "poon"	73%	58%
Liquid Simplification	"rabbit" → "wabbit"	29%	29%
Velar Fronting	"cup" → "tup"	79%	68%
Palatal Fronting	"chair" → "sair"	0%	0%
Deaffrication	"watches" → "washes	33%	50%
Initial Voicing	"telephone" → "delephone"	0%	0%
Final Devoicing	"five" → "fife"	16%	3%

In Post-Treatment, MW produced 46 separate phonological processes in the 53 words of the *GFTA-2* (Goldman & Fristoe, 2000). This raw score of 33 converted to a standard score of 83, which placed MW at the 18^{th} percentile for children her age. MW's advancements in treatment were notable using her pre- and post- treatment KLPA standard scores, as her changes over treatment made to her overall standard score increase moving her from the 14^{th} percentile to the 18^{th} percentile. Most notable gains were seen in the phonological processes velar fronting and cluster simplification. Over the course of treatment, MW's velar fronting and cluster simplification processes reduced by 15% and 11%, respectively. Although these two processes were not directly targeted through treatment, they were indirectly targeted in treatment through the shaping of the /r/. For example, the /g/ was used to elicit the posterior tongue position of /r/, as in "grrrrr". There is a relationship between /r/ and /g/ and /k/, as they are all velar-type sounds. MW's KLPA standard and percentile scores pre- and post-treatment are summarized in table 37 at the end of the chapter.

The *Assessment of English Phonology* (AEP; Barlow, 2003) was used to assess four different measures of phonological ability pre- and post-treatment: phonemic (Gierut et al., 1994), and phonetic inventories (Dinnsen et al., (1990), PPC, and PCC. The following paragraphs will discuss in detail analysis done using the AEP. A summary of MW's pre- and post-treatment AEP phonetic and phonemic inventories (table 25), PPC and PCC results are summarized at the end of the chapter in figures 16 and 17.

Table 25 MW's pre- and post-treatment phonetic and phonemic inventories.

SSD01_MW Profile: Non Word Treatment Group					
Phonetic Inventory					
Pre-TXT	**p b t d**	**f v**	**s z ʃ ʧ ʤ**	**ts dz**	**m n ŋ l r w j h**
Post-TXT	p b t d k	f v	s z ʃ ʒ ʧ ʤ		m n ŋ l r w j h
Phonemic Inventory					
Pre-TXT	**p b t d**	**f**	**s z ʃ ʧ**		**m n r w**
Post-TXT	p b t d	f v	s z ʃ ʒ ʧ		m n r w j h

In MW's post-treatment phonetic inventory, she no longer produced the phonological processes of alveolar fronting, as evidenced by the exclusion of the immature productions of /ts/ and /dz/ from her phonetic inventory. Also, MW added the /k/ and /ʒ/ phonemes to her phonetic inventory post-treatment. The exclusion of incorrect phonemes and an addition of adult phonemes illustrate positive gains MW made to her phonetic inventory and overall speech.

The post-treatment analysis of MW's phonemic inventory illustrated her increased knowledge of phonemes /v, j, h, ʒ/, as she added them to her inventory. Thus, MW increased her phonemic inventory from 13 phonemes to 17 phonemes, which was a 31% increase in her overall phonemes. A 31% increase or knowledge of three additional phonemes is a positive and notable increase that can be directly attributed to treatment.

Two other ways to assess MW's performance using the AEP was to compare MW's overall intelligibly at the single word level pre- and post-treatment by calculating her pre- and post-treatment Percent Phonemes Correct and Percent Consonants Correct (PCC). Pre-treatment MW had a PPC score of 66%, which increased by 1% post-treatment to a score of 67%. MW's pre-treatment PCC score was 51%, which increased by 1% post-treatment to a score of 52%. A 1% increase in PPC and PCC was too minimal to suggest any impact on MW's overall intelligibility.

Individual sound accuracy was also calculated on specific phonemes in error using MW's productions on the AEP (Barlow, 2003) probe. Only consonants in error greater than 50% of the time were included in the analysis, in order to complete a large-scale relational analysis, which correlates to overall speech intelligibility. MW's results are summarized below in figure 5.

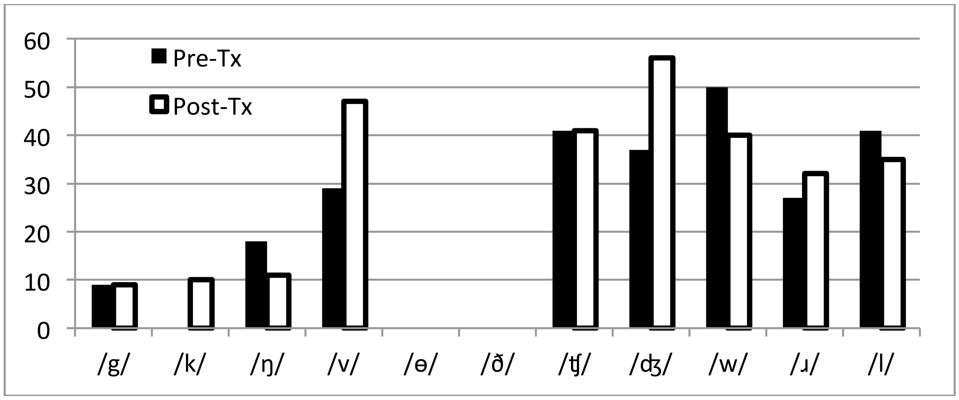


Figure 5. MW's Pre- and Post-Tx AEP: Analysis of consonants produced ≤50% percent correct

Also a sound substitution analysis was completed to measure how many different sounds each participant produced for a specific adult target sound and to measure how many different sounds were produced for the treatment target sounds pre-treatment compared to post-treatment (Table 37, and Figures 18 and 19). The substitution analysis was calculated using an error consistency index (ECI; Tyler, 2002; Tyler, Lewis, & Welch, 2003), which represents the total number of substitutions for all sounds in error. For example, if a child produced the sounds /p, d, p/ sound for /p/ in the target /p/ words "pop"→ "bod" and "pan" → "pan", the phoneme /p/ would have three substitutions /b, d, p/ thus an ECI of 3.0. If the child had accurately produced the phoneme /p/ in all positions they would have had an ECI of 1.0, which is most representative of adult speech. Thus, the higher the ECI, the more substitutions the child has in his or her speech. The ECI was calculated from all 24 English consonant sounds, which will be consistent across all participants. Of these 24 sounds MW had 59 substitutions in the pre-treatment AEP probe giving her an ECI of 2.45. Post-treatment MW had 40 substitutions for the 24 sounds, giving her an ECI of 1.66. Thus MW's ECI decreased by .79, which suggests that she had more adult like speech post-treatment and improved her overall intelligibility.

The final assessment measure was the Zero-One-Two (ZOT; Robinson, 2013) assessment of T2 vocabulary words. During the pre-treatment ZOT assessment MW responded correctly to one T2 word receiving a score of 1 out of 40 possible points, which translated to a 3% correct total score. MW received a score of 1 because she was able to partially define the word "rescue" correctly though her response was vague and did not illustrate complete knowledge of the word. In the post-treatment ZOT assessment MW received a score of 0% correct, as she could not correctly define or use any T2 word. This result suggests that MW's initially partially correct definition for the word "rescue" was more by chance and that she did not have a conceptualized understanding of the word. During the course of treatment MW was not presented with T2 vocabulary words through an incidental learning approach because she was assigned to the NW treatment group. Thus, MW's low ZOT scores were not surprising, as she was assigned to the NW group. MW's pre- and post- treatment ZOT results are summarized in Figure 22.

MW (NW) Results Interpretations.

MW's performance was impacted by her age, the complexity of the /r/ sound, and the amount of treatment sessions. The /r/ is one of the most complex sounds (Shriberg, 1993) for a child to produce and even with MW's young age, she was able to make notable progress. Throughout treatment MW was focused on clinical activities and easily adapted to the structured setting (e.g., having to sit in her chair, following simple rules, listening to the clinician, etc.).

MW produced [w] for /r/ in the selected target words throughout all sessions but her ability to repair her inaccurate productions improved as treatment progressed. MW was provided with perceptual sound training[6] and differential sound characteristics on the /w/ and /r/, along with being given descriptive feedback of her productions. She developed an awareness of the articulation characteristics of /ɹ/ (e.g., tongue back and up, smile, don't let your lips touch). The clinician was able to use a visual aid representing the sound parts of the target /r/ to cue MW to produce use the sound parts and correct her productions, illustrating a conceptual understanding of each sound part as it relates to her productions. MW also transferred her awareness of the target /r/ from her own productions to the clinician's production. MW was also able to use the articulation characteristics to comment on the clinician's productions. For example, when the clinician provided a model for the word /rɛzbɔmb/, MW used her sound part knowledge of "not letting your lips touch" to comment on the clinician's lips touching during the production of /rɛzbɔmb/.

SSD02_AA: NW Treatment Results

AA completed 11 one-hour treatment sessions typically occurring twice weekly. During each session, he spent approximately ten minutes listening to target NWs that were presented within the treatment storybook. The /θ/ was targeted in word-initial position, using five NW targets: "thali" (/θæli/), "thene" (/θin/), "thedvil" (/θɛdvɪl/), "thalaby" (/θɑlæbi/), and "thig" (/θɪg/). The clinician spent 5 sessions working with AA on shaping the target /θ/ sound in isolation and segmented words. At the end of treatment AA, was able to produce his selected treatment words containing a prolonged /θ/ in word-

[6] The child had to differentiate between two sounds presented in minimal pairs. For example, the child had to identify if the clinician's production was with the good /r/ sound or the wrong /w/ sound when presented productions of words "relieved" & "welieved". If the child was unable to identify the good production, the clinician would give descriptive contrastive feedback on the sound characteristics of /w/ and /r/, such as rounded lips for "witch" or tight and smiling lips for "rich".

initial position with approximately 62% accuracy during imitation. Although AA was not producing adult /θ/ consistently and needed an adult model and a prolonged production to maintain accuracy of the target /θ/ sound, he was capable of adult productions. For example, he spontaneously produced a storybook word "thunder" with the target /θ/ sound during an activity during the last day of treatment. AA's progress over treatment is illustrated below in terms of four different production levels: /θ/ in isolation or shaping, a segmented /θ/ in words, a prolonged /θ/, and finally an adult /θ/ production which were all presented in the imitation phase of treatment. Each of these different production levels are part of traditional speech treatment and serve as a hierarchy to achieving spontaneous /r/ productions in words. A summary of how long AA was in each of the four different production levels can be found in table 22 above in the methods section. A summary of AA's accuracy in each of the 4 imitation phase production levels can be found below in Figure 7 and his production level accuracy for each session can be found in Figure 6.

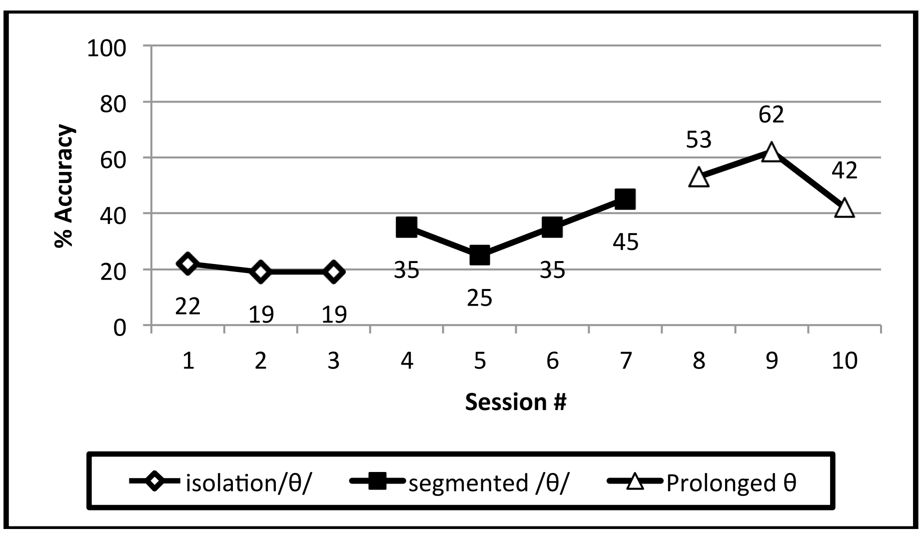


Figure 6. AA's Production Level and Accuracy for Each Session. AA was at the isolation production level of treatment for the first 3 sessions; the production level segmented /θ/ from sessions 4-7; the production level prolonged /θ/ from sessions 8-10.

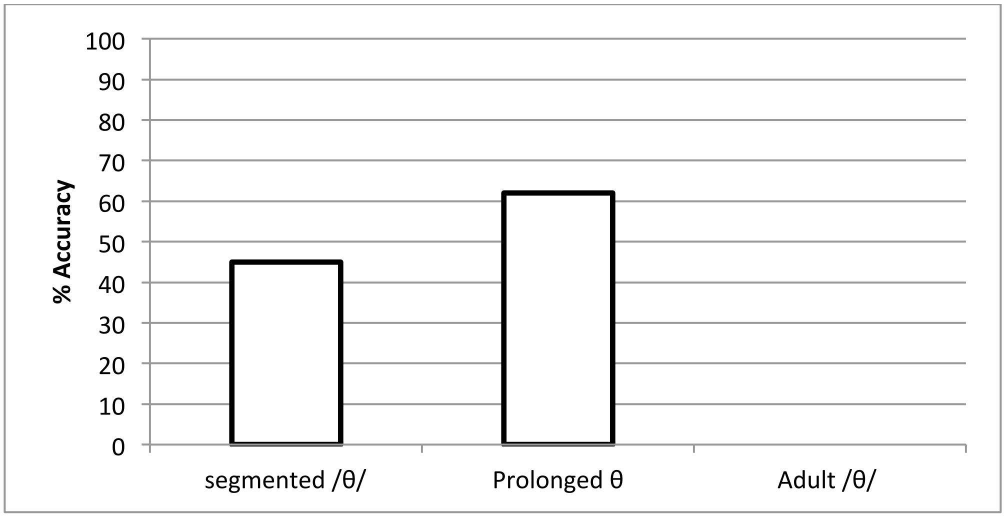


Figure 7. AA's progress in Tx through different speech sound treatment levels (all at the imitative level). The best accuracy achieved within each of the production levels is displayed.

Behaviorally, AA struggled with structured clinical activities that required prolonged attention. His performance of the target /θ/ sound would significantly increase or plummet depending on his daily temperament. AA's performance was highly correlated to his attitude, and prior activities he completed prior to attending the day's treatment session. For example, on the seventh session, AA appeared tired after spending a long weekend away on a family trip. AA displayed poor behavior by refusing to participate in all session activities. He also had difficulty self-regulating his emotions and calming himself down once he was upset. In addition, AA needed more prompting and feedback on his productions of the /θ/, as he had a difficult time producing the sound. AA struggled to copy the clinician's model of the treatment sound placement due to difficulties with his gross and fine oral motor control. AA's performance and accuracy of the target /θ/ increased with more visual and tactile feedback than auditory. Although, AA's behavior did have negative impacts on his performance accuracy, it was not consistently a problem and positive changes from treatment did occur.

AA was in the NW treatment group and as a result did not receive the T2 incidental learning. However, he was able to complete story prediction and inferential questions about the narratives, and identify nonsensical or contradicting retelling of the narratives by the clinician. These literacy techniques and questions kept AA's attention on the story or redirect his attention if he lost focus. For example, the clinician would substitute AA's name in the story for the main story character's name "Alexander" which would draw AA's attention back to the story. Also, AA enjoyed when the clinician would add nonsensical parts to the story, which were used to keep him engaged and listening to the NWs.

Post-treatment assessments.

Articulation Skills. A comparison of AA's pre-treatment and post-treatment GFTA-2 (Goldman & Fristoe, 2000) scores were used to assess AA's production of speech sounds. All standardized GFTA-2 changes were minimal in the short time span of the current study due to standardized assessments small sampling size. Table 26 lists the sounds produced in error in Pre-treatment and Post-treatment GFTA-2 assessments; the word positions in which they were incorrect are marked with an "X".

Table 26. AA's Pre- and Post-Tx Sound Errors in Initial, Medial, and Final Word Positions.

		Word Initial		**Word Medial**		**Word Final**	
Sound symbol	**Letter and example**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
/θ/	"th" in "thumb"	X	X	X	X	X	X
/ð/	"th" in "feather"	X	X	X	X		
/ʃ/	"sh" in "shovel"			X		X	X
/tʃ/	"ch" in "watches"			X	X	X	X
/dʒ/	"j" in "jumping"					X	
/z/	"z" in "zipper"					X	
/l/	"l" in "ball"	X	X			X	X
/v/	"v" in "vacuum"	X		X			

In the post-treatment assessment using the GFTA-2, the following sound blends were also produced in error in word initial position: "kw", "br", "dr", "fl", "sp", "pl", and "sw". Using AA's production of words on the *GFTA-2*, the KLPA-2 was completed to assess his use of phonological patterns/processes. AA's percentage of occurrence for each of the 10 phonological processes is listed below in table 27.

Table 27. Participant AA's Pre- and Post-Tx KLPA percent occurrence of processes

	Target Word → Process	**Pre-Tx**	**Post-Tx**
Deletion of final Consonants	"scissors" → "scissor-"	5%	0%
Syllable Reduction	"banana" → "nana"	0%	0%
Stopping of Fricatives/Affricates	"this" → "dis"	8%	6%
Cluster Simplification	"spoon" → "poon"	8%	4%
Liquid Simplification	"rabbit" → "wabbit"	42%	16%
Velar Fronting	"cup" → "tup"	5%	5%
Palatal Fronting	"chair" → "sair"	44%	33%
Deaffrication	"watches" → "washes	0%	0%
Initial Voicing	"telephone" → "delephone"	0%	0%
Final Devoicing	"five" → "fife"	19%	0%

Post-treatment AA produced 12 separate phonological processes in the 53 words of the *GFTA-2.* His raw score of 12 converted to a standard score of 102, which placed AA at the 41st percentile for children his age. AA's advancements in treatment were notable using his pre- and post- treatment KLPA standard scores, as his changes over treatment made to his overall standard score increase moving him from the 16th percentile to the 41st percentile. AA's KLPA standard and percentile scores pre- and post-treatment are summarized in table 38.

The AEP was used to measure pre- and post-treatment phonological change pre- and post-treatment data of four different analyses: phonemic and phonetic inventories (table 28) PPC (figure 16), and PCC (figure 17). The following paragraphs will discuss in detail analyses done using the AEP, starting with the phonetic and phonemic inventories.

Table 28. AA.'s pre- and post-treatment phonetic and phonemic inventories.

SSD02_AA Profile: Non Word Treatment Group																							
Phonetic Inventory																							
Pre-Tx	**p**	**b**	**t**	**d**	**k**	**g**	**f**	**v**	**s**	**z**		**ʧ**	**ʤ**	**ts**	**dz**	**m**	**n**	**ŋ**	**l**	**r**	**w**	**j**	**h**
Post-Tx	p	b	t	d	k	g	f	v	s	z	s*	ʧ	ʤ	ts	dz	m	n	ŋ	l	r	w	j	h
Phonemic Inventory																							
Pre-Tx	**p**	**b**	**t**	**d**	**k**		**f**		**s**	**z**		**ʧ**	**ʤ**	**ts**						**r**			**h**
Post-Tx	p	b	t	d	k	g	f	v	s			ʧ		ts	dz	m	n		l	r	w	j	h

* An asterisk was used to mark any production of /s/ and /z/ that were characterized by a substitution of an inter-dental (between the teeth) "s" sound, similar to a soft "th" (E.g., "houth" for "house"; "thpoon" for "spoon"). These sounds were noted to be in error due to the use of the inter-dental tongue position for those sounds, which is not the typical place of articulation of healthy adult speech.

AA did not add any phonemes to his phonetic inventory post-treatment. The post-treatment analysis of AA's phonemic inventory illustrated his increased knowledge of phonemes /g, v, m, n, l, w, j/, as he added them to his phonemic inventory. Thus, AA increased his phonemic inventory from 12 phonemes to 15 phonemes, which was a 25% increase in his overall phonemes. A 25% increase or knowledge of 7 additional phonemes is a positive and notable increase that can be directly attributed to treatment.

The AEP was also used to compare AA's overall intelligibly at the single word level pre- and post-treatment through calculating his pre- and post-treatment PPC and PCC scores. Pre-treatment AA had a PPC score of 80%, which decreased by 1% post-treatment to a score of 79%. AA's pre-treatment PCC score was 74%, which decreased by 2% post-treatment to a score of 72%. Thus, there were no advancements to AA's overall intelligibility.

Individual sound accuracy was also calculated on specific phonemes in error using AA's productions on the AEP probe. Only consonants in error greater than 50% of the time were included in the analysis, in order to complete a large-scale relational analysis, which correlated to overall intelligibility. AA's results are summarized below in Figure 8. AA increased his accuracy on 3 out of 5 sounds over the course of treatment.

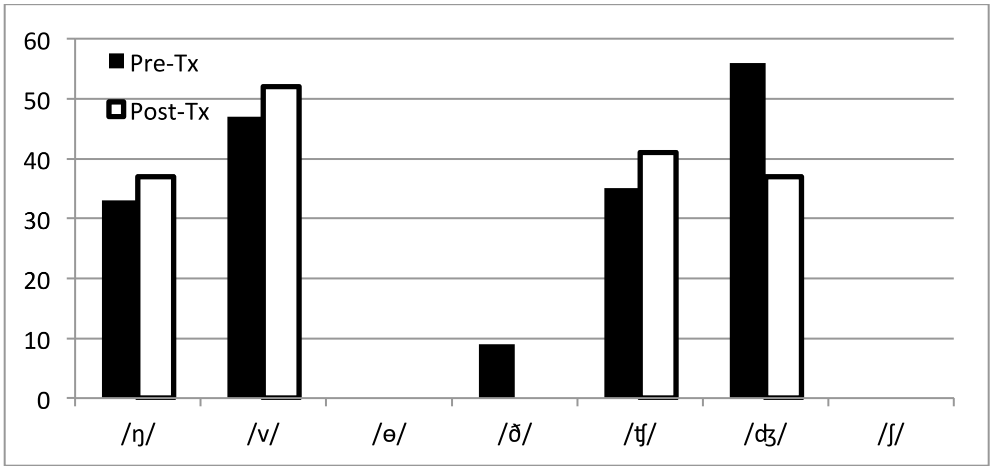


Figure 8. AA's Pre- and Post-Tx AEP: Analysis of consonants produced ≤50% correct

Also a sound substitution analysis was completed to measure how many different sounds each participant produced for a specific adult sound and how many different sounds were produced by the child for the treatment target sounds pre-treatment compared to post-treatment (Table 37, and figures 18 and 19). The substitution analysis was calculated using the ECI (Tyler et al., 2003), which represents the total number of substitutions for all sounds in error. The ECI was calculated from 24 total sounds. Of these 24 sounds, AA had 43 substitutions in the pre-treatment AEP probe giving him an ECI of 1.79. Post-treatment AA had 42 substitutions for the 24 sounds giving him an ECI of 1.75. Thus AA's ECI decreased by .04, which was minimal and probably did not increase his intelligibility.

AA had 3 substitutions for his target /θ/ sound pre-treatment, and 4 substitutions post-treatment. Pre-treatment AA did not produce the /θ/ sound in the AEP and was not stimulable for the /θ/ during stimulability testing; thus he was completely inaccurate in producing the /θ/ sound. Over the course of treatment, AA's awareness of the /θ/ sound and ability to produce his target treatment sound increased. Although AA was unable to produce an adult /θ/ sound, his sound knowledge and ability increased, suggesting that

AA might be in the process of reorganizing his sound system which could account for the additional substitutions.

Also, given that AA had multiple sounds in error pre-treatment, this might have been characteristic of a highly disorganized sound system pre-treatment. Children who produce multiple substitutions sound systems reflect instability in their representations of different phonemes (Tyler & Lewis, 2005). The multiple substitution patterns across his entire sound system possibly reflected instability in his representation of a variety of phonemes. This would suggest that AA needed more treatment sessions in order to generalize the target sound to untreated words (Forrest, Elbert, & Dinnsen, 2000).

The final assessment measure was the ZOT vocabulary assessment of T2 vocabulary words. During the pre- and post-treatment ZOT assessment, AA received a score of 0% correct, as he could not correctly define or use any T2 word. During the course of treatment, AA was not presented with T2 vocabulary words because he was assigned to the NW treatment group. Thus, AA's low ZOT scores were not surprising, as he was assigned to the NW group. AA's pre- and post- treatment ZOT results are summarized in Figure 22.

AA (NW) Results Interpretation

AA's performance was impacted by his behavior, the complexity of the /θ/ sound, and the number of treatment sessions he attended. After perceptual training of the /θ/ sound and its sound parts, AA's accuracy of the sound increased, but it took five sessions to shape the target /θ/ sound. Thus it was evident in his performance that the /θ/ sound was motorically difficult for AA to produce. In addition, throughout treatment AA displayed a waning focus during clinical activities, he frequently disengaged from treatment activities, and he was occasionally oppositional within the structured setting (e.g., having to sit in his chair, following simple rules, listening to the clinician, etc.). All of the previously listed factors might have contributed to his overall performance and generalization in treatment. If AA had been enrolled in treatment longer some of his behavioral issues might have been changed with the consistency and the structure of the clinical setting, which might have allowed for more effective speech sessions. AA might have been going through an adjustment period, as he had never received speech services prior to his enrollment into the current study and his performance might have been impacted by the novelty of the one-on-one therapy session.

SSD03_AS: T2 Treatment Results

AS completed eleven one-hour treatment sessions, which typically occurred twice weekly. During each session, she spent approximately ten minutes listening to target T2 words that were presented within the treatment storybook. The /r/ was targeted in word-initial position, using seven T2 targets: “rescue”, “region”, “removes”, “respond”, “relieved”, “retreated” and “rigid”. At the end of treatment AS, was able to produce her selected treatment words containing a prolonged pre-vocalic /r/ in word-initial position with approximately 43% accuracy during imitation. AS’s progress over treatment is illustrated below in terms of four different production levels: /r/ in isolation or shaping, a post-vocalic segmented /r/ in words, a prolonged pre-vocalic /r/, and finally an adult /r/ production which were all presented in the imitation phase of treatment. Each of these different production levels are part of traditional speech treatment and serve as a hierarchy to achieving spontaneous /r/ productions in words. A summary of how long AS was in each of the four different production levels can be found above in table 22 in the methods section and MW's accuracy in each of the 4 imitation phase production levels can be found below in Figure 10. AS's progress over treatment is illustrated below in Figure 9.

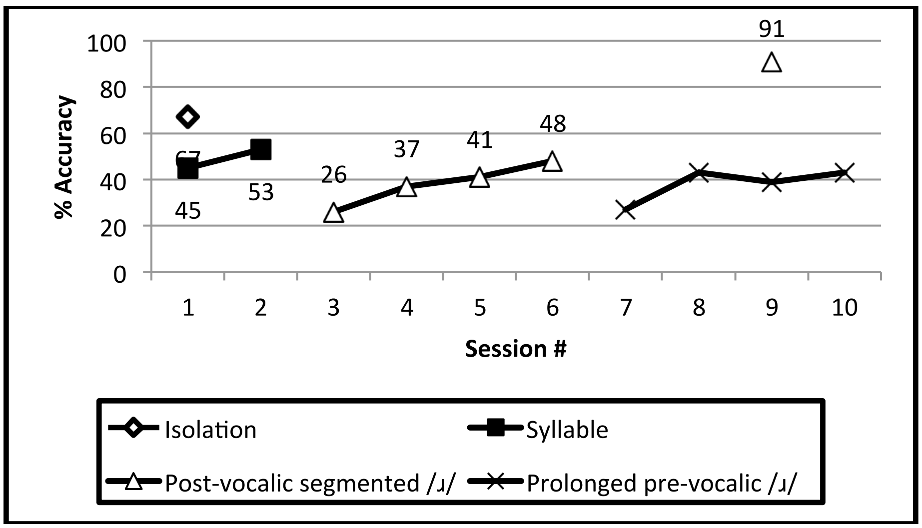


Figure 9. AS's Production Level and Accuracy for Each Session. AS was at the isolation production level of treatment for session 1 & 2; the production level post-vocalic segmented /r/ for sessions 1, 3, 4, 5, 6, & 9; the production level prolonged pre-vocalic /r/ from sessions 7-10.

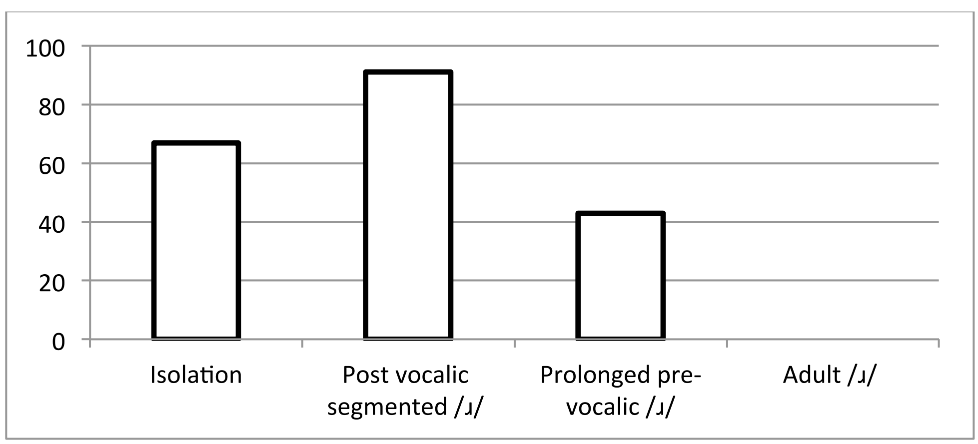


Figure 10 AS's progress in Tx through different speech sound levels (all at the imitative level). The best accuracy achieved within each of the production levels is displayed.

Behaviorally, AS struggled with focusing on one task as her attention waned during most activities. Throughout treatment AS displayed immature behaviors/emotions such as attention crying to avoid or refuse activities. Her behavior improved with visual schedules, more structured and shorter durational activities, and scheduling adjustments. For example, initially AS was scheduled to receive treatment in the afternoon but her behavioral problems were exacerbated at that time of day; her performance significantly improved when she was re-scheduled to morning appointments. Thus, while AS's behavioral difficulties were managed as well as possible by the clinician, they still slowed her overall progress in treatment.

AS was in the T2 treatment group and received the T2 incidental learning. The story narratives motivated her, as she would actively recite different characters' narratives in the story. For example, the clinician would say, "Grandma tells Alexander he can pick the eggs all by himself. Alexander thought, (clinician pause)" and AS would fill in the narrative by saying, "What! Is that logical? Does that make sense? Grandma always picks the eggs!" Also, AS was able to complete story predictions, answer inferential questions about the narratives, identify nonsensical or contradicting retelling of the narratives by the clinician and adequately repair the narratives. Unfortunately, AS's focus and behavioral problems negatively impacted her T2 word learning and accuracy consistency. For example, AS was able to accurately use a variety of the target T2 words during the ninth session within the story context, but the clinician needed to explicitly tell her the quick incidental word learning definition four times before she could accurately use it. Also, AS would resort to saying, "I don't know" when explicitly asked for a T2 word meaning, but would then use the definition later in the story without the clinician attempting to elicit the T2 meaning. Thus, AS was a difficult child to formally assess due to her behavioral issues.

Post-treatment assessments.

Articulation Skills. A comparison of AS's pre-treatment and post-treatment GFTA-2 scores were used to assess her production of speech sounds. Table 29 lists the sounds produced in error in Pre-treatment and Post-treatment GFTA-2 assessments; the word positions in which they were incorrect are marked with an "X".

Table 29. AS's Pre- and Post-Tx Sound Errors in Initial, Medial, and Final Word Positions.

		Word Initial		**Word Medial**		**Word Final**	
Sound symbol	**Letter and example**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
/θ/	"th" in "thumb"	X	X	X	X	X	X
/ð/	"th" in "feather"	X	X	X	X		
/ʃ/	"sh" in "shovel"	X		X	X	X	X
/tʃ/	"ch" in "watches"	X	X	X	X	X	X
/dʒ/	"j" in "jumping"	X	X	X	X	X	
/z/	"z" in "zipper"	X	X	X	X	X	X
/s/	"s" in "scissors"	X	X	X	X	X	X
/v/	"v" in "vacuum"	X			X	X	
/r/	"r" in "rabbit"	X	X	X	X		

In the post-treatment assessment using the GFTA-2, the following sound blends were also produced in error in word initial position: "br", "dr", "fl", "fr", "gr", "kr", "kw", "sl", "sp", "st", and "tr". Using AS's production of words on the GFTA-2, the *KLPA-2* was completed to assess her use of phonological patterns/processes. AS's percentage of occurrence for each of the 10 phonological processes is listed below in table 30.

Table 30. Participant AS's Pre- and Post-Tx KLPA percent occurrence of processes

	Target Word → Process	Pre-Tx	Post-Tx
Deletion of final Consonants	"scissors" → "scissor-"	2%	0%
Syllable Reduction	"banana" → "nana"	0%	0%
Stopping of Fricatives/Affricates	"this" → "dis"	10%	16%
Cluster Simplification	"spoon" → "poon"	46%	50%
Liquid Simplification	"rabbit" → "wabbit"	45%	29%
Velar Fronting	"cup" → "tup"	0%	5%
Palatal Fronting	"chair" → "sair"	89%	56%
Deaffrication	"watches" → "washes	0%	0%
Initial Voicing	"telephone" → "delephone"	0%	0%
Final Devoicing	"five" → "fife"	16%	3%

Post-treatment AS produced 34 separate phonological processes in the 53 words of the *GFTA-2*. This raw score of 34 converted to a standard score of 91, which placed AS at the 23rd percentile for children her age. AS's changes over treatment made her overall standard score increase moving her from the 18th percentile to the 23rd percentile. Most notable gains were seen in the phonological processes palatal fronting and liquid simplification. Over the course of treatment AS's palatal fronting and liquid simplification processes reduced by 33% and 16%, respectively. While liquid simplification was directly targeted the treatment of /r/, palatal fronting was not directly targeted though it was indirectly targeted via treatment of /ɹ/. For example, AS was taught throughout treatment to produce the palatal /r/, as she was instructed to slide her tongue tip back along her palate to the target posterior position. Thus, the posterior palatal movement of her tongue to produce /r/ was part of a sound shaping technique for /r/ that might have indirectly targeted AS's occurrence of the palatal fronting process measured by the KLPA. AS's KLPA standard and percentile scores pre- and post-treatment are summarized in Table 38.

The AEP was used to measure AS's system-wide phonological generalization, PPC, and PCC pre- and post-treatment. AS's pre- and post-treatment AEP data was organized into four different measures: phonetic and phonemic inventories (Table 31), PPC (figure 16) and PCC (figure 17) which are summarized in the following paragraphs.

Table 31. AS's pre- and post-treatment phonetic and phonemic inventories.

SSD03_AS Profile: T2 Word Treatment Group	
Phonetic Inventory	
Pre-Tx	**p b t d k g f v s s* z* ʃ ts ts* dz* m n ŋ l w j h**
Post-Tx	p b t d k g f v s s* z* ʃ dz ts* dz* m n ŋ l r w j h
Phonemic Inventory	
Pre-Tx	**p b t d k g f s s* z* ʃ m n l w h**
Post-Tx	p b t d k g f v s s* z* dz ts* dz* m n ŋ l r w j h

* An asterisk was used to mark any production of /s/ and /z/ that were characterized by a substitution of an inter-dental (between the teeth) "s" sound, similar to a soft "th" (E.g., "houth" for "house"; "thpoon" for "spoon"). These sounds were noted to be in error due to the use of the inter-dental tongue position for those sounds, which is not the typical place of articulation of healthy adult speech.

AS added the /r/ phoneme to her phonetic inventory post-treatment, which was attributed to the direct treatment of the /r/. The post-treatment analysis of AS's phonemic inventory illustrated her increased knowledge of phonemes /r, j, v/, as she added them to her inventory. Thus, AS increased her phonemic inventory from 14 phonemes to 17 phonemes, which was a 21% increase in her overall phonemes. A 21% increase or knowledge of three additional phonemes is a positive and notable increase that can be directly attributed to treatment.

The AEP was also used to compare AS's overall intelligibly at the single word level pre- and post-treatment through calculating his pre- and post-treatment PPC and PCC scores. Pre-treatment AS had a PPC score of 68%, which increased by 6% post-treatment to a score of 74%. AS's pre-treatment PCC score was 57%, which increased by 8% post-treatment to a score of 65%. AS's PCC score significantly increased from pre-treatment to post-treatment suggesting the effects of treatment generalized across her sound system and increased her intelligibility.

Individual sound accuracy was also calculated on specific phonemes in error using AS's productions on the AEP probe. AS's sound accuracy scores were calculated for individual phonemes in error using her AEP probes. Only consonants in error greater than 50% of the time were included in the table analyses, in order to complete a large-scale relational analysis, which correlated to overall intelligibility (figure 11).

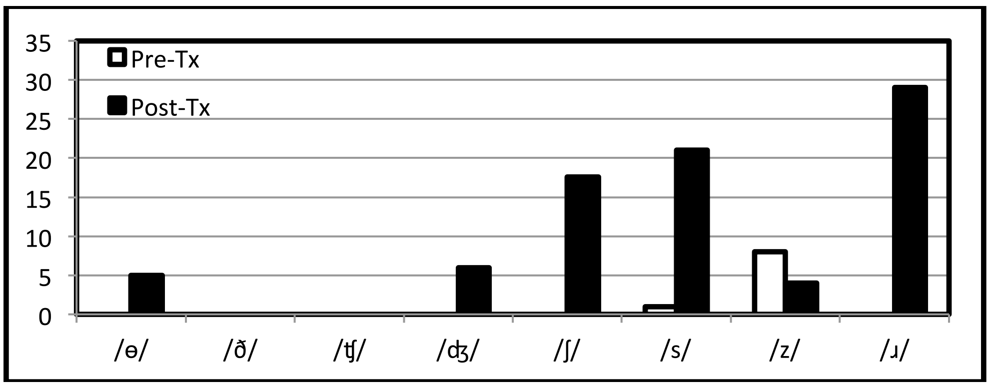


Figure 11. AS's Pre- and Post-Tx AEP: Analysis of consonants produced ≤50% correct

Also a sound substitution analysis was completed to measure how many different sounds each participant produced for a specific adult sound and how many different sounds were produced by the child for the treatment target sounds pre-treatment compared to post-treatment. The substitution analysis was calculated using the ECI (Tyler et al., 2003), which represents the total number of substitutions for all sounds in error. The ECI was calculated from 24 total sounds. Of these 24 sounds AS had 51 substitutions in the pre-treatment AEP probe giving her an ECI of 2.12. Post-treatment AS had 37 substitutions for the 24 sounds giving her an ECI of 1.54. Thus the .58 decrease in AS's ECI score increased her intelligibility. AS's results are summarized at the end of the chapter in table 37, and figures 18 and 19.

AS had 3 substitutions for her target /r/ sound pre-treatment, and 3 substitutions post-treatment. In the pre-treatment AEP, AS had zero occurrences of the /ɹ/ phoneme due to her inability to produce the /r/ sound. In the post-treatment probe, she added the /r/, but was not consistently using it in all word positions. Thus, she added the sound to her inventory, but had not yet mastered her production of it within all words. It was not unexpected that she continued to use some of the previous substitution errors along with the newly added /r/ phoneme.

The final assessment measure was the ZOT assessment of T2 vocabulary words. During the pre-treatment ZOT assessment AS responded correctly to no T2 word receiving a score of 0 out of 40 possible points, which translated to a 0% correct total score. In the post-treatment ZOT assessment AS received a score of 4 out of a possible 40 points, which translated to a 10% correct total score. Due to AS's behavioral issues, formal de-contextualized testing was difficult. AS appeared inattentive and hurried or sped through the ZOT assessment questions as she would hastily responded with non-elaborative responses. For example, for 'use' of ZOT words "route", "region", and "respond", AS responded with, "Route with a doggie.", "Region in a story with not a doggie", and "A doggie running", respectively. Thus, it appeared as though AS was not motivated by the ZOT assessment. Measures such as sticker rewards were used to coax AS to participate in order to get a representative sample of her T2 knowledge. AS's pre- and post- treatment ZOT results are summarized in table 22. It must be noted that AS's performance on the ZOT might have been due to the complexity of the assessment and AS's developmental age.

As a result of the complexity of the ZOT, secondary ZOT testing to assess AS's T2 understanding was also completed using the storybook pictures as a context and to help engage AS in an attempt to get a comprehensive evaluation of her vocabulary knowledge. The storybook was used to provide a context for the T2 words, since the ZOT in its designed form was considered to be a complex task. The formal ZOT test assessed 13 T2 words, with each of the 13 words being worth 4 possible points: 2 for accurate definition and 2 for accurate use of the T2 word. Since it was of interest to know if children were learning the T2 words targeted in treatment, only the 7 words (i.e., 28 points) targeted in treatment were assessed using the ZOT storybook context. AS accurately defined and/or used 3 of the 7 words and received credit for 7 out of 28 possible points, which translated to a 25% correct score. Although AS's contextual ZOT score of 25% was significantly higher than the de-contextualized ZOT assessment score of 10%, it is questionable how much AS's behavioral interfered with her performance.

Specifically, AS was able to define and use different T2 words to varying extents in each of the ZOT assessments, which were administered on two different days during the final two post-treatment assessments, though no further treatment on the words were provided between assessment administrations. For example, AS received a full 4 points for the T2 word, "rigid" during the formal ZOT assessment, but only received 3 points for rigid in the contextualized assessment using the storybook. In addition, it was noted that AS's accuracy and consistency of target T2 words' use and definition would increase and/or decrease depending on her attention and focus that day. Thus, her inconsistencies in performance might not solely reflect on her knowledge of the target T2 words, but also her behavior and attention to the task. Regardless, the formal ZOT assessment and the contextual ZOT using the storybook suggest that AS did not have a holistic understanding of the T2 words.

AS (T2 words): Results Interpretations.

Throughout treatment sessions AS displayed a waning focus and immature behaviors during clinical activities, as she was frequently disengaged in activities, and was occasionally oppositional within the structured setting (e.g., having to sit in her chair, following simple rules, listening to the clinician, etc.). AS's behaviors negatively impacted her phonological learning and vocabulary expansion, as her performance on both tasks were impacted by her willingness to perform tasks and attention to tasks.

AS initially produced [w] for /r/ in the target words in early sessions, but her behavior of gliding liquids (replacing /r/ with [w]) changed with treatment. AS was provided with perceptual sound training and differential sound characteristics on the /w/ and /r/, along with being given descriptive feedback of her productions. In later sessions AS struggled most with pulling her tongue back far enough rather than producing a /w/ for /r/. She developed an awareness of the target /r/ sound parts (e.g., tongue back and up, smile, don't let your lips touch), as she would correct her production when provided clinician cues of the /r/ sound parts. For example, the clinician would signal AS using a physical prompt AS knew represented pulling back her tongue, and AS was able to repair her productions.

It was noted by the clinician that AS was inconsistent in her ability to define and use T2 treatment target words, as AS could state a T2 definition during one session or activity, but when instructed to do it again at a later time or within a new activity, she would resort back to saying, “I don’t know.” It is unclear whether AS truly did not know the word or if she was unmotivated by the complexity of the activity, as she often appeared inattentive. All the issues related to AS’s age and behaviors are considered in detail within the following discussion chapter.

SSD04_AG: T2 Treatment Results

AG completed ten one-hour treatment sessions, which typically occurred twice weekly. During each session, she spent approximately ten minutes listening to target T2 words that were presented within the treatment storybook. The /r/ was targeted in word-initial position, using seven T2 targets: “rescue”, “region”, “removes”, “respond”, “relieved”, “retreated” and “rigid”. At the end of treatment AG, was able to produce her selected treatment words containing a prolonged pre-vocalic /r/ in word-initial position with approximately 65% accuracy during imitation. AG’s progress over treatment is illustrated below in terms of four different production levels: /r/ in isolation or shaping, a post-vocalic segmented /r/ in words, a prolonged pre-vocalic /r/, and finally an adult /r/ production which were all presented in the imitation phase of treatment. Each of these different production levels are part of traditional speech treatment and serve as a hierarchy to achieving spontaneous /r/ productions in words. A summary of how long AG was in each of the four different production levels over the course of treatment can be found in figure 12 and AG’s total accuracy in each of the 4 imitation phase production levels can be found below in figure 13.

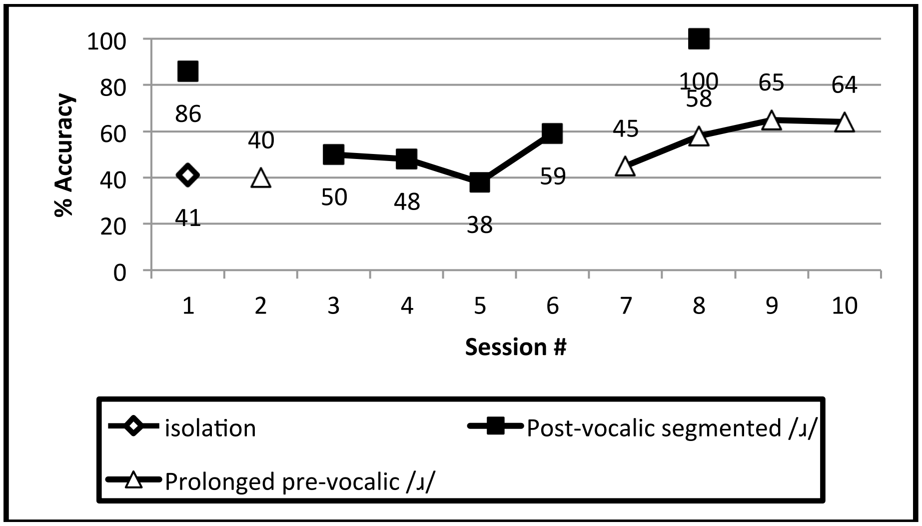


Figure 12. AG's Production Level and Accuracy for Each Session. AG was at the isolation production level of treatment for session 1; the production level post-vocalic segmented /r/ for sessions 1, 3, 4, 5, 6, & 8; the production level prolonged pre-vocalic /r/ for sessions 2 & 7-10.

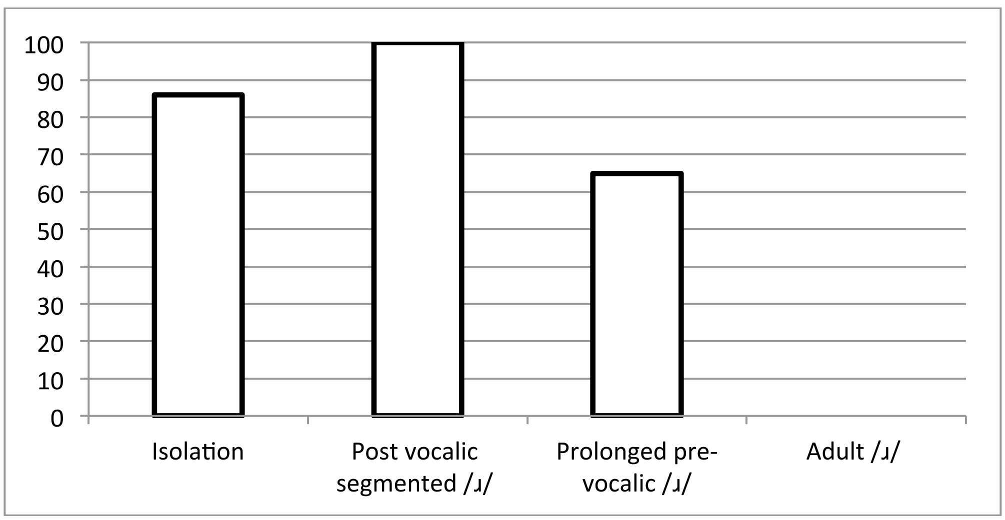


Figure 13. AG's progress in Tx through different speech sound levels (all at the imitative level). The best accuracy achieved within each of the production levels is displayed.

Behaviorally, AG worked hard during session activities but had limited attention due to her sensory-seeking tendencies. Tasks involving movement and tactile feedback were motivating to AG. For example, tasks where AG was able to get out of her chair and move around the room helped her focus on clinician models and satisfy her sensory needs. Also, tasks involving tactile stimulation such as water activities, digging for beans, and movements served as great reinforcers or motivators for good behaviors and performance accuracy.

AG was in the T2 treatment group and did receive the T2 incidental learning, although books were not motivating to AG. Due to her older age, she was able to use a visual schedule and followed along with the story. For example, AG was not engaged in the story narratives like other participants, but she was able to complete the reading with the clinician in order to do the next activity. AG did have a firm grasp of the storyline and the storybook narrative, thus was able to associate T2 words presented in the story to drill-play activities throughout the session. When the clinician presented pictures representing the T2 words, AG would pair actions to the meaning of the T2 words in the story. The clinician would reinforce AG's actions representing the T2 words meaning with the incidental learning definition of the target T2 word. For example, AG would pretend to be "rigid" like Grandma in the story, and the clinician would respond to AG's engagement using the incidental approach by saying, "Look! You're stiff and not moving just like Grandma was."

Post-treatment assessments.

Articulation Skills. A comparison of AG's pre-treatment and post-treatment GFTA-2 scores were used to assess AG's production of speech sounds. Table 32 lists the sounds produced in error in Pre-treatment and Post-treatment GFTA-2 assessments; the word positions in which they were incorrect are marked with an "X".

Table 32. AG's Pre- and Post-Tx Sound Errors in Initial, Medial, and Final Word Positions.

		Word Initial		**Word Medial**		**Word Final**	
Sound symbol	**Letter and example**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
/θ/	"th" in "thumb"			X		X	
/ð/	"th" in "feather"		X	X	X		
/tʃ/	"ch" in "watches"			X	X		
/dʒ/	"j" in "jumping"	X	X				
/z/	"z" in "zipper"	X	X	X	X		X
/s/	"s" in "scissors"	X	X	X	X	X	X
/r/	"r" in "rabbit"	X	X	X	X		
/l/	"l" in "ball"					X	X

In the post-treatment assessment using the GFTA-2, the following sound blends were also produced in error in word initial position: "br", "dr", "fl", "fr", "gl", "gr", "kl", "kr", "pl", "sl", "sp", "st", "sw", and "tr". Using AG's production of words on the GFTA-2, the KLPA-2 was completed to assess her use of phonological patterns/processes. AG's percentage of occurrence for each of the 10 phonological processes is listed below in table 33.

Table 33. Participant AG's Pre- and Post-Tx KLPA percent occurrence of processes

	Target Word → Process	**Pre-Tx**	**Post-Tx**
Deletion of final Consonants	"scissors" → "scissor-"	0%	0%
Syllable Reduction	"banana" → "nana"	0%	0%
Stopping of Fricatives/Affricates	"this" → "dis"	13%	3%
Cluster Simplification	"spoon" → "poon"	23%	12%
Liquid Simplification	"rabbit" → "wabbit"	61%	52%
Velar Fronting	"cup" → "tup"	0%	0%
Palatal Fronting	"chair" → "sair"	0%	0%
Deaffrication	"watches" → "washes	17%	33%
Initial Voicing	"telephone" → "delephone"	0%	0%
Final Devoicing	"five" → "fife"	0%	0%

Post-treatment AG produced 22 separate phonological processes in the 53 words of the GFTA-2. This raw score of 22 converted to a standard score of 79, which placed AG at the 8th percentile for children her age. AG's advancements in treatment are viewed using her pre- and post- treatment KLPA-2 standard scores. AG's changes over treatment made her overall standard score increase moving her from the 5^{th} percentile to the 8^{th} percentile.

Most notable gains were seen in the phonological processes stopping of fricatives/affricates, cluster simplification, and liquid simplification. Over the course of treatment AG's stopping of fricatives/affricates, cluster simplification, and liquid simplification processes reduced by 10%, 11%, and 9%, respectively. Also, liquid simplification was directly targeted in treatment, thus can be solely contributed to treatment of the /r/. Although, both fronting of affricates/fricatives and cluster simplification was not directly targeted in treatment, it was indirectly targeted in treatment of the /r/. For example, the /r/ is a palatal/post-alveolar sound, thus palatal placement was targeted in treatment and fricatives /ʃ/ and affricates /ʧ, ʤ/ have palatal placement. Also, many clusters include liquids such as the /l, r/ as in "clown", "green", "flowers", "brush", etc. which incorporate the treatment target /r/. In other words, placement and manner features of the treatment target /r/ might have indirectly caused changes to processes stopping of fricatives/affricates, and cluster simplification, along with directly caused change to liquid simplification. AG's KLPA standard and percentile scores pre- and post-treatment are summarized in table 38.

The AEP was used to measure AG's system-wide phonological generalization, PPC, and PCC pre- and post-treatment. AG's pre- and post-treatment AEP data was organized into four different measures: phonetic and phonemic inventories (Table 34), PPC (figure 16) and PCC (figure 17), which are summarized in the following paragraphs.

Table 34. AG's pre- and post- treatment scores: context free phonetic inventory, and phonemic inventory.

SSD04_AG Profile: Non Word Treatment Group																											
Phonetic Inventory																											
Pre-Tx	**p**	**b**	**t**	**d**	**k**	**g**	**f**	**v**	**ɵ**	**ð**	**s**	**z**	**s***	**z***	**ʃ**	**ʧ**	**ʤ**	**ts**	**dz**	**m**	**n**	**ŋ**	**l**		**w**	**j**	**h**
Post-Tx	p	b	t	d	k	g	f	v	ɵ	ð			s*	z*	ʃ	ʧ	ʤ	ts	dz	m	n	ŋ	l	r	w	j	h
Phonemic Inventory																											
Pre-Tx	**p**	**b**	**t**	**d**	**k**	**g**	**f**		**ɵ**	**ð**			**s***		**ʃ**	**ʧ**	**ʤ**			**m**	**n**		**l**		**w**	**j**	**h**
Post-Tx	p	b	t	d	k	g	f			ð			s*		ʃ	ʧ	ʤ			m	n	ŋ	l	r	w	j	h

* An asterisk was used to mark any production of /s/ and /z/ that were characterized by a substitution of an inter-dental (between the teeth) "s" sound, similar to a soft "th" (E.g., "houth" for "house"; "thpoon" for "spoon"). These sounds were noted to be in error due to the use of the inter-dental tongue position for those sounds, which is not the typical place of articulation of healthy adult speech.

AG added the /r/ phoneme to her phonetic inventory post-treatment which was attributed to the direct treatment of the /r/. The post-treatment analysis of AG's phonemic inventory illustrated her increased knowledge of phonemes /r, ŋ, h/, as she added them to her inventory. The phoneme /ɵ/ was present in her pre-treatment phonemic inventory, but was absent from her post-treatment phonemic inventory; this was probably due to a lack of "good" minimal pairs for this phoneme. Thus, AG increased her phonemic inventory from 17 phonemes to 18 adult phonemes, which was a 6% increase in her overall phonemes.

The AEP was also used to compare AG's overall intelligibly at the single word level pre- and post-treatment through calculating her pre- and post-treatment PPC and PCC scores. Pre-treatment AG had a PPC score of 77%, which increased by 4% post-treatment to a score of 81%. AG's pre-treatment PCC score was 70%, which increased by 5% post-treatment to a score of 75%. Through the course of treatment AG's overall PCC increased 5%, thus impacting her overall intelligibility and phonological functioning.

Individual sound accuracy was also calculated on specific phonemes in error using AG's productions on the AEP (Barlow, 2003) probe. Only consonants in error greater than 50% of the time were included in the analysis, in order to complete a large-scale relational analysis, which correlates to overall speech intelligibility. AG's results are summarized below in Figure 14.

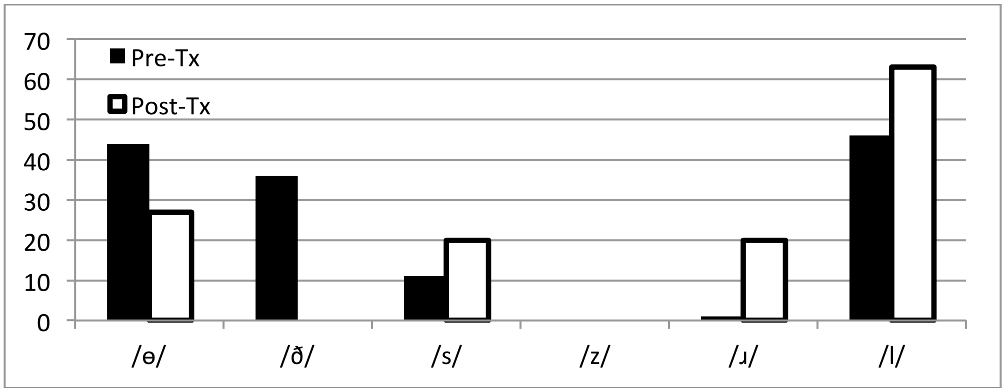


Figure 14. AG's Pre- and Post-Tx AEP: Analysis of consonants produced ≤50% correct

Also a sound substitution analysis was completed to measure how many different sounds each participant produced for a specific adult sound and how many different sounds were produced for the treatment target sounds pre-treatment compared to post-treatment by the child (Table 37, and Figures 18 and 19). The substitution analysis was calculated using an ECI, which represents the total number of substitutions for all sounds in error. The ECI was calculated from 24 total sounds. Of these 24 sounds, AG had 45 substitutions in the pre-treatment AEP probe giving her an ECI of 1.87. Post-treatment AG had 42 substitutions for the 24 sounds giving her an ECI of 1.75. Thus AG's ECI decreased by .12 suggesting that she had slightly less variance in her productions.

As for AGs target /r/ sound, she had 3 substitutions pre-treatment and 4 substitutions post-treatment, which was similar to AA and AS who also both did not decrease the number of substitutions for their target sounds. This finding suggests that AG might have been in the process of reorganizing her sound system. As in the pre-treatment AEP probe, AG did not have the target /r/ phoneme in her phonemic or phonetic inventory but in the post-treatment probe she added the /r/ to her inventories and added it to her substitutions or ECI. Thus, AG had not consistently added the /r/ in all word positions, as she still displayed some of the same substitution patterns as pre-treatment which is why she still had the 3 previous substitutions and added target /r/ sound.

The final assessment measure was the ZOT assessment of T2 vocabulary words. During the pre-treatment ZOT assessment AG responded correctly to two T2 words receiving a score of 2 out of 40 possible points, which translated to a 5% correct total score. In the post-treatment ZOT assessment, AG received a score of 21 out of a possible 40 points, which translated to a 53% correct total score. AG's pre- and post- treatment ZOT results are summarized in figure 22.

Secondary ZOT testing to assess AG's T2 understanding was done using the storybook pictures as a context in order to get a comprehensive evaluation of her vocabulary knowledge. Recall that the ZOT requires participants to define and use T2 vocabulary words without a context, which is a metalinguistic skill (Wehren, De Lisi, & Arnold, 1981; Snow, 1990) that begins emerging in kindergarten (Litowitz, 1077; Watson, 1985; Nippold, 1995). Also, recall that AG was identified as having a language disorder and SSD, and her nonverbal intellectual performance was at the low end of the normal range, putting her at risk for academic failure. Since AG's performance all on above-mentioned tasks are highly correlated to metalinguistic skills, her ability to define the T2 words on the ZOT might have been impaired. Thus, AG might have needed the extra support provided by the contextualized ZOT due to the complexity of the task, her language deficits, and age. During the final session of treatment, the clinician tested AG's contextualized ZOT vocabulary knowledge of the target T2 words when presented with the storybook pictures, AG received 21 out of a possible 28 points to achieve an accuracy of 75% on target words definitions and use.

AG (T2 words): Results Discussion.

AG's performance was unique due to her presenting disorders, age, and history, as in she was the only participant who had both a SSD and language disorder, was the oldest participant by over a year and received high intensity speech and language services for many years prior to being enrolled in the current research study. All of these factors need to be considered when interpreting AG's results and analyzing her performance within the T2 group. In addition, AG exhibited sensory seeking behaviors, which might have influenced her learning in general.

Since AG also had a concomitant language disorder, she potentially had the most to gain from the speech treatment that incorporated the T2 words. Since children with SSD often have lower expressive language scores and unintelligible communication, which negatively impacts their lexical development (Camarata, 1996; Smith & Camarata, 1999), they could benefit from added lexical development. Moreover, when children have a diagnosis of both SSD and language disorder, they are at an even greater risk for early academic failure and could especially benefit from the additional academic language in their speech treatment. Thus, children such as AG who have both a speech and language disorder potentially have the most to gain from the inclusion of academic vocabulary in treatment because they are at a higher risk for academic failure. Treatment integrating academic language with a pronounced phonological focus due to the complexity and age of acquisition of target words and sounds might elicit the largest phonological and lexical gains.

AG's treatment results illustrated promising evidence for T2 vocabulary words being used in treatment for children with SSD and potentially with children with conglomerate language disorders. For example, AG added the treatment /r/ phoneme to her phonemic inventory and increased her PCC score, illustrating system-wide phonological changes and generalization of the treatment /r/ sound into her everyday communication. Thus, AG's results advocate for the use of T2 words in treatment of SSD, promoting word lexicality.

Also, AG made significant gains on the ZOT vocabulary assessment, which measured treatment word learning over pre- and post-treatment. AG's generalization of T2 vocabulary words through an incidental learning approach generalized to other vocabulary words presented within the storybook context. For example, post-treatment AG was able to define and use T2 words presented within the storybook that were not targeted directly through an incidental learning approach. The words "reverse", "route", and "relax" were presented to all of the participants within the storybook and never directly targeted. AG was able to give a superficial definition of "reverse" and "route" and used the "route" within a meaningful context (e.g., "Route to go to Grandma's house."). AG's vocabulary expansion to non-treatment words suggests that the additional lexical properties of the T2 words paired with the quick incidental learning approach might have accelerated AG's novel word learning by drawing her attention to new words within a context.

Group-Level Participant Results

The AEP probe was used to analyze sounds added to participant phonemic inventories (Figure 15, and tables 35 and 36), PPC (Figure 16), PCC (Figure 17), Sound Substitution (ECI) for Treatment Sounds (Table 37), Sound Substitutions (ECI) for ALL sounds pre-treatment compared to post-treatment (Figure 19) and the percentage that each participant's ECI decreased from pre- to post- treatment (Figure 19); Pre- and post-treatment standard and percentile scores on the KLPA-2 (Table 38) Pre- and post-treatment ZOT vocabulary scores (Figure 22). Each of the figures and tables will be discussed in details in relation to the T2 word and NW group participant performance.

The AEP allowed for an analysis of all participants' pre- and post-treatment phonetic and phonemic inventories (Tables 35 and 36). Both of the NW participants made more gains to their phonemic inventories (Figure 15), as MW added five phonemes and AA added 7 phonemes. Alternatively, the T2 word participants added fewer phonemes, as AS added 3 phonemes and AG added only 2 phonemes. These results are consistent with the research suggesting NWs have been shown to cause more immediate changes to treated and untreated sounds than real words (Thompson, 2007; Gierut, 2001, 2007).

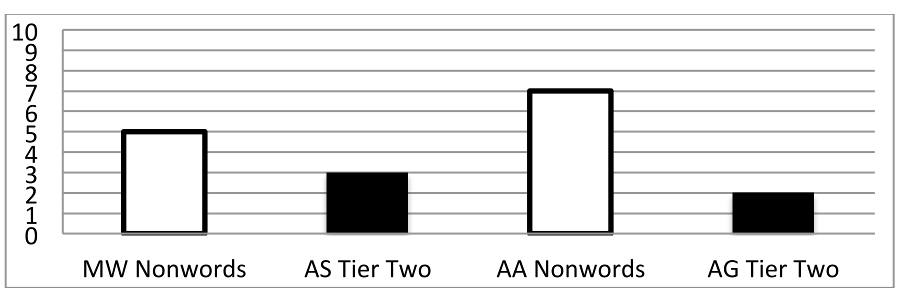


Figure 15. Sounds added to participants' phonemic inventories, as measured by the AEP.

Table 35. Sounds missing from each participant's phonetic inventories pre- and post-Tx. No distortions or non-adult sounds are included in this inventory. Sounds missing from participants' phonetic inventory Pre- and Post-Tx are marked with an "X".

	MW (NWs)		**AS (T2 Words)**		**AA (NWs)**		**AG (T2 Words)**	
Phonemes	**Pre-Tx**	**Post-Tx**	**Pre-Tx**	**Post-Tx**	**Pre-Tx**	**Post-Tx**	**Pre-Tx**	**Post-Tx**
/p/								
/b/								
/t/								
/d/								
/k/	X							
/g/	X	X						
/f/								
/v/								
/s/								X
/z/			X	X				X
/θ/	X	X	X	X	X	X		
/ð/	X	X	X	X	X	X		X
/ʃ/					X	X		
/ʧ/			X	X				
/ʤ/			X	X				
/m/								
/n/								
/ŋ/								
/w/								
/j/			X					
/r /			X				X	
/l/								
/h/			X					

Table 36. Sounds missing from each participant's phonemic inventories pre- and post-Tx. No distortions or non-adult sounds are included in this inventory. Sounds missing from participants' phonemic inventory Pre- and Post-Tx are marked with an "X".

	MW (NWs)		**AS (T2 Words)**		**AA (NWs)**		**AG (T2 Words)**	
Phonemes	**Pre-Tx**	**Post-Tx**	**Pre-Tx**	**Post-Tx**	**Pre-Tx**	**Post-Tx**	**Pre-Tx**	**Post-Tx**
/p/								
/b/								
/t/								
/d/								
/k/	X	X						
/g/	X	X			X			
/f/								
/v/	X				X		X	X
/s/				X			X	X
/z/			X	X			X	X
/θ/	X	X	X	X	X	X		X
/ð/	X	X	X	X	X	X		
/ʃ/				X	X	X		
/ʧ/			X	X				
/ʤ/	X		X	X				
/m/					X			
/n/					X			
/ŋ/	X		X		X	X	X	
/w/					X			
/j/	X		X	X	X			
/r /			X				X	
/l/	X				X			
/h/	X		X		X	X	X	

Each participant's AEP PPC and PCC change from pre- to post-treatment can be found below in Figures 16 and 17. The results from the PCC scores indicate the T2 group participants made more changes over the course of treatment, which suggests that T2 words might be superior targets because they elicited greater gains in the children's intelligibility.

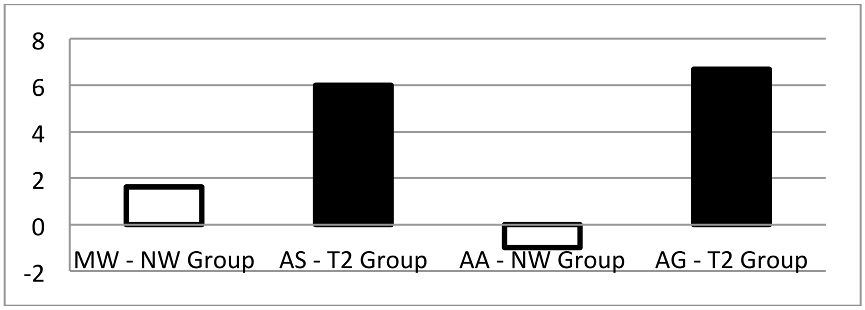


Figure 16. Participants' Pre- and Post-Tx changes in PPC scores on the AEP

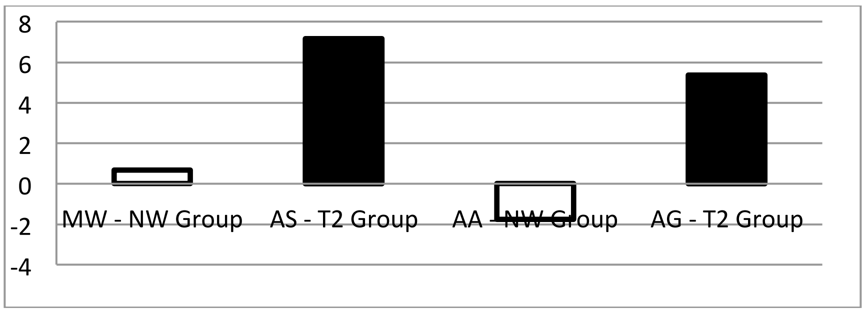


Figure 17. Participants' Pre- and Post-Tx changes in PCC scores on the AEP

The total number of substitution errors for each participant's treatment sound is summarized in table 37. In the NW group, MW reduced the errors she made on the treatment /r/ sound but AA increased the errors he made on his treatment /θ/ sound. In the T2 word group, AS did not have any changes in her substitutions of the treatment /r/ sound but AG increased the number of errors she made on the treatment /r/ sound. Thus, it is unclear whether T2 words or NWs are superior in making changes to a child's ECI on treatment sounds, although a possible rationale is explored within chapter 5.

Table 37. Participants' number of sounds substituted Pre- & Post-Tx for their Treatment Sound

	Pre-Tx	**Post-Tx**	**Tx Sound**
MW	5	4	/r/
AA	3	4	/θ/
AS	3	3	/r/
AG	3	4	/r/

Each participant's sound substitution ECI scores pre-treatment and post-treatment on the AEP are found below in figures 18 & 19. The results indicate that neither group was better at eliciting change since children in both groups were inconsistent with their sound substitutions. Thus, these results suggest that T2 words and the NWs are similar in this aspect. It must be noted that the ECI scores of the youngest two participants, MW and AS, showed the greatest amounts of decrease, which is an improvement. Since both MW and AS made the most notable decreases to their ECI, and were of a similar age and had the largest ECI pre-treatment, it is important to consider why they were better at reducing their total number of sound substitutions.

MW and AS were the youngest participants in the study. This means that they might have had less time to practice producing the sounds incorrectly, essentially making changes to their sound systems easier. Although it cannot be certain that age contributed to changes in the participants' ECI, it is a factor to consider in interpreting these preliminary results and will be discussed in more detail to follow in the discussion chapter.

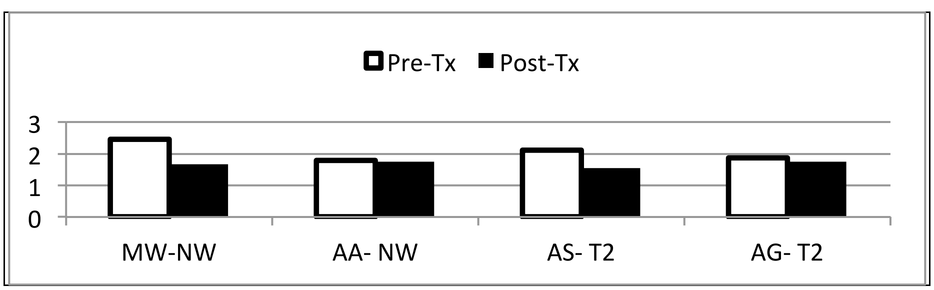


Figure 18. Participants' ECI scores Pre- & Post-Tx.

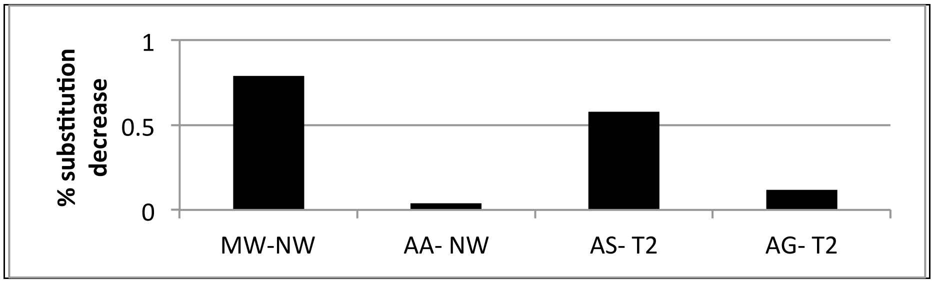


Figure 19. Participants' ECI for ALL sounds Pre- and Post-Tx % substitution decrease

The last phonological analyses completed were calculated from the GFTA-2. All participants' PPC and PCC scores and KLPA scores were compared pre- and post-treatment using the GFTA-2. One interesting thing to note is that the GFTA-2 PPC and PCC analyses yielded different results than the AEP PPC and PCC analyses. The GFTA-2 PPC scores found in Figure 20 illustrate the mixed results of the T2 and NW groups as both AS and AA made the most improvements to their PPC scores. Alternatively, the AEP PPC found in Figure 16 were clearly indicated T2 treatment group superiority. Moreover, while the AEP PCC scores showed that the T2 participants made more notable gains with AA's performance decreasing (Figure 17), the GFTA-2 PCC scores indicate little variance between participants MW (NW group), AS (T2 word group), and AG (T2 word group), with notable gains from AA's PCC score (Figure 21). These discrepant findings could be due to the fact that the AEP is a larger phonological probe than the GFTA-2, as it has 256 words where the GFTA-2 only samples 53 words. Thus, the small sampling of words from the GFTA-2 might not have been enough to accurately measure phonological generalization. Discrepancies in PPC and PCC on the AEP and GFTA-2 results are covered in the discussion chapter.

The KLPA scores, which specifically analyzed the participants' sound systems in terms of phonological processes, suggested that the NW participants made more gains

(Figure 38). Both NW participants significantly increased their standard scores and corresponding percentile scores pre- to post-treatment, as MW increased her percentile rank by 6% and AA produced his percentile rank by 25%. Whereas, T2 participants AS increased her percentile rank by 5% and AG increased her percentile rank by 3%. Although by far the most gains were noted by AA who had three times more gains than the any other participant. Thus, these results should be interpreted with caution and not weighed as heavily on group performance but rather performance as a whole, as all participants made positive gains to their sound systems.

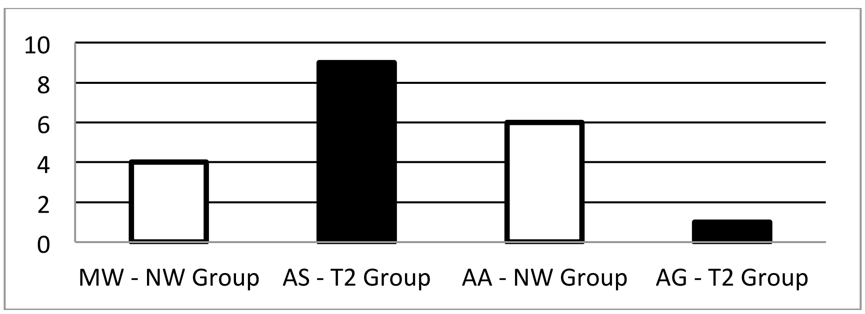


Figure 20. PPC: Participants' Pre- and Post-Tx changes in scores on the GFTA-2

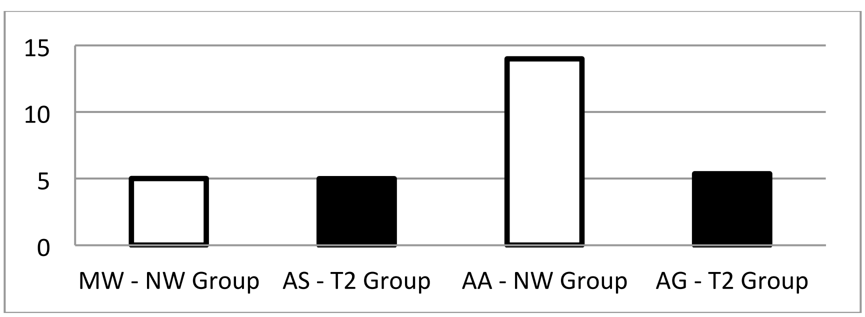


Figure 21. PCC: Participants' Pre- and Post-Tx changes in scores on the GFTA-2

Table 38. Pre- & Post-treatment KLPA Standard Scores (SS) & Percentile Ranks (%ile)

	Pre-Tx		**Post-Tx**	
	SS	**%ile**	**SS**	**%ile**
MW	83	14	88	20
AS	87	18	91	23
AA	86	16	102	41
AG	70	5	79	8

The final analysis was the ZOT vocabulary assessment, which is summarized below in figure 22. The T2 word treatment group clearly made greater gains than the NW treatment group, illustrating T2 words' ability to provide the opportunity for vocabulary expansion within speech treatment. Both T2 participants made gains on the ZOT vocabulary assessment, as AS had a 3-point increase and AG had a more significant 19-point increase. Not unexpectedly, no vocabulary expansion was seen in either NW participant. Thus T2 words directly targeted within speech treatment can expand children's vocabularies through treatment words. T2 word treatment might even promote vocabulary expansion across untreated words. For example, not only did AG make vocabulary gains to treatment target T2 words, but also to other untreated T2 words presented within the storybook.

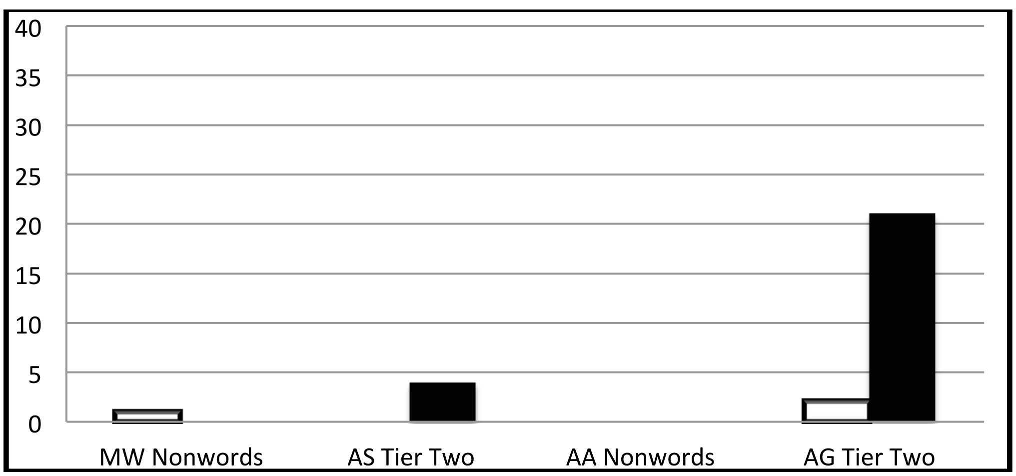


Figure 22. Each of the participants' Pre- and Post-Tx ZOT Vocabulary Scores

These results suggest that NWs might be better treatment targets for adding new sounds to a child's phonemic inventories, and for reducing the number of phonological processes a child exhibits. Alternatively T2 words might be better at increasing a child's PCC, and promote vocabulary expansion. It is unclear to whether T2 words or NWs reduce the amount of sound substitutions to a child's system, or cause more change to the target treatment sound, as these results were inconclusive. Results suggesting T2 treatment and NW treatment results and implications are summarized below in table 39.

Table 39. Treatment Group Comparisons.

	Adding Sounds [Phonemic Inventory]	Adding Sounds [Phonetic Inventory]	Reducing Phonological Processes [KLPA]	Increasing Intelligibility [PPC-AEP]	Increasing Intelligibility [PCC-AEP]	Promoting Vocabulary Expansion [ZOT]
T2 Treatment Group		X		X	X	X
NW Treatment Group	X		X			

The results above indicate that NWs and T2 words play distinctively different roles when it comes to targeting specific parts of a child's sound system. For instance the NW group added more phonemes to their phonemic inventories and were able to reduce the number of phonological processes on their KLPA more significantly than the T2 word group. The T2 participants did however add sounds to their phonemic inventories, just not to the same extent as the NW group. Adding sounds could be especially important if the child does not have many sounds within his or her inventory. In addition, adding sounds to an inventory may reduce the number of phonological processes a child makes, which would explain the improvement seen on KLPA scores in the NW group. On the other hand if a child has a fairly full phonemic inventory, but is still highly unintelligible, he/she might likely benefit more from T2 words. The T2 words elicited greater changes in PCC accuracy, which directly relates to overall speech intelligibility. It is possible that the T2 participants had higher PCC score because they had more opportunities to use the treatment words outside of the treatment room, however this was not measured in the present study. The T2 participants were able to form a stronger representation of the treatment words, as demonstrated by their increased ZOT vocabulary scores. Thus, the T2 participants were able to learn their treatment target words more holistically. Since children are capable of learning the T2 words at a young age, speech treatment using T2 words possibly helps develop metalinguistic skills, as well improving their speech production abilities. In summary, T2 words might be more functional treatment targets because they can elicit increases in children's phonetic and phonemic inventories, PCC, and vocabulary awareness while NWs only elicited notable gains in phonemic inventories and KLPA scores.

CHAPTER VI

DISCUSSION

The current study investigated how the word frequency and lexicality of nonwords (NWs) and Tier 2 vocabulary words (T2 words) induce phonological change in children with speech sound disorders (SSD). Since NWs are not present in the English lexicons of adults or children, they can be key components of phonological change (Gierut et al, 2010; Leonard, 1973; McNeil & Stone, 1965; Winitz & Bellerose, 1965). The NWs were compared to T2 words, which were also low in frequency and acquired later in development. In addition, the T2 words had the potential to expand children's vocabularies, which could help with future academic success.

Four participants with SSD were enrolled into the treatment study and randomly assigned to either the T2 word group or NW group. Each participant received a minimum of 10 1-hour sessions occurring twice weekly. Treatment sessions consisted of traditional speech treatment with T2 words or NWs, presented within a storybook context at the beginning of every session, followed by the targeting of the selected treatment words in drill-play activities. The T2 group participants were also supplied with a quick incidental learning (QUIL; Oetting, J. B., Rice, M., L., & Swank, L. K., 1995) definition for each T2 word both during the reading of the storybook, as well as throughout treatment activities. A variety of assessments were completed both pre- and post-treatment to measure generalization of sound and word learning. The current study's findings on the effects of T2 and NW targets in treatment are discussed in detail. In addition, the potential benefits and limitations, as well as future implications from the current study's findings will be discussed.

Phonological Learning During Treatment.

All participants in the study made some phonological changes their sound systems, but interpretation or generalizations of the changes was limited due to minimal changes observed both within and across groups. The lack of phonological change seen in the children's treatment results might have been due to the short number of treatment hours. The typical time needed to change a speech difference is 15 to 20 hours (Jacoby et al., 2002); however, only 10 treatment hours were allotted for treatment due to summer clinic scheduling. It is assumed that if the children had received 15 to 20 hours of treatment, they would have made it to the spontaneous phase of treatment and more sound change would have occurred. Thus, it would be recommended that every child be seen for at least 15 1-hour sessions of treatment.

While the imitation phase in treatment is important in order to teach the complex motor skills necessary for the production of treatment words, the spontaneous phase is even more important as it promotes generalization[7] of treatment words and sounds into everyday speech. To clarify, children have limited information processing capabilities and any additional cognitive load (e.g., learning the meaning/use of a new word) while learning a complex motor skill (such as speech) may be detrimental to learning (Maas, Robin, Austermann, Freedman, Wulf, Ballard, et al., 2008). In addition, providing

[7] Generalization refers to the transfer of learning from treatment (Gierut et al., 2010), as the proportion of production accuracy relative to the pre-treatment baseline. Production accuracy of treated sounds can be monitored within treatment words, within non-treatment words containing the treatment sound during session-by-session tracking, pre- and post-treatment within individual measures, and between treatment groups' measures.

immediate and high frequency feedback during imitation tasks can enhance motor learning in children by reducing the information processing load and cognitive demands (Maas et al., 2008; Sullivan, Kantak, & Burtner, 2008). In other words, the imitation stage of treatment allows the child to hear an adult model and repeat the speech sound or phonological form of the word without an excessive cognitive load, which can promote the learning of a complex motor skill. The participants in the current study did not meet the criteria to move beyond the imitation phase of treatment. Thus, while the children learned the motor production patterns of the sounds in the new words, the lack of practice in spontaneous speech was potentially detrimental to their overall sound generalization.

In other words, children need to practice saying the word spontaneously in order to expand their phonological knowledge. If a child is always provided with a model by the clinician, the processing demands are lessened because the correct model is provided for them. During imitation tasks, the child must focus on only the behavior or motor programming, rather than applying cognitive processing to conceptualize the treatment sound with words (Maas et al., 2008; Sullivan et al., 2008). More importantly, having to produce words without a model requires children to not only conceptualize the sound prior to production, but also to monitor and control their speech output, which will greatly increase the potential for generalization into spontaneous speech. Sound mastery is a gradual process from when the sound first emerges to the time it is produced in spontaneous speech with consistent accuracy and this mastery continues to occur once treatment is withdrawn (Diedrich & Bangert, 1980; McKercher, McFarlane, & Schneider 1995; Olswang & Bain, 1985).

Pre- and post-treatment analyses measures/probes such as the AEP and GFTA-2 both measured the participants' speech productions at the spontaneous level. While each of the participants made gains in production of his/her target speech sounds throughout treatment, none of the participants were 100% accurate in his/her productions of the treated sound in these probes. This result could be explained by the fact that none of the participants reached the spontaneous phase of treatment so they did not have adequate support levels for their sound productions (Diedrich et al., 1980; McKercher et al., 1995; Olswang & Bain, 1985). In other words, since the children were still at the imitation phase level at the end of treatment, they still required a model and descriptive feedback to accurately produce their sounds.

Word Form Learning During Treatment.

Each participant's ability to make phonological changes to his/her production of the treatment words was measured over the course of treatment. Different aspects of T2 words and NWs might have inhibited or accelerated phonological learning of the treatment words. Since word learning involves both lexical configuration (phonological or production level) and lexical engagement (mental lexicon, how words function and interact with other lexical entities; Leach & Samuel, 2007; Gaskell & Dumay, 2003; Vitevitch, Armbrüster & Hogan, 2006), both of these characteristics were contrasted within T2 words and NWs.

Specifically, since T2 words had both lexical and phonological information, children in the T2 word group needed to focus on both the lexical configuration and engagement aspects of the words in order to successfully produce them. Alternatively, since the NWs did not have any lexical meaning, the NW participants should have only needed to focus on the lexical configuration of the NWs. Both T2 words and NWs were presented similarly within treatment, and phonological change in both treatment groups was similar. These findings suggest that it is not clearly evident whether T2 words or NWs are better candidates for inducing phonological change. The following paragraphs discuss the subtleties of T2 words and NWs, and their influence on speech treatment outcomes.

The T2 word and NW groups were matched in terms of treatment sound selection. All of the participants' treatment sound selections consisted of OUT phonemes, according to their phonemic inventories (Gierut et al., 1994) and stimulability testing (Elbert, Dinnsen, & Powell, 1984; Carter & Buck, 1958; Glaspey & Stoel-Gammon, 2005). Thus, they were unable to articulate their target treatment speech sounds due to sound complexity (Dinnsen, 1984; Elbert 1992; Hoffman, Schuckers, & Daniloff, 1989; Stoel-Gammon, 1985). By teaching the participants sounds that they had the least amount of knowledge of, phonological learning was facilitated in both groups (Gierut, 1992, 1999, 2007; Gierut & Champion, 2001). Both treatment groups increased sound accuracy of their treatment target sounds throughout treatment, which was consistent with previous findings (Dean, Howell,Waters,&Reid, 1995; Dinnsen & Elbert, 1984). In addition, targeting nonstimulable sounds resulted in the acquisition of untreated stimulable sounds (Powell, Elbert, & Dinnsen, 1991).

There were no consistent group differences in the learning of the treatment sound within treatment words. It is not clearly evident why no differences between NW participants and T2 participants were seen, though one possible explanation concerns the similarities in the phonological forms of both treatment groups' treatment words. For example, all participants were learning nonstimulable sounds, which require motor learning and practice for accurate production. Thus, children might have focused on the phonological properties of the words. Even though it was hypothesized that T2 words would promote additional amounts of word learning due to their additional lexical information, this additional level of support might not have been useful during the early stages of treatment since all of the children were still mastering the phonological forms of the words. Thus, it is a possibility that children were only able to attend to the articulatory properties or motoric components of the words, which would account for similarities in treatment progress across all participants.

Since the children were not stimulable for their treatment sounds, they needed to learn how to produce their treatment sound. Thus, all participants initially were in the same treatment stage, and all progressed to the same treatment level within the imitation stage. More specifically, all the children produced prolonged versions of their treatment sounds in words following a model at the end of treatment (MW- 72% accuracy; AA- 42% accuracy; AS 43% accuracy; AG 65% accuracy). In summary, the lack of group differences in treatment sound production accuracy could be at least partially explained in terms of the OUT phonemes and sound stimulability.

Generalization of Untreated Sounds in Untreated Words.

The frequency characteristics of the treatment words resulted in change to different aspects of children's sound systems. For example the zero frequency of the NWs caused greater changes than the T2 words in terms of adding new sounds to the participant's phonemic inventories. This finding is consistent with research suggesting that children can focus their attention exclusively on the articulatory routines of NWs, without competition from any previously stored syntactic, semantic, or lexical information (Storkel & Morrisette, 2002). Thus, NWs were able to make an immediate impact on children's phonemic inventories due to the strong phonological component of NWs.

While it has been demonstrated that NWs elicited generalization to untreated sounds in untreated words (Gierut et al., 2010), it was anticipated that T2 word would make similar gains due to their similarities with NWs in terms of frequency and complexity. Indeed, the children in the T2 word group did add sounds to their phonemic inventories, just not to the extent as the NW group. The T2 words were novel to all of the participants as seen in the pre-treatment ZOT scores, which meant that the children had to process both the phonological and lexical features of T2 words. Thus, learning the additional lexical information associated with the T2 words might have inhibited some of the immediate phonological learning and generalization.

Speech Intelligibility.

T2 participants were provided with a QUIL approach, which was used to accelerate lexical configuration by providing word meaning to the phonological properties of the T2 words. Thus, participants in the T2 word group had functional opportunities to learn and use their treatment words both in and out of treatment. Since the T2 participants demonstrated larger increases in their AEP PCC scores as compared to the NW group, it is possible that T2 vocabulary words can better promote a functional application of treatment sounds. Moreover, the PCC scores can be interpreted in terms of speech intelligibility: The more consonants that children produce correctly, the more likely it is that a listener will understand the content of their message.

Variability in Sound Substitutions for Treated and Untreated Sounds.

Children who produce multiple system-wide sound substitutions reflect instability in their phonological representations of different phonemes (Tyler & Lewis, 2005). Thus, children with more substitution errors need longer treatment times to make changes to their sound systems. Only one participant, MW, reduced the number of substitutions she made for her treatment sound. It is possible that her pre-treatment stimulability of 30% for the treatment /r/ sound might have promoted her sound learning in treatment. Children make quicker gains in treatment when targeting sounds that are stimulable (Hodson, 2007). Thus, of all of the participants, MW had the most knowledge of her treatment sound pre-treatment, which would account for her ability to make quicker gains in learning her treatment sound.

AS had the same number of substitution errors pre-treatment and post-treatment for her treatment target /r/ sound. While the number of sound substitutions did not change, the pattern of the substitutions did. Specifically, pre-treatment AS had 3 substitution patterns for /r/, none of which contained the /r/; post-treatment she had 2 substitution patterns along with the adult target /r/ sound. Therefore, she reduced the amount of substitutions that were in error while adding the target /r/ sound. AS's results might be as equally notable as MW's results because she was able to reduce of the total amount of substitution errors for the treatment /r/ sound. Both AS's and MW's results positively impacted their treatment target sound development and illustrated generalization of their treatment target sounds into untreated words.

Both AG and AA produced additional sounds incorrectly for their treatment target sounds during post-treatment assessments. Pre-treatment AG did not use the treatment target /r/ sound, though similar to AS, AG added the target /r/ sound to her number of substitutions post-treatment, but did not eliminate any other substitution patterns. Because AG was unable to accurately produce her added treatment /r/ sound in all word positions, she still displayed some of the same substitution patterns as pre-treatment. Alternatively, AA had did not add his treatment target sound to his sound substitution inventory; instead he added a different sound. The multiple substitution patterns noted across AA's entire sound system possibly reflected instability in his representation of a variety of phonemes. This would suggest that AA needed more treatment sessions in order to generalize the target sound to untreated word positions (Forrest, Elbert, & Dinnsen, 2000) in his treatment target /θ/ sound.

All of the participants' treatment target sound ECI changes were similar to the changes in their total ECI scores. Specifically, MW and AS made the most gains to their total ECI scores and treatment target sound ECI scores whereas both AA and AG made the least gains in reducing their total ECI scores and treatment target sound ECI scores. Errors in treatment sounds might correlate to the participants' overall system substitutions or total ECI scores. This suggests that the participants' ability to make changes in treatment to their treatment sounds is influenced by their sound system organization pre-treatment.

Along with examining the children's substitutions for the treated sounds, the number of substitutions for all of the English consonants was also examined. All participants decreased their total ECI scores for all sounds post-treatment. Thus, it is not clear whether T2 words or NWs were superior in reducing the total number of sound substitution errors. The youngest two participants, MW and AS, had the most sounds in error prior to starting treatment, and showed the greatest decreases in overall error consistencies. Although it is not completely clear as to why MW and AS made more notable gains, it could be due to their age and it was easier for them to reorganize their sound systems because they have not practiced repeatedly producing incorrect substitutions (Forrest, Elbert, & Dinnsen, 2000). In addition, MW and AS only had SSD, while AG and AA had concomitant language disorder or fluency disorders, respectively, which could have also affected their results.

Vocabulary Expansion.

Children in the T2 word treatment group had more vocabulary expansion than the NW treatment group, as demonstrated by their ZOT vocabulary scores. This suggests that the use of T2 words in treatment might promote more opportunities for children to use their target words in everyday communication outside of treatment and support vocabulary development. While the T2 participants made more gains to their ZOT vocabulary scores, varying degrees of improvement were observed. Not all seven T2 treatment words were mastered after the 10 sessions of treatment. Since using T2 words is a new approach to speech treatment, different explanations for slower vocabulary expansion are explored below.

It is possible that children’s phonotactic constraints influenced their acquisition of expressive vocabulary, as children typically more readily produce new words containing sounds that they can produce (IN sounds) as compared to sounds they do not produce (OUT Sounds; Schwartz & Leonard, 1982; Velleman & Vihman, 2002). Thus, linguistic knowledge can be inhibited by a child's limited sound system or absent phonotactic structures. While children in the current study were treated with OUT sounds in order to cause the most system-wide phonological change to the child's sound system, this sound choice may have negatively impacted vocabulary expansion. More vocabulary expansion in the T2 participant group might have occurred if more gains were made to the child's phonological system. If more gains were seen in participants' phonological knowledge, the children might have been able to focus more on the lexical features of words. This suggests that children address their treatment words first at a phonological level, prior to adding these words to their lexicons (Velleman & Vihman, 2002).

Moreover, the word-learning literature has shown that novel NWs initially transfer onto other real words in the lexicon, particularly those that share similar phonological structure (Dunmay & Gaskell, 2007; Gaskell & Dumay, 2003; Magnuson, Tanenhaus, Aslin, & Dahan, 2003). Since the speech treatment in the present study targeted OUT phonemes, children might have been unable to dissociate the treatment words (both NWs and T2 words) from other words in their lexicon. It is quite likely that children with SSDs need more processing time for words containing OUT phonemes in general, and the T2 words might have increased the processing time even more so due to their additional lexical information. In order to fully understand whether vocabulary expansion is more affected by a word's lexicality or its phonological composition, T2 words containing OUT and IN sounds would need to be taught with QUIL in a storybook context. If young children in take a longer time to learn words containing OUT phonemes, this might account for why T2 participant AG made more vocabulary gains than did AS.

The age of the participants might have affected the children's vocabulary acquisition as measured by the ZOT. AS's young age may have been a factor in her performance since she was 3 years, 9 months when she was enrolled in the current study. Vocabulary definition skills emerge in kindergarten and progress through adulthood (Litowitz, 1077; Watson, 1985; Nippold, 1995); thus it can be expected that the formal quality of children's definitions would increase as a function of age. For example, definitions of 5- and 6-year-old children often are composed mainly of descriptions of objects (e.g., a dog has 4 legs; Davidson, Kline & Snow, 1986; Benelli, Arcuri, & Marchesini, 1988; Snow, 1990; Johnson & Anglin, 1995). Since the T2 academic words on the ZOT are abstract concepts that cannot be defined by only descriptors, it is possible that the preschool aged children in this study might not have clear, quality answers to the ZOT questions asking them "What does (stimulus word) mean?".

The complexity of the ZOT vocabulary assessment is another factor to consider in understanding why AG made more gains in vocabulary acquisition than AS, even though AG had a conglomerate language disorder. More specifically, the ZOT was a decontextualized vocabulary assessment, which required higher-level language knowledge, often referred to as metalinguistic skills (Wehren, De Lisi, & Arnold, 1981; Snow, 1990). Due to this potential complexity confound in ZOT testing, secondary, contextual ZOT testing was completed using the storybook pictures. Thus, this secondary testing was thought to ease the metalinguistic processing load that the traditional ZOT required.

In order to determine if the complexity of the traditional ZOT affected the T2 participants' performance on vocabulary expansion, the T2 participants' ZOT scores were compared to their contextual ZOT scores. Both T2 participants achieved higher scores on the contextual ZOT and were better able to illustrate their gains in vocabulary knowledge of the treatment target words with the modified procedure. This suggests that the contextual ZOT was a better-suited measure of vocabulary expansion for younger children. It is recommended that both versions of the ZOT continue to be used with future participants in this treatment program. With more children of a wider age range, it will become apparent whether or not the ZOT is more appropriate for school-aged children.

It must be noted that only the T2 participants received contextual ZOT testing. Moreover, the current study only assessed T2 vocabulary words since the NWs were not taught with any explicit meaning. However, it is a possibility that assessing the vocabulary knowledge of the children in the NW condition might have also revealed that they applied at least some meaning to their treated NWs. This is suggested because both NW participants used their NWs in some meaningful ways during treatment, such as during storybook reading in which the NWs were used with the same syntactic structures as their corresponding T2 words. For example, the clinician said, “Grandma tells Alexander that he can pick the eggs all by himself. Alexander thought what! Does Grandma need … (clinician paused)”. Participant AA from the NW treatment group would fill in the narrative using the NW, “thalabi”. Thus, AA applied his knowledge of syntactic structure and the picture context to use the NW within the narrative, essentially applying lexical properties to the NW. AA’s example is just one of many incidents in which the children in the NW treatment group applied meaning to the NWs.

The children’s similar reactions to NWs and T2 words suggest that both the NWs and T2 words were given similar meaning by the participants. However, the only way to test this possibility would be to use the ZOT vocabulary assessment to also provide a measure of the NWs' meaning. While the NWs did not have defined meaning, they were used in a storybook context and were used in place of real words; thus in the treatment context, the NWs did (arguably) hold meaning. The ZOT assessment could be used to score the NWs' meaning in comparison to their matched T2 words. For example, if the child defined the NW using the same definition as the matching T2 word, it could be inferred that children are placing the same lexical values on the NWs as they are with the T2 words.

In summary, the results of this study suggest that both types of treatment words can be effective treatment targets, but in different ways. Specifically, NWs may be better initially in treatment of SSD, perhaps in the imitation phrase of treatment, as they help children learn new sounds. Alternatively, T2 words could also serve an important purpose in the spontaneous phase of treatment. During the spontaneous phase, children build stronger lexical representations of their treatment words because they are no longer supplied with a model. In order for children to spontaneously produce treatment words within the treatment paradigm using lexical and syntactic entities, children need to more accurately process treatment words. Once children begin using the treatment words within syntactic and lexical entities, the child has formed a strong lexical representation for the treatment word and has added it to his/her mental lexicon. In addition, after T2 words have been added to a child's mental lexicon, they have the ability to promote generalization of treatment words and sounds from treatment into the child's everyday communication due to their lexical properties.

Study Limitations.

While the current study focused on phonology and vocabulary acquisition within children with SSDs, a range of variations did occur within the participants. Heterogeneity was the norm rather than the exception, which is to be expected within a single subject design (Compton, 1970; Dinnsen & Chin, 1993; Dinnsen, 1999). For example, while each of the participants presented with similar sound inventories, their individual sounds in error and phonological processes were different.

In order to better compare the effects of T2 and NW treatment, it was important to consider and interpret how participants' individual differences affected treatment outcomes. In the current study, participants had varying degrees of prior treatment, presenting disorders, and were of different ages. Both MW and AG had previously received speech treatment prior to being enrolled in the current study while AS and AA had received no previous speech therapy. It is possible that prior speech therapy might have improved MW's and AG's speech sound awareness and their adaptation to the structured clinical setting due to their previous experiences.

The current study was intended for children with SSDs, although some of the participants had concomitant disorders. For example, AG also had a language disorder, which makes it difficult to compare her results with the children who only had SSD. Theoretically, the additional language impairment would have made her progress slower than children without language difficulties (Schwartz, 1994; Nippold, 2007). AA's fluency and rate of speech was also a concomitant disorder issue. His overall rate of speech varied throughout sessions and activities, but as a whole improved over the course of treatment. His rate of speech was most influenced and dependent on his excitement level, as his rate of speech increased with his excitement level. While in the sessions, AA's rate of speech was usually within normal limits, especially during drill play activities, but his rate of speech could drastically increase with a loss of focus and increased excitement. In addition, AA's fluency outside of the treatment room, such as in the clinic waiting room was much more cluttered, making him highly unintelligible. Thus, AA's rate of speech might have been another reason for the observed inconsistencies in his articulation or speech performance during pre- and post-testing.

Finally, age is another factor that varied between participants and treatment groups. When conducting a treatment study, it is ideal to match participants by age because children of different ages have varying degrees of skills, which can affect treatment outcomes. For example, 3-year-olds do not perform the same way as a 6 year old in terms of motor, speech, and/or language development because individuals grow and progress at different rates. There are specific milestones in development of speech sounds, intelligibility, phonological processing, reading, writing, etc., at which are developmentally appropriate for a child based on his/her age (American Speech-Language-Hearing Association; ASHA, 1997-2014). The best matched participants in the T2 and NW groups were AS and MW, who both presented with only a SSD and were both 3-year-olds.

The preliminary results suggest that T2 words have promise as treatment targets since they increased children's speech intelligibility, PPC and PCC, increased their phonetic and/or phonemic inventories, built their metalinguistic skills and expanded their vocabulary. Since children in the NW group added more sounds to their phonemic inventories, NWs might be more effective during the initial stages of speech treatment.

However, study replication is necessary due to individual differences in previous treatment experiences, concomitant disorders, and age. Since this was a pilot study, a large number of participants were not required. Ideally at least eight participants would have provided a better sampling of the T2 and NW groups (Gierut & Morrisette, 1998; Gierut, 1998, 2001; Gierut, Morrisette, & Champion, 1999).

Word Stimuli Limitations.

Not all participants were treated with the same words and sounds. T2 words and NWs were used in treatment targeting both /θ, r/ phonemes, respective to the individual participant's assigned group. Since the purpose of the study was to compare treatment word lexicality of NWs and T2 words, the different stimulus words were a necessity. The different treatment target sounds were a result of the children's varying pre-treatment phonetic and phonemic inventories, as AA was able to produce /r/, which none of the other children could do. The /θ/ was targeted in word-initial position, using only five NW targets while /r/ was targeted in word-initial position, using seven NW and T2 word targets, respectively. Thus, only participant AA received a different treatment sound and only five treatment words compared to all of the other participants being treated on /r/ and received seven stimulus treatment words.

The differences in the amount of stimulus words and the different treatment sound that AA received make his results more difficult to directly compare to the other children. However, this was a pilot study and AA's results did support the use of T2 words. This was because throughout treatment AA was unable to define or use the T2 words, proving that T2 words are low to no frequency in pre-literate children due to their later age of acquisition.

Word Frequency.

NWs and T2 words were selected for the current study to analyze phonological changes in two different types of no-to-low frequency words in children. Due to their low frequency and non-existence within the English language, NWs have already been proven efficacious in facilitating immediate system wide phonological gains (Gierut, Morissette, & Zeimer, 2010; Leonard, 1973; McNeil & Stone, 1965; Winitz & Bellerose, 1965), promoting greater generalization in treated and untreated aspects of a sound system (Thompson, 2007; Gierut, 2001, 2007), and establishing treatment target sounds (Cummings et al., 2010).

The T2 words used in the current study were all considered to be low frequency (Kučera & Francis, 1967) and acquired later in development (Beck, McKeown, & Omanson, 1987). All of the participants within the study were judged to have limited exposure to the T2 words, making them comparable to NWs in terms of frequency and complexity. In addition all participants were unable to define and use the selected T2 words pre-treatment, with the exception of AG's somewhat random correct definition of one word. These findings suggest that T2 words are in fact similar to NWs in terms of frequency initially in treatment.

Future Studies.

The current study directly compared word lexicality between T2 and NWs, with the assumption that lexical properties would only be associated with T2 words. However, as evidenced by the NW treatment anecdotes, children also applied meaning to NWs, though the amount of lexical influence on treatment outcomes was unknown. Thus, it is important to determine whether QUIL promotes word learning and use in speech treatment or whether it might take the focus off of phonological learning. One way to test how much lexical processing children are using with NWs and T2 words would be to set up four different treatment groups: 1) NW treatment with no incidental learning, 2) NW treatment with incidental learning, 3) T2 word treatment with no incidental learning, 4) T2 word treatment with incidental learning.

Similar to the present study, the ZOT assessment would be used to test lexical processing of the treatment target words. While the NWs would still have no meaning outside of the treatment context, the clinician could compare the NW participants' responses to those of the participants in the T2 word group. Based on the results of the current study, we would predict that children would apply similar lexical features to both the NWs and T2 words. The current study did not pair the NWs in the story with the QUIL approach, so the effects that the incidental learning had on vocabulary expansion are not certain. However, it is anticipated that the NW group would learn and apply the same lexical features as the T2 participants.

It is also potentially important to examine T2 and NW treatment effects within a single child, which would eliminate participant variability. One approach to this would be to switch the T2 and NW treatment stimuli midway through treatment, so that children who were initially treated with T2 words would then use NWs for the remainder of their treatment. Switching the treatment stimuli would test the efficacy of using NW/T2 words in the initial phase of treatment as opposed to using NW/T2 words in a later phase treatment.

Preliminary results suggested that NWs might be better initially in speech treatment because participants in the NW group added more sounds to their phonemic inventories. Alternatively, the T2 participants made more improvements in their overall speech production accuracy, as measured by PCC. Thus T2 words and NWs may serve different roles in speech treatment. To clarify, it may be best to initially introduce NWs into drill play activities within treatment sessions using only picture representations, and not within a storybook that can provide a rich learning context. Since children naturally learn word meaning through storybooks, it may be better to avoid contexts that promote lexical learning. By only using pictures, and not a contextually based storyline, a child could focus solely on the phonological form of the NWs, without or with less competition from lexical features of words.

Alternatively instead of using drill-play activities, the T2 words could be introduced within a storybook using the QUIL approach. This could allow children to focus on the lexical properties of the words within a rich semantic context. Thus, initially in treatment the focus on T2 words would be to teach the lexical features of the words while NWs would focus on the phonological features. The T2 words would not be introduced into drill play activities until the children could produce the target phoneme in the NWs. Once children have formed a conceptual understanding of the treatment target phoneme and are able to produce it at the word level within the NWs, treatment can switch to targeting the same phoneme in T2 words presented within the storybook context.

One rationale for switching from NWs to T2 words in speech treatment is that once words are presented within multiword utterances, children use grammatical information to process linguistic input (Shi & Melançon, 2010; Sebastián-Gallés, 2007). Thus, it would be more beneficial for the children to hear and learn the T2 words within a storybook context because unlike NWs, they hold lexical meaning and can transfer from the treatment room into the child's everyday environment. On the other hand, NWs can be targeted in the earliest stages of speech treatment, especially when there is a strong phonological component to word learning. The NWs could be phased out once children start applying their treatment sound knowledge to syntactic structures that require lexical knowledge.

These preliminary results suggest that T2 words promote more generalization from treatment into the child's everyday speech. However, further studies need to explore whether T2 words have an overall positive or negative impact on speech treatment. Specifically, it is a possibility that they can stress a child's limited processing capabilities too much by taking their attentional focus away from the phonological knowledge necessary for accurate motor production (Maas, Robin, Austermann, Freedman, Wulf, Ballard, et al., 2008). It is also a possibility that T2 words can promote speech production accuracy because children are better able to retrieve a lexical representation due to their increased frequency (Jescheniak & Levelt, 1994; Balota & Chumbley, 1995).

The preliminary results suggest that T2 words targeting the late eight speech sounds (ʃ, θ, s, z, ð, l, r, ʒ; Shriberg, 1993) presented with a QUIL approach might be the best speech treatment for children with SSDs entering the academic setting or kindergarten. T2 words make good speech treatment targets for school-aged children because the child's previous exposure to the T2 words can be assessed using the ZOT. Since novel low frequency words allow the child to focus on the phonological form of words (Storkel et al., 2002), T2 words could enhance phonological learning.

T2 words used in speech treatment can also indirectly target metalinguistic skills, which are developmentally emerging in kindergarten (Litowitz, 1077; Watson, 1985; Nippold, 1995). Metalinguistic skills are naturally learned in speech treatment that incorporates the QUIL approach with the T2 words. Moreover, given that the child is entering into an academic setting, exposure to T2 words will increase with the development of literacy skills, promoting improved accuracy of the treated sounds in words (Hodson & Paden, 1991; Rvachew & Nowak, 2001; Tyler, Edwards, & Saxman, 1987). Using the QUIL approach in conjunction with the ZOT, would allow school SLPs to create measurable vocabulary learning outcomes on selected speech treatment target words. Further study replication is needed to confirm these preliminary findings and to establish a more comprehensive understanding of the use of T2 words in speech treatment.

APPENDICES

Appendix A
Tier Two Vocabulary and Nonword word frequency and grammatical unit data.

Frequency data comes from Washington University in St.Louis's website: http://128.252.27.56/Neighborhood/SearchHome.asp contributors Dr. David Pisoni and the Speech Research Lab at Indiana University.

/r/-Tier Two Target Words	**IPA transcription**	**Grammatical Unit**	**Washington-Frequency**	**/r/-NonWord Targets**	**IPA transcription**
Rescue	/rɛskju/	Noun	15	rezgu	/rɛskgu/
Region	/ridʒɪn/	Noun	76	reachim	/ritʃɪm/
Removes	/rimuvz/	Verb	58	renoff	/rɛnɔf/
Respond	/rispɔnd/	Verb	21	rezbomb	/rɛzbɔmb/
Relieved	/rilivd/	Adjective	13	rewived	/riwaɪ̯vd/
Rigid	/rɪdʒɪd/	Adjective	24	richit	/ritʃɪt/
Retreated	/ritritɪd/	Verb	14	ridreadet	/ridɹidɪt/

/l/-Tier Two Target Words	**IPA transcription**	**Grammatical Unit**	**Washington-Frequency**	**/l/-NonWord Targets**	**IPA transcription**
labour	/leɪbɚ/	Noun	19	lopper	/lɑpɚ/
layer	/leɪjɚ/	Verb	12	lewere	/lɛwɪɹ/
logic	/lɑdʒɪk/	Noun	17	lowchig	/loʊtʃɪg/
lecture	/lɛktʃɚ/	Verb	16	legjer	/leɪgdʒɚ/
locate	/loʊkeɪt/	Verb	16	laygaid	/leɪgeɪd/

/th/-Tier Two Target Words	**IPA transcription**	**Grammatical Unit**	**Washington-Frequency**	**/ɹ/-NonWord Targets**	**IPA transcription**
Theory	/θiɹi/	Noun	129	thaly	/ θæli/
Theme	/θim/	Noun	55	thene	/θin/
Thoughtful	/θɑtfɪl/	Adjective	155	thedvil	/θɛdvɪl/
Therapy	/θɛɹæpi/	Noun	12	thoulaby	/θɑlæbi/
Thick	/θɪk/	Adjective	67	thig	/θɪg/

Appendix B

Story narratives for /ɹ/ T2 treatment words.

Treatment Story-Alexander's visit to the Farm /ɹ /& /l/

Incidental Learning (I.L.) definitions are in text below.

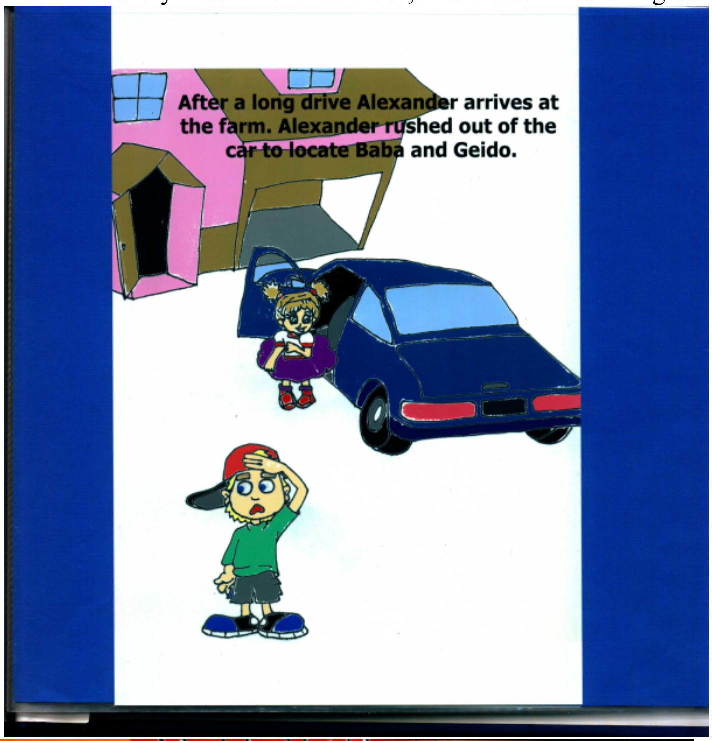
/ɹ /- region, remove, respond, rigid, rescue, relieved, and retreated.

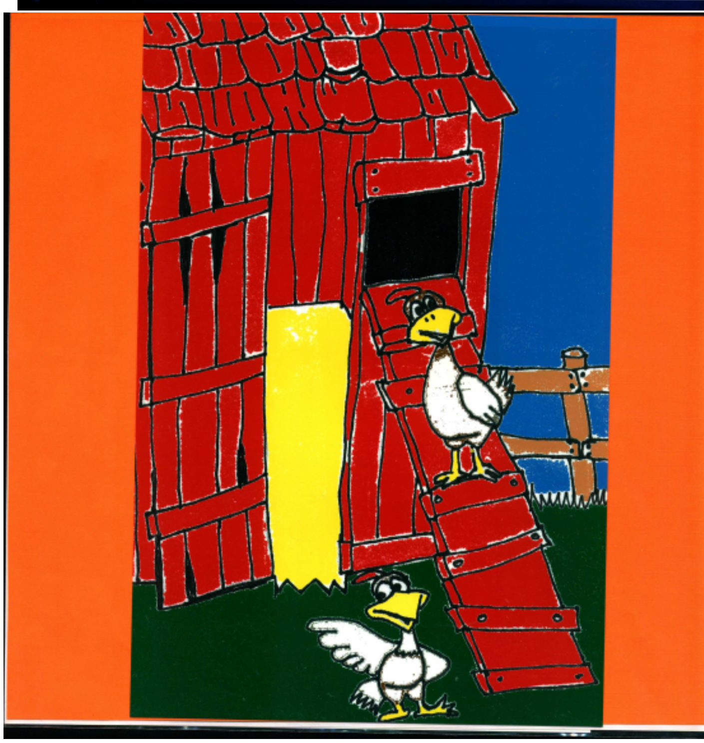
/l/- labour, label, logic, layer, lecture, locate (all AWL words; Coxhead, 2000)

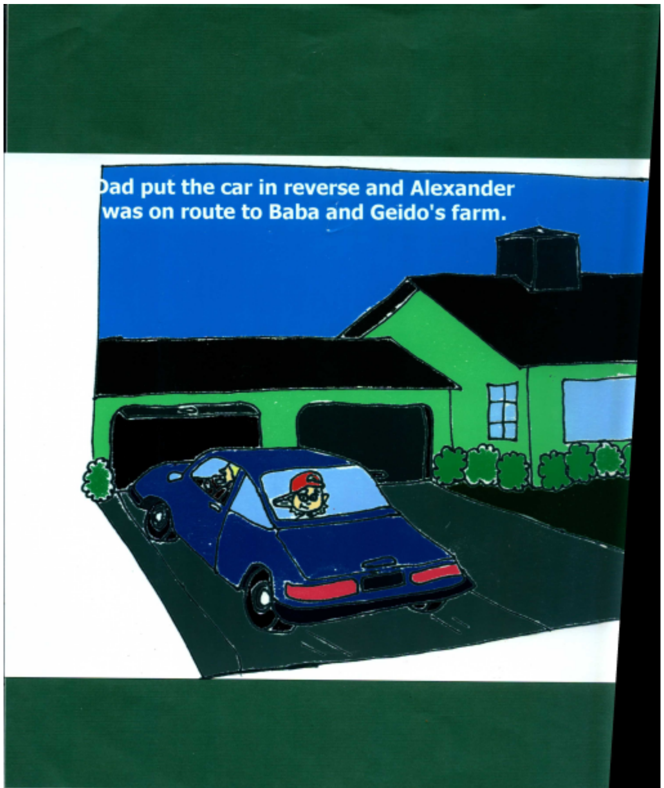
Dad put the car in reverse and Alexander was on route to Grandma and Grandpa's farm. After a long drive Alexander arrives at the farm. Alexander rushed out of the car to *locate* (*I.L. - means to find something)* Grandma and Grandpa. Finally, he located them cutting wood. He was *relieved (I.L. - means not worried)* to be out of the car and running freely on the farm. Alexander helped *layer (I.L. - means to put on top of each other)* the cut wood into tall piles. Grandma thought Alexander looked tired and sweaty, so she invited him to come pick eggs. He was relieved because layering the wood was hard *labor (I.L.-means he is working hard)*. Grandma tells Alexander that he can pick the eggs all by himself. Alexander thought, "What? Is that *logical*? *(I.L.-logic means it makes sense)*Does that make sense? Grandma always picks the eggs". The problem was the eggs were in a *region* (*I.L.-means part of a place)* right below a scary chicken's belly. Alexander reaches into the nest and *removes* (*I.L. - means take away)* one egg at a time. The chicken was really angry now that all of her eggs were gone. So, Alexander slowly *retreated (I.L. - that means to get away from something)* from the nest. Alexander *retreated* away from the chicken by walking backwards, when he... TRIPPED! He could not *respond (I.L. - that means to answer)* fast enough and broke the eggs. Grandma was *rigid* (*I.L. - that means not moving)* with anger because Alexander broke her eggs. Then luckily for Alexander, Grandpa came to the *rescue (I.L. that means he was saved)* and invited him to help feed the cows. Alexander did not want to stick around for Grandma to *lecture (I.L. - means talk about his behavior)* him. He went with Grandpa so Grandma could have some time to relax.

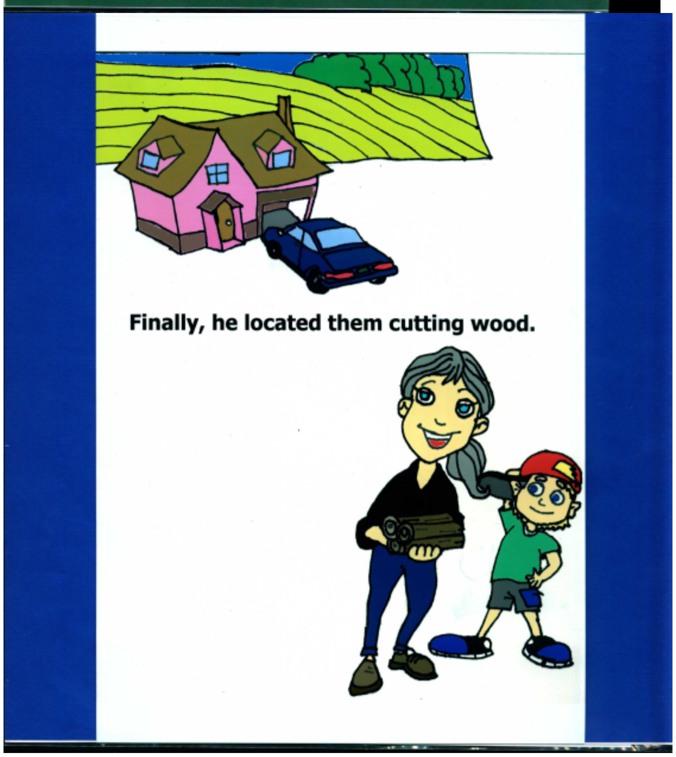
Appendix C

Treatment Story illustration narratives, and incidental learning definitions for /ɹ/ words.





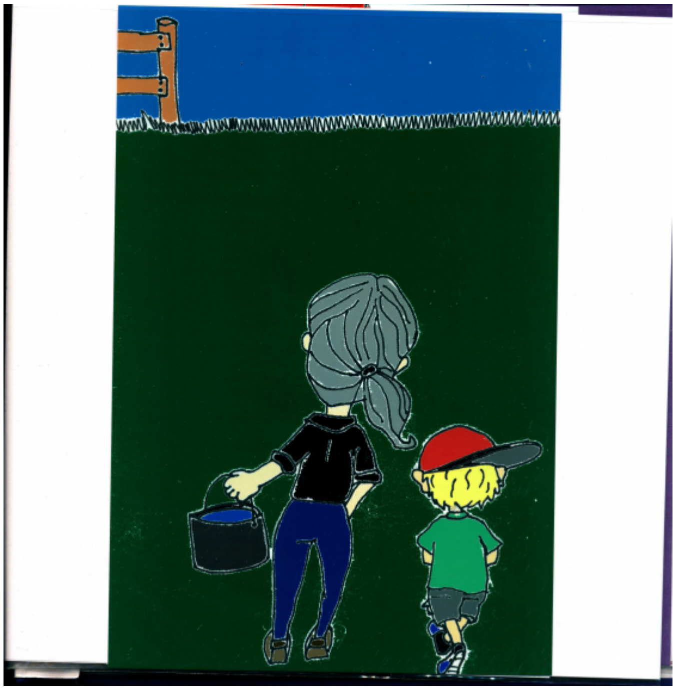

Dad put the car in reverse and Alexander
was on route to Baba and Geido's farm.


Finally, he located them cutting wood.

Relieved means Not Worried

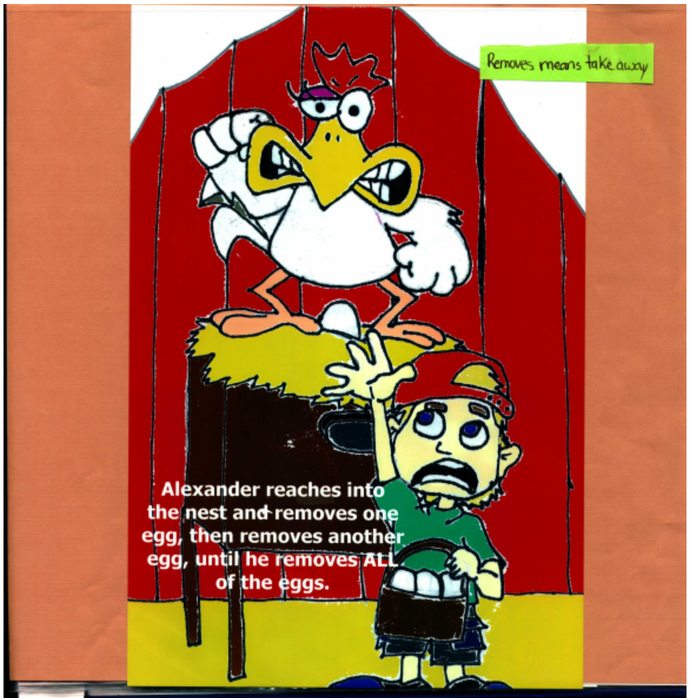
He was relieved to be out of the car and running freely on the farm.

Alexander helped layer the cut wood into tall piles. Baba thought Alexander looked tired and sweaty, so she invited him to help pick eggs. He was relieved because layering the wood took hard labor.

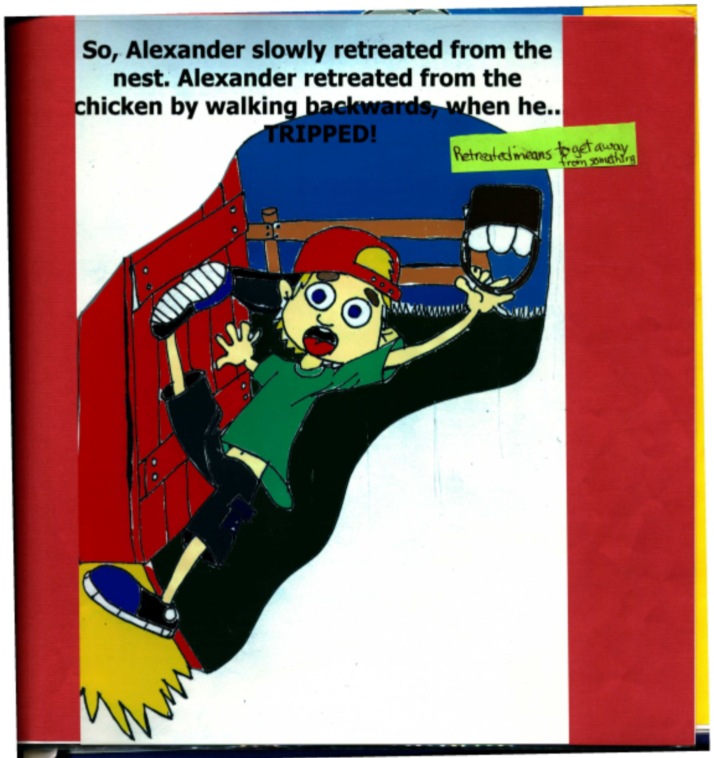


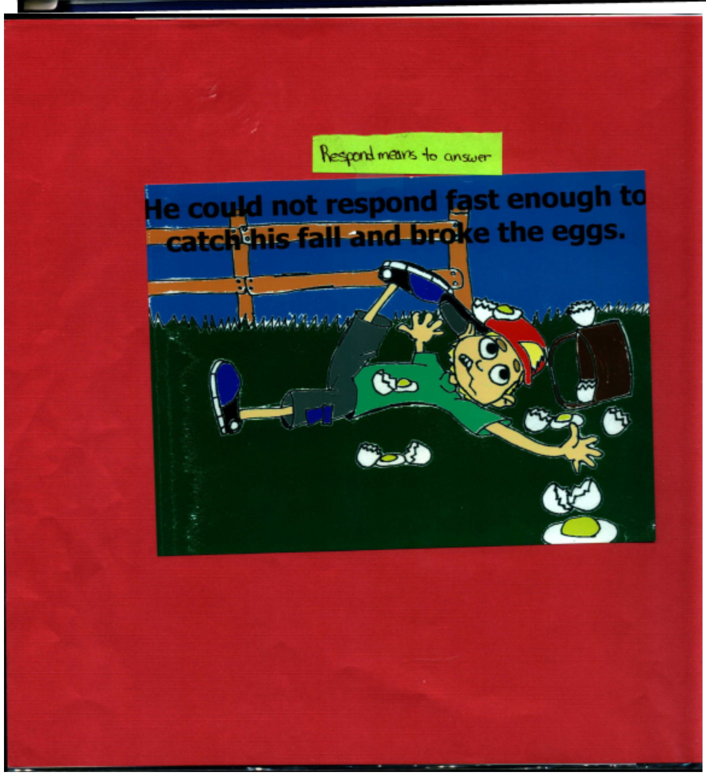
Baba tells Alexander he can pick the eggs all by himself. Alexander thought, What! Is that logical? Does that make sense? Baba always picks the eggs!

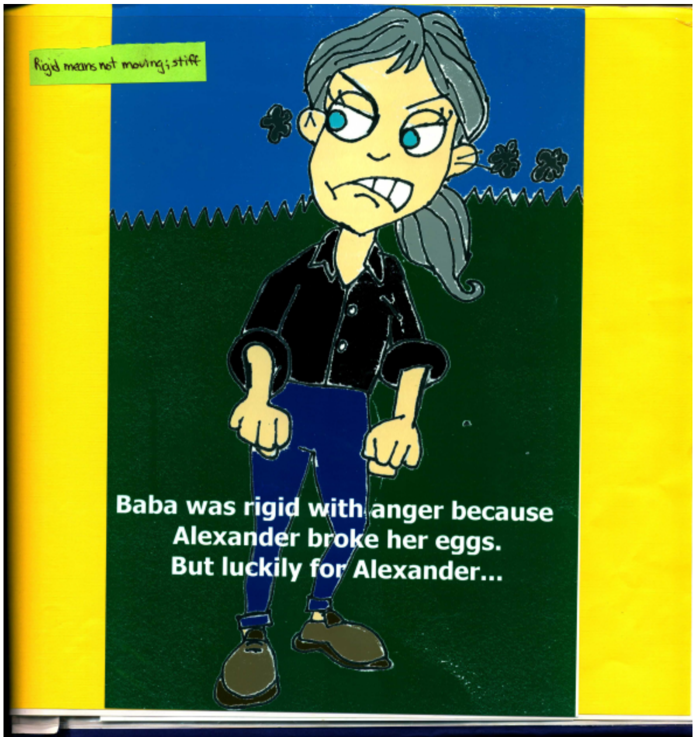

Region means part of a place
The problem was the eggs were in a region right below a scary chicken's belly.

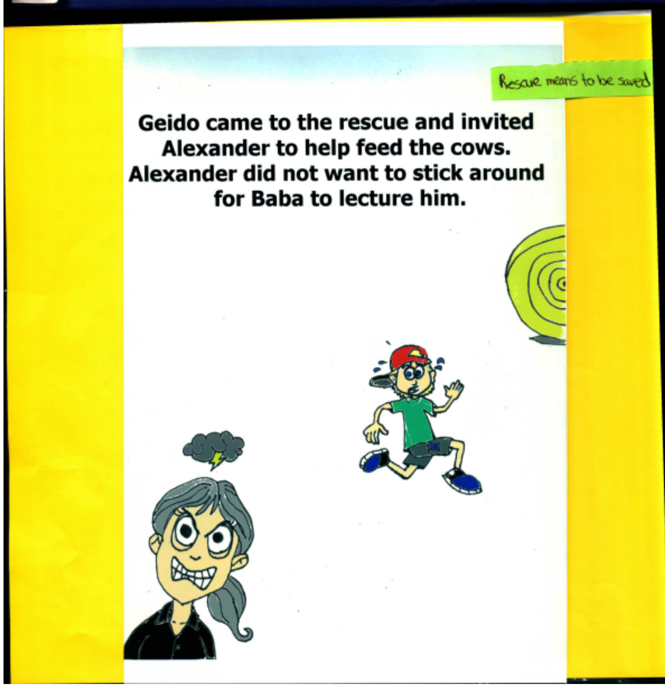

Removes means take away
Alexander reaches into the nest and removes one egg, then removes another egg, until he removes ALL of the eggs.

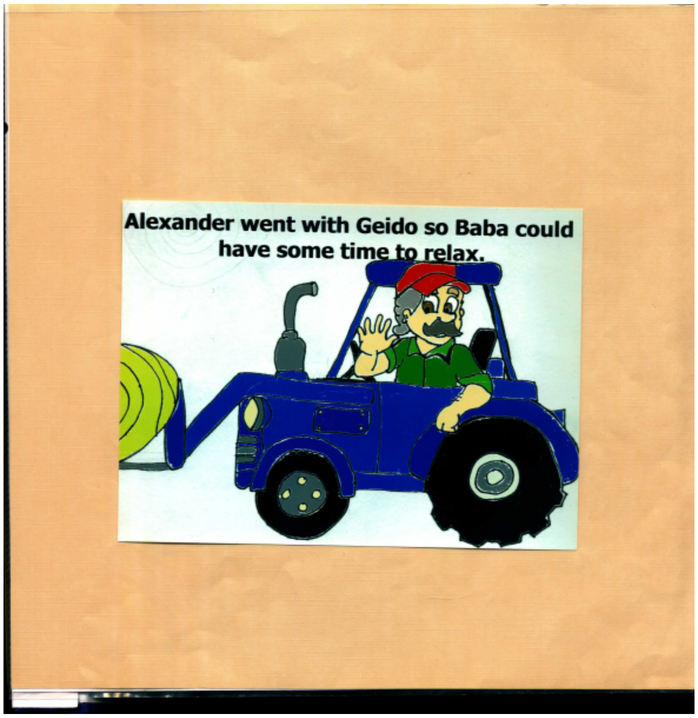

The chicken was really angry now that all of her eggs were gone.


So, Alexander slowly retreated from the nest. Alexander retreated from the chicken by walking backwards, when he..
TRIPPED!
Retreated means to get away from something


Respond means to answer
He could not respond fast enough to catch his fall and broke the eggs.


Rigid means not moving; stiff
Baba was rigid with anger because
Alexander broke her eggs.
But luckily for Alexander...


Rescue means to be saved
Geido came to the rescue and invited
Alexander to help feed the cows.
Alexander did not want to stick around
for Baba to lecture him.

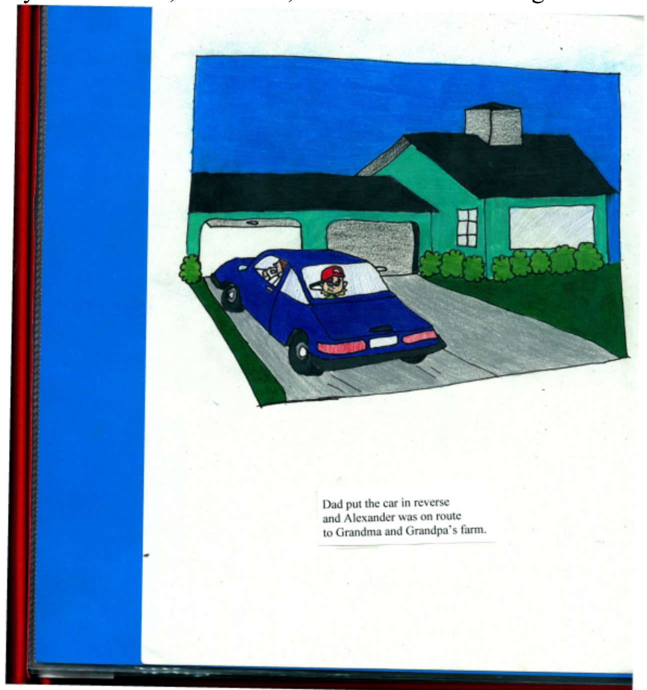

Alexander went with Geido so Baba could have some time to relax.

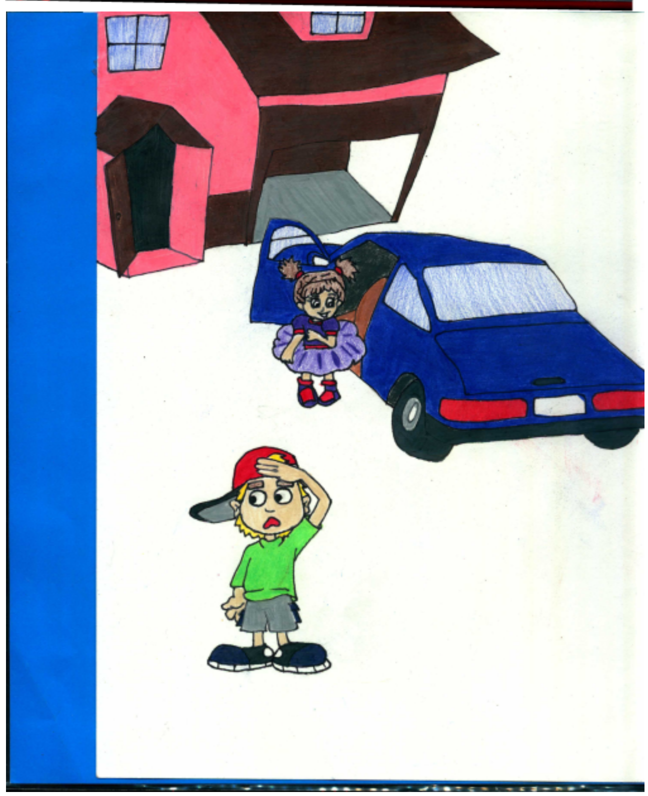
Appendix D.
Treatment Story Narrative for the /θ/

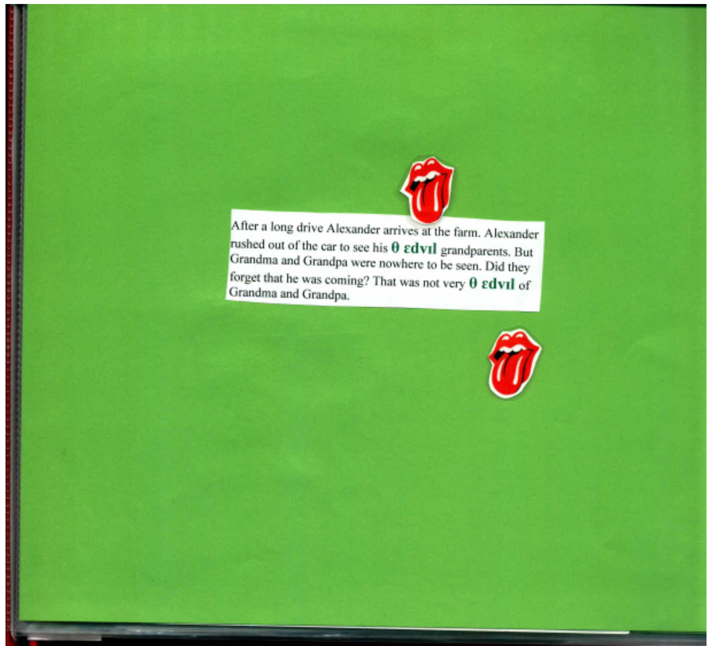
ALEXANDER'S TRIP TO THE FARM [θ]
Incidental Learning definitions are followed in the text by a (*).
T2 Words: thoughtful, thick, therapy, theme, & theory
NWs: /θɪg, θɑlæbi, θɛdvɪl, θin, θæli/

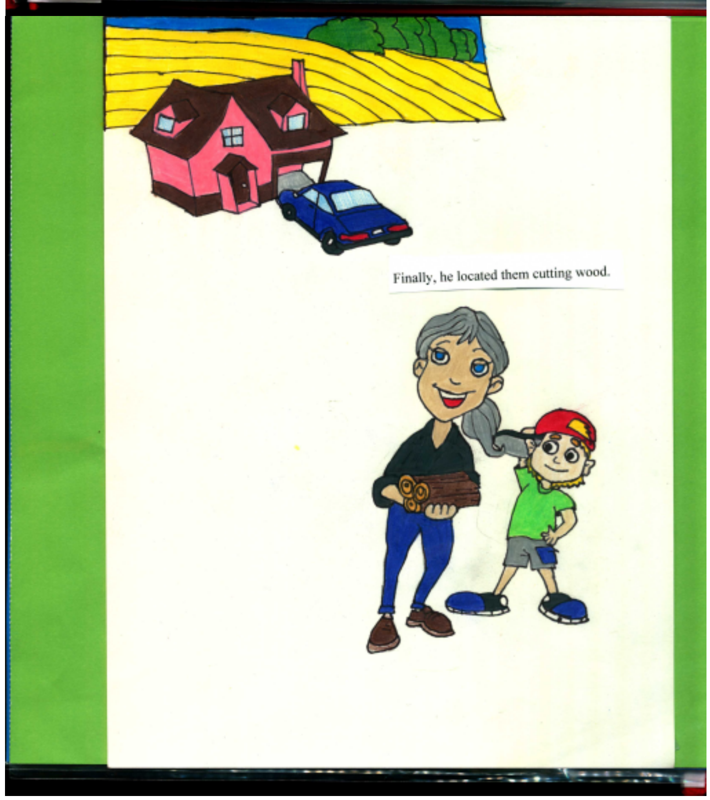
Dad put the car in reverse and Alexander was on route to Grandma and Grandpa's farm. After a long drive Alexander arrives at the farm. Alexander rushed out of the car to see his *thoughtful* (I.L.-*thoughtful means to care about others*) grandparents. But Grandma and Grandpa were nowhere in sight. Did they forget that he was coming? That was not very thoughtful of Grandma and Grandpa. Finally, he located them cutting wood. He was relieved to be out of the car and running freely on the farm. Alexander helped stack the *thick* (I.L.-thick means wide; big; dense; great distance from the surface wood into tall piles. Grandma thought Alexander looked tired and sweaty, so she asked if he needed a break. Baba tells Alexander that he can pick the eggs all by himself. Alexander thought, "What! Does Grandma need *therapy* (I.L.-therapy means to help a problem; make better? Is she crazy?!? Grandma never lets me pick the eggs!"Alexander remembered when Grandpa would come back with scratches on his hands from the chicken's sharp feet. The scary chicken does not want to give up her eggs! The hunt for eggs was the *theme* (I.L.- theme means a topic) at the farm. And the scary chicken made that theme hard because she does not give up her eggs without a fight! Alexander reaches into the nest and removes one egg, then removes another egg, until he removes ALL the eggs. Alexander had a *theory* (I.L.- theory means an idea or a good thought), if the angry chicken is upset he will walk backwards away from the nest before she notices her eggs are gone. But the angry chicken noticed her eggs were gone and flew right at Alexander. Alexander's *theory* of the chicken not noticing her eggs missing did NOT work. So, he tried backing away from the nest really fast when he … TRIPPED! He could not move fast enough to catch his fall and broke the eggs. Grandma became really angry at Alexander for breaking her eggs. Grandma was so mad, a storm of anger formed above her head. Then luckily for Alexander…Grandpa saved him by inviting him to help feed the cows. Just in time because Alexander could hear thunder coming from Grandma because she was so mad. Plus, Alexander did not want to stick around for Grandma to lecture him. Alexander went with Grandpa so Grandma could have some time to relax.

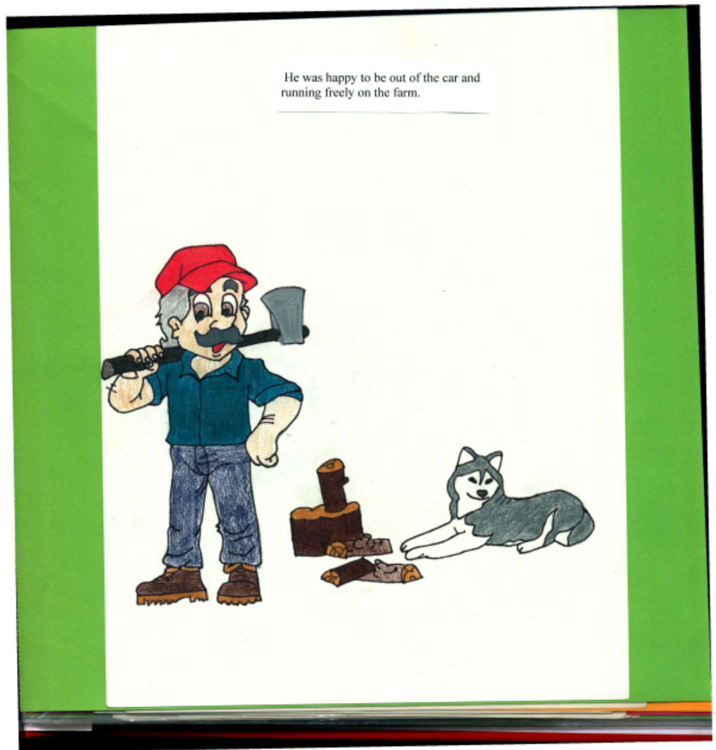
Appendix E
Treatment Story illustrations, narratives, and incidental learning definitions for the /θ/.



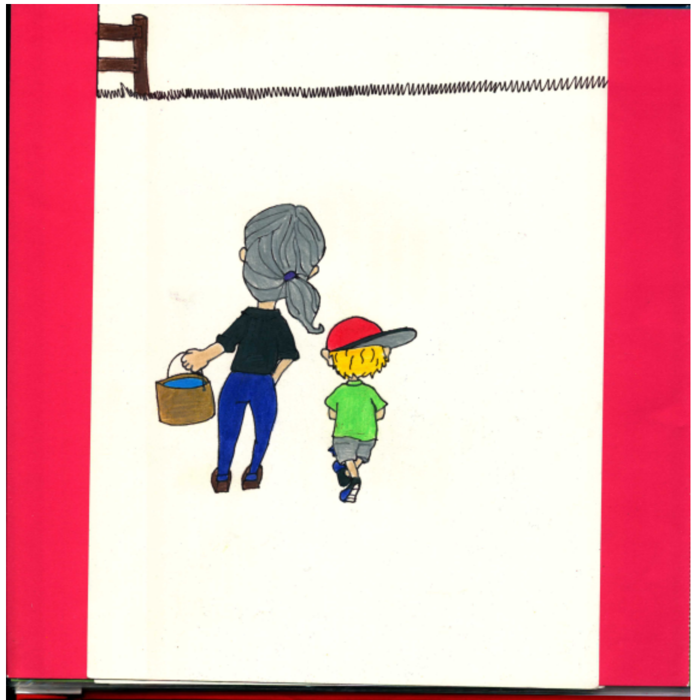



After a long drive Alexander arrives at the farm. Alexander rushed out of the car to see his θ ɛdvɪl grandparents. But Grandma and Grandpa were nowhere to be seen. Did they forget that he was coming? That was not very θ ɛdvɪl of Grandma and Grandpa.

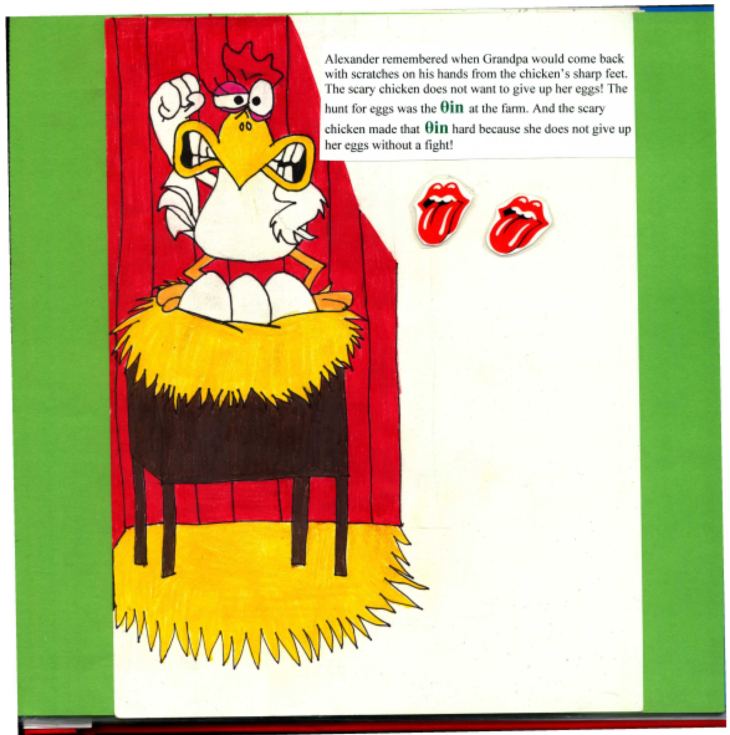

Finally, he located them cutting wood.


He was happy to be out of the car and
running freely on the farm.

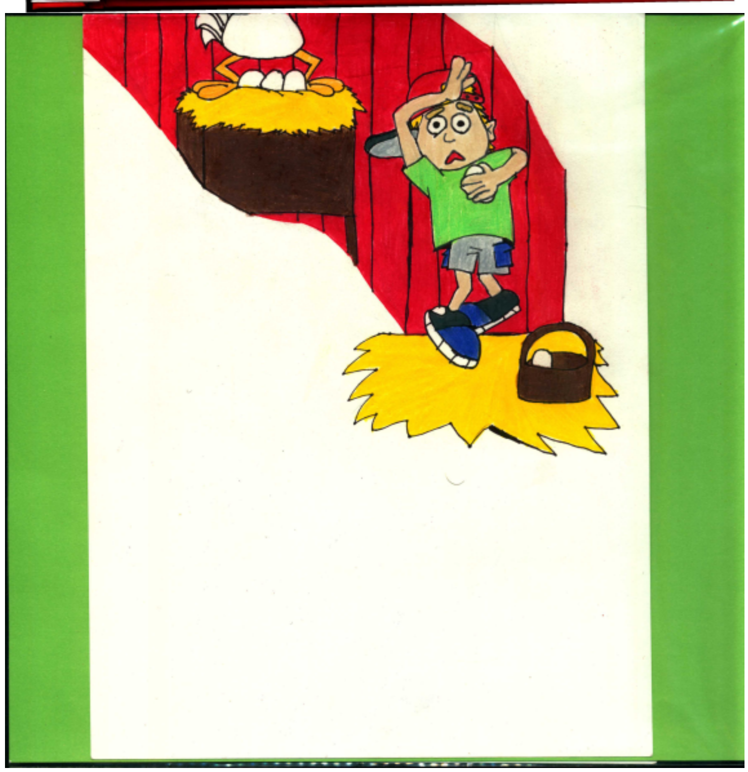

Alexander helped stack the big wood into tall piles.
Grandma thought Alexander looked tired and sweaty,
so she asked him if he needed a break.




Grandma tells Alexander that he can pick the eggs all by himself. Alexander thought,
"What! Does Grandma need /θɑlæbi/?
Is she crazy?!? Grandma never lets me pick the eggs!"



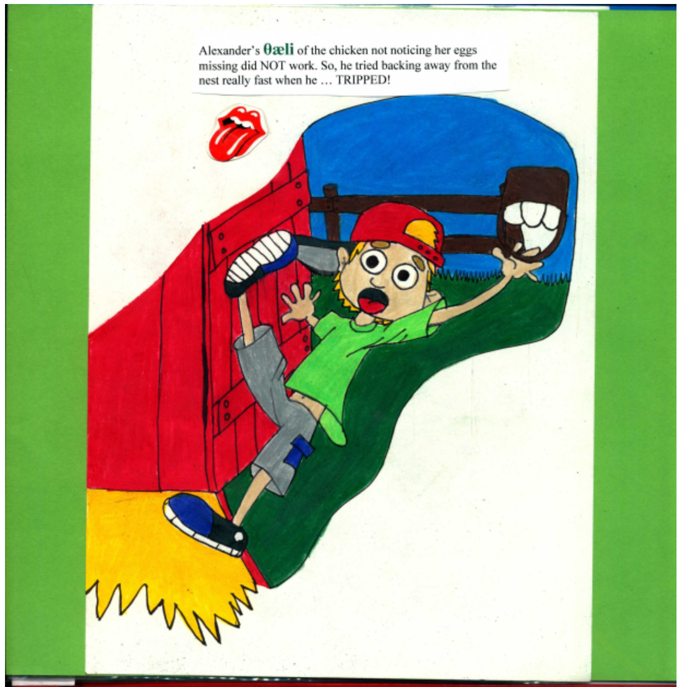
Alexander remembered when Grandpa would come back with scratches on his hands from the chicken's sharp feet. The scary chicken does not want to give up her eggs! The hunt for eggs was the θin at the farm. And the scary chicken made that θin hard because she does not give up her eggs without a fight!



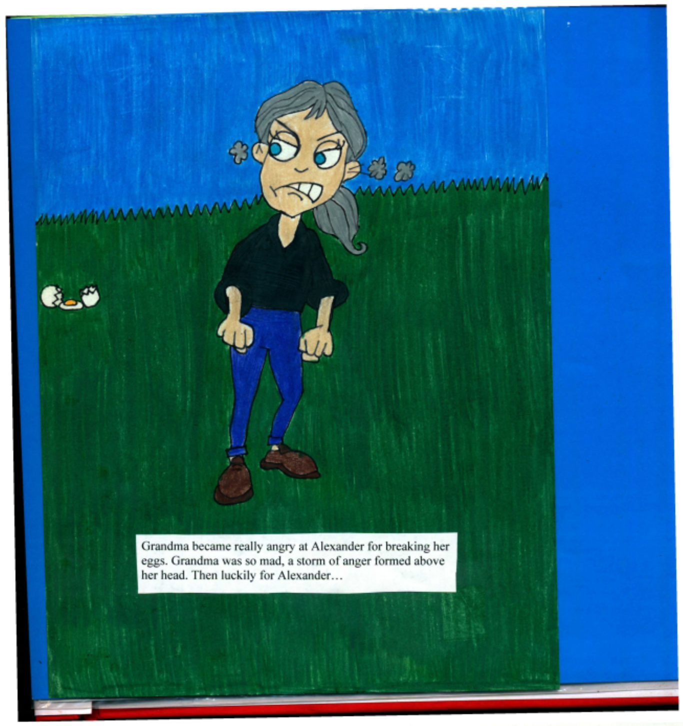
Alexander reaches into the nest and takes away one egg, then takes away another egg, until he takes ALL of the eggs. But, Alexander was not scared because he had a **θæli**.

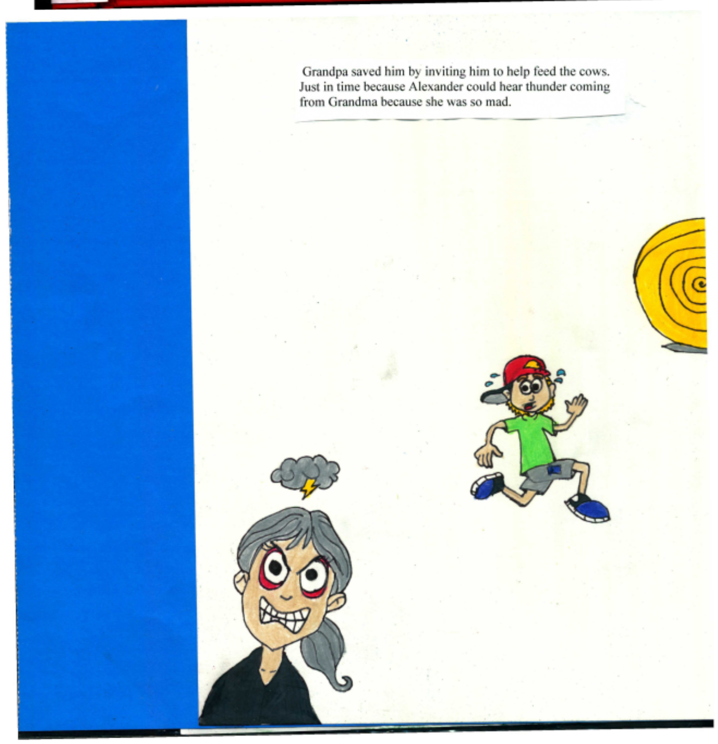
Alexander's **θæli** was, if the angry chicken is upset he will walk backwards away from the nest before she notices her eggs are gone.

But the angry chicken did notice her eggs were gone and flew right at Alexander.


Alexander's θæli of the chicken not noticing her eggs missing did NOT work. So, he tried backing away from the nest really fast when he … TRIPPED!


He could not move fast enough to catch his fall and broke the eggs.


Grandma became really angry at Alexander for breaking her eggs. Grandma was so mad, a storm of anger formed above her head. Then luckily for Alexander…


Grandpa saved him by inviting him to help feed the cows. Just in time because Alexander could hear thunder coming from Grandma because she was so mad.

Appendix E

ZOT Vocabulary Assessment for T2 /ɹ/ Words.

The definitions beside the numbers for each word correspond to the point values for the child's response. In order to receive a score of 2 the child has to use the number 2 definition or a corresponding definition. For example, if the target word was "response" and the child responded, "to go backward or in the opposite direction" the child would receive a score of 2 or if the child responded, "behind" they would receive a score of 1. Each target word is presented twice, with the 1st presentation requiring a formal definition & with the 2nd presentation of the target word requiring the use of the word within a sentence illustrating awareness of the words semantic use.

Directions: Tell me what "_________" means. Use "__________" in a sentence or story. For example, I'll use the word "save" in a sentence or story, "Spiderman will save me from the bad guys." Or I can use the word "dog" in a sentence, "The dog had a loud bark".			
Target word		Scoring	
Reverse 1: go behind 2: move (go) backward Definition:	0	1	2
Reverse Sentence:____	0	1	2
Route 1: a path 2: one way to go Definition:	0	1	2
Route Sentence:____	0	1	2
Relieved 1: happy 2: not worried Definition:	0	1	2
Relieved Sentence:____	0	1	2
Region 1: a spot 2: part of a place Definition:	0	1	2

Region Sentence:____	0	1	2
Removes 1: grab 2: take away Definition:	0	1	2
Target word	Scoring		
Removes Sentence:____	0	1	2
Retreated 1: leave 2: to get away from something Definition:	0	1	2
Retreated Sentence:____	0	1	2
Respond 1: move 2: to answer Definition:	0	1	2
Respond Sentence:____	0	1	2
Rigid 1: not moving, stiff 2: Definition:	0	1	2
Rigid Sentence:____	0	1	2
Rescue 1: 2: to be saved Definition:	0	1	2

Rescue	0	1	2
Sentence:____			
Relax 1: less worried 2: happy to rest Definition:	0	1	2

Target word	Scoring		
Relax	0	1	2
Sentence:____			

Appendix F

.ZOT Vocabulary Assessment for T2 /θ/ Words.

Directions: Tell me what "_________" means. Use "__________" in a sentence or story. For example, I'll use the word "save" in a sentence or story, "Spiderman will save me from the bad guys." Or I can use the word "dog" in a sentence, "The dog had a loud bark".			
Target word	Scoring		
Thoughtful 1: care 2: care about the needs of others Definition:	0	1	2
Thoughtful Sentence:___________________________	0	1	2
Thick 1: wide 2: a lot of space from surface to surface (side to side) Definition:	0	1	2
Thick Sentence:___________________________	0	1	2
Therapy 1: help 2: to heal or make better Definition:	0	1	2
Therapy Sentence:___________________________	0	1	2
Theme 1: a subject or topic 2: the main idea Definition:	0	1	2
Theme Sentence:___________________________	0	1	2

Theory 1: thinking about something 2: an idea Definition:	0	1	2
Target word	Scoring		
Theory Sentence:____	0	1	2
Thesis 1: a long talk 2: a long paper talking about a new idea Definition:	0	1	2
Thesis Sentence:____	0	1	2

Appendix G.
Picture Representations for treatment sounds and replacement sound errors.

“Wicked Witch Sound”- /w/ 

“Angry Dog Sound”-/ɹ/ 

“Tongue Tickler Sound” –/θ/ 

“Fuzzy Kitten Sound”-/f/ 

Appendix H.
Assessment of English Phonology

Assessment of English Phonology - Electronic (v. 1) Page 1

Name: ______________________ **Transcriber:** ______________________
Subj#: __________ **Date:** __________
Age: __________ **Assessment:** __________

Slide #	Target Word	Response
2	glasses	
3	ghost	
4	six	
5	vacuum	
6	elephant	
7	zebra	
	zoo	
8	brush	
	blue	
9	plate	
10	knife	
11	shark	
	teeth	
12	feather	
	green	
13	vanilla	
14	shovel	
	this/that	
	there	
15	yoyo	
16	guitar	
17	lemon	
	yellow	
18	stretch	
19	popcorn	
20	mother	
	father	
	behind	
	yes	
	you	
21	present	
	thank you	
	please	
22	strawberry	
23	snail	
24	beehive	
25	chicken	
26	cloud	
27	flower	
	vase	
28	music	
Slide #	**Target Word**	**Response**

Slide #	Target Word	Response
29	sock	
30	jeep	
31	doll	
32	game	
33	nail	
	hammer	
34	hanger	
	nothing	
35	ladder	
36	magic(ian)	
	rabbit	
	other	
37	rocket	
	space	
38	ocean	
39	teacher	
	finger	
40	wagon	
41	chair	
42	thirsty	
43	queen	
44	twins	
	them	
45	zipper	
46	pig	
47	screw	
48	shower	
49	theirs	
50	thunder	
51	vest	
52	treehouse	
53	cob	
	these/them	
54	sun	
55	pie	
56	drum	
57	water	
58	toes	
59	twelve	
60	zero	
61	gum	
Slide #	**Target Word**	**Response**

62	three		72	grapes	
63	judge		73	slippers	
64	jelly		74	jump(rop)ing	
65	brother		75	light (or lamp)	
66	(french) fries		76	spoon	
67	skunk		77	yawn	
68	noise		78	prince(ss)	
	quiet		79	smoke	
69	shoes		80	thermometer	
70	zipping		81	mop	
71	crayons		82	chain	
Diminutives					
83	SOAP		99	HILL	
	SOAP I			HILL I	
84	FISH		100	TRAIN	
	FISH I			TRAIN I	
85	BATH		101	MUD	
	BATH I			MUD I	
86	TUB		102	PAGE	
	TUB I			PAGE I	
87	THUMB		103	DOG	
	THUMB I			DOG I	
88	FROG		104	BED	
	FROG I			BED I	
89	CAR		105	CHEESE	
	CAR I			CHEESE I	
90	LEAF		106	SQUARE	
	LEAF I			SQUARE I	
91	GLOVE		107	COMB	
	GLOVE I			COMB I	
92	CHALK		108	ICE	
	CHALK I			ICE I	
93	JUICE		109	PEACH	
	JUICE I			PEACH I	
94	CUP		110	DUCK	
	CUP I			DUCK I	
95	WITCH		111	RING	
	WITCH I			RING I	
96	HAT		112	WATCH	
	HAT I			WATCH I	
97	BADGE		113	DOOR	
	BADGE I			DOOR I	
98	NOSE		114	BRIDGE	
	NOSE I			BRIDGE I	
Slide #	**Target Word**	**Response**	**Slide #**	**Target Word**	**Response**
115	OFF		121	MOUTH	
	OFF I			MOUTH I	

116	MOTH			122	WISH	
	MOTH I				WISH I	
117	ROBE			123	STOVE	
	ROBE I				STOVE I	
118	TOOTH			124	CAGE	
	TOOTH I				CAGE I	
119	VAN			125	SPRING	
	VAN I				SPRING I	
120	WEB			126	GOAT	
	WEB I				GOAT I	
			Progressives			
127	Laugh			143	Cough	
	Laugh ing				Cough ing	
128	Fly			144	Crash	
	Fly ing				Crash ing	
129	Run			145	Swim	
	Run ing				Swim ing	
130	Hug			146	Fall	
	Hug ing				Fall ing	
131	Smile			147	Sing	
	Smile ing				Sing ing	
132	Splash			148	Sleep	
	Splash ing				Sleep ing	
133	Blow			149	Dig	
	Blow ing				Dig ing	
134	Skate			150	Rain	
	Skate ing				Rain ing	
135	Break			151	Hiss	
	Break ing				Hiss ing	
136	Swing			152	Climb	
	Swing ing				Climb ing	
137	Buzz			153	Stir	
	Buzz ing				Stir ing	
138	Catch			154	Rake	
	Catch ing				Rake ing	
139	Kiss			155	Read	
	Kiss ing				Read ing	
140	Ride			156	Drive	
	Ride ing				Drive ing	
141	Rub			157	Throw	
	Rub ing				Throw ing	
142	Shave			158	Snow	
	Shave ing				Snow ing	

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